Geology and Paleontology of Canal Zone and Adjoining Parts of Panama

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 306-D

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By W. P. WOODRING

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A contribution to the history of the Panamá land bridge

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DESCRIPTION OF TERTIARY MOLLUSKS (GASTROPODS: EULIMIDAE, MARGINELLIDAE TO HELMINTHOGLYPTIDAE)

By W. P. Woodring

ABSTRACT

The present chapter completes the description of the gastropods in the fossilferous formations, with the exception of some 20 species in recently acquired collections. It covers 187 species and subspecies in 18 families and 13 other unnamed species are briefly described or mentioned. This brings the total so far covered to 444 and 56, respectively, in the two categories. Special attention is devoted to the family Turridae, represented by 70 species and subspecies.

Only two of the species were found in the Gatuncillo formation, the middle Eocene part of the formation. A late Eocene or early Oligocene age is retained for the marine member of the Bohio(?) formation, although Eocene affinities outweigh Oligocene. Perhaps the most striking example of Eocene affinity is afforded by *Glyptostyla panamensis*, which is redescribed and reillustrated. It is closely related to an Eocene Nigerian species. *Averellia stewarti*, from the Bohio(?), is the oldest land snail from Central America.

The late Oligocene part of the Bohio formation yielded *Strioterebrum listrotum*, the first unequivocal *Strioterebrum* from the Oligocene of the Caribbean region. The fossils from the Caimito formation, also of late Oligocene age, include *Vaginella lophota*, the first Oligocene American pteropod of the genus *Vaginella*, and the earliest pteropod of the genus *Cavolina: C. xenica*.

The name Carabra formation is adopted for strata formerly assigned to the Caimito formation. The Panamá formation is redefined to include strata in the Pacific coastal area formerly assigned to the Bohio and Caimito formations. Both the Caraba and Panamá include marine lenses containing late Oligocene larger foraminifera.

Due to the shifting of fossil localities from the Culebra formation to the La Boca formation, distribution tables have been compiled for all of the gastropods from both of those early Miocene formations. Those from the La Boca described in the present chapter include *Floribella aldrichi*, a remarkable philinid, and *Ellobium* aff. *E. pellucens*, the first American fossil representative of the salt-marsh pulmonate genus *Ellobium*. The Emperador limestone member of the La Boca yielded *Campanile* cf. *C. herculeanus*. That form and *C. herculeanus* itself are the last American species of the genus, younger than any in Europe. The fine-grained rocks in Madden basin, overlying the agglomerate of the pyroclastic-clay member of the Caimito formation of former usage, are now assigned to the La Boca.

The early Miocene Alhajuela formation is defined to include the youngest strata in Madden basin. It includes a lower member (the calcareous sandstone member of the Caimito formation of former usage) and an upper member (the Alhajuela sandstone member of the Caimito formation of former usage).

As in other chapters, the bulk of the fossils—135 species and subspecies and two unnamed forms—were collected in the Gatun formation. They include 18 cancellarids, 16 conids, 50 turrids, and 13 terebrids. The distribution of the nonendemic species of the Gatun indicates that the entire formation is of middle Miocene age. The upper part in the western area, west of the Canal Zone, formerly was considered to be late Miocene. A late Miocene age is adopted for the Chagres sandstone, instead of early Pliocene.

According to radiocarbon dates, the informally named Atlantic and Pacific muck, formerly assigned a Pleistocene age, were deposited during the post-glacial rise of sea level.

INTRODUCTION

Preparation of chapter D was started in 1962, but was interrupted at intervals by other activities. This chapter was designed to complete description of the gastropods and it does so, with the exception of some 20 species in recently acquired collections from the Gatuncillo, La Boca, and Gatun formations. Six of those species of special interest, however, are included in the present chapter and additional data, including corrections, are presented for three species described in preceding chapters.

Chapter D covers 187 species and subspecies and 13 other unnamed species that are briefly described or mentioned. This brings the total so far covered to 444 and 56, respectively, in the two categories. Two additional chapters are planned to take care of the remaining recently acquired gastropods and also the scaphopods, pelecypods, and cephalopods: an estimated 250 species.

As shown in the following table, the gastropods so far described are unevenly distributed in the marine formations.

Species of gastropods in marine formations

Formation	Number of species
Eocene series:	
Gatuncillo	33
Eocene or Oligocene series:	
Marine member of Bohio(?)	37
Oligocene series:	
Bohio	29
Caimito	41
Caraba	2
Miocene series:	
Culebra	32
La Boca, Gaillard Cut area	78
La Boca, Madden basin	6
Alhajuela	5
Gatun	293
Chagres	38

Though it is improbable that any two formations exactly duplicate each other in biofacies, the molluscan paleontology would be on a better footing, if the percentage of potential species were as high for all the formations as it is for the Gatun. The collections, mostly small, from the La Boca formation in Madden basin and the overlying Alhajuela formation consist chiefly of pelecypods.

Inasmuch as the gastropods make up about two-thirds of the molluscan faunas, it is appropriate at this time to reappraise the age of the fossiliferous formations. It is appropriate also to correct errors in stratigraphy and areal geology that have come to light since publication of chapter A. Other errors are certain to turn up as the geology becomes better understood.

FIELDWORK AND ACKNOWLEDGMENTS

Since the project started in 1947 fieldwork was undertaken in the Canal Zone and adjoining parts of Panamá that year and in 1949, 1954, 1959, 1965, and 1967. The work in 1965 was specially rewarding so far as the La Boca formation is concerned. At that time, as a result of the program of widening the Panama Canal, excavations on the west side of Las Cascadas Reach afforded an opportunity to examine the La Boca, including the Emperador limestone member, from the base upward through a thickness of 77 meters.

I am specially indebted to R. H. Stewart, geologist of the Panama Canal Company, and his assistant Joanne Allen Stewart. Through their official work they have uncovered errors in chapter A and through weekend activities they have forwarded the largest collections from the Gatuncillo, La Boca, and Gatun formations. Mr. Stewart also offered advice on subsurface geology based on his study of thousands of core holes. I have profited from advice from my colleagues A. A. Olsson and Druid Wilson, and from members of the staff of the Division of Mollusks, of the U.S. National Museum.

CHANGES IN FORMATION AND AGE ASSIGNMENTS

The geographic and geologic features mentioned in the following summary are shown on plate 1, chapter A.

The name Caraba formation, defined on page 307, is adopted for strata in the Río Mandinga area (south of Gamboa), on the south side of Madden basin, and south of the continental divide east of Madden Highway, formerly assigned to the Caimito formation. Like the Caimito formation, it is of Oligocene age.

The Panamá formation is redefined on page 308. It formerly was considered to be of early Miocene age, but now is known to be Oligocene. The strata in the Pacific coastal area formerly assigned to the Bohio and Caimito formation are reassigned to the Panamá.

The agglomerate and tuff in the so-called pyroclastic-clay member of the Caimito formation in Madden basic (p. 32) are identified by Mr. Stewart as the Las Cascadas agglomerate and the overlying fine-grained nonvolcanic rocks as the La Boca formation. The fine-grained rocks include coralliferous limestone like the Emperador limestone member of the La Boca in the Gaillard Cut area.

The Alhajuela formation is defined on page 317 to include a lower member (the calcareous sandstone member of the Caimito formation of page 32) and an upper member (the Alhajuela sandstone member) of the Caimito formation of page 33).

The upper part of the Gatun formation in the western area is now considered to be of middle Miocene age, instead of late Miocene, and the Chagres sandstone late Miocene, instead of early Pliocene.

These changes are summarized in the following table:

Changes in formation and age assignments

Former usage	Present usage
Chagres sandstone, early Pliocene.	Chagres sandstone, late Miocene.
Upper part of Gatun formation, western area, late Miocene.	Upper part of Gatun formation, western area, middle Miocene.
Alhajuela sandstone member of Caimito formation, early Miocene.	Upper member of Alhajuela formation, early Miocene.
Calcareous sandstone member of Caimito formation, early Miocene.	Lower member of Alhajuela formation, early Miocene.
Pyroclastic-clay member of Caimito formation, late Oligocene.	Las Cascadas agglomerate, Oligocene(?) and La Boca formation, early Miocene.
Caimito formation, Río Mandinga area, late Oligocene.	Caraba formation, late Oligocene.
Panamá formation, early Miocene.	Panamá formation, late Oligocene.
Bohio and Caimito formations, Pacific coastal area, late Oligocene.	Panamá formation, late Oligocene.

ADDITIONS TO ANNOTATED BIBLIOGRAPHY

The first three items should have been included in former lists.

1862. Blake, C. C., Sharks' teeth at Panama: Geologist, v. 5, p. 316.
Three species of shark teeth, including a new species, *Lamna eurybathrodon*, from Miocene deposits at Monkey Hill [upper part of Gatun formation at Mount Hope]. According to the author, "it would be very injudicious to found a species on one solitary tooth." Nevertheless he did it.

1889. Woodward, A. S., Catalogue of the fossil fishes in the British Museum (Natural History), pt. 1, 474 p., 17 pls.
Blake's species is briefly described on p. 438.

1955. White, E. I., On *Lamna eurybathrodon* Blake: Annals and Mag. Nat. History, 12th ser., v. 8, p. 191–193, 14 figs.
Blake's species is assigned to *Negaprion*, redescribed, and recorded also from a Miocene Australian locality.

1960. Woodring, W. P., Panamá: XX Cong. Géol. Internat., Com. Stratigraphique, Lexique Stratigraphique International, v. 5, Amérique Latine, fasc. 2a, Amérique Central, p. 307–357, map.
Alphabetical list of valid, dubious, and nude stratigraphic names.

1962. Tuan, Yi-Fu, A coastal reconnaissance of central Panama: California Geographer, v. 3, p. 79–96, 12 figs.
Three USGS C^{14} dates on muck, erroneously considered to be of Pleistocene age on page 50 of chapter A, are cited in a footnote on page 94.

1962. Eames, F. E., and others, Fundamentals of mid-Tertiary stratigraphical correlation, 163 p., 17 pls., 20 figs., Cambridge Univ. Press.
Gatuncillo, Bohio, and Caimito formations are of Aquitanian (early Miocene) age (p. 36–37).

1963. Vokes, E. H., Cenozoic Muricidæ of the western Atlantic region; pt. 1, *Murex* sensu stricto: Tulane Studies Geology, v. 1, no. 3, p. 93–123, 4 pls.
Includes species of *Murex* from Gatun formation.

1964. Vokes, E. H., Additions to the New World Turbinellas: Tulane Studies Geology, v. 3, no. 1, p. 95–96.
Includes discussion of species from Canal Zone.

1964. Jenkins, D. G., Panama and Trinidad Oligocene rocks: Jour. Paleontology, v. 38, p. 606.
Foraminifera from Gatuncillo formation at locality 21 of present report are of early Oligocene age.

1965. Eames, F. E., and others, Dating of some beds in Panama and Trinidad: Idem, v. 39, p. 162–163.
Fossil bed at locality 21 is of Aquitanian (early Miocene) age.

1965. Whitmore, F. C., Jr., and Stewart, R. H., Miocene mammals and Central American seaways: Science, v. 148, p. 180–185, 2 figs.
North American mammals, considered to be of middle Miocene age, from Cucaracha formation.

1965. Vokes, E. H., Cenozoic Muricidæ of the western Atlantic region; pt. 2, *Chicoreus* sensu stricto and *Chicoreus* (*Siratus*): Tulane Studies Geology, v. 3, no. 4, p. 181–208, 4 pls.
Includes a species from Gatun formation.

1966. Woodring, W. P., Estratigrafía Terciaria de la Zona del Canal y partes adyacentes de la República de Panamá (Tertiary stratigraphy of Panama Canal Zone and adjoining parts of the Republic of Panamá): Inst. Centroamericano In. y Tecnología Indus., Pub. Geol. no. 1, p. 43–45.
Includes correction of formation assignments in Pacific coastal area.

1967. Stewart, R. H., The quartz minerals of Panama and the Canal Zone: Lapidary Jour., v. 21, no. 1, p. 185–190; no. 2, p. 324–333, illus.
Includes localities where silicified corals and wood can be collected.

1967. Bold, W. A. van den, Miocene Ostracoda from Costa Rica: Micropaleontology, v. 13, no. 1, p. 75–86, 2 pls., 1 fig.
Includes a species from Caimito formation and one from Gatun formation.

1967. Bold, W. A. van den, Ostracoda of the Gatún formation, Panamá: Idem, v. 13, no. 3, p. 306–318, 2 pls.
Twenty-eight species.

1969. Blacut, Gustavo, and Kleinpell, R. M., A stratigraphic sequence of benthonic smaller foraminifera from the La Boca formation, Panama Canal Zone: Cushman Found. Foram. Research Contr., v. 20, pt. 1, p. 1–22, pls. 1–6, 4 figs.
Foraminifera from a measured section on west side of Las Cascadas Reach and a nearby core hole.

1969. Bartlett, A. S., Barghoorn, E. S., and Berger, Rainer, Fossil maize from Panama: Science, v. 165, p. 389–390, 3 figs.
Wild maize pollen and at higher level cultivated maize in radiocarbon dated muck in Gatun Lake area.

ADDITIONS TO LOCALITIES AT WHICH FOSSILS WERE COLLECTED

No. used in this report	USGS Cenozoic No.	Description of locality
		Gatuncillo formation
23b	24553	Upper course of Río Palenque, 3.4 km in direct line west of Nuevo San Juan and 1.3 km northwest of settlement of Palenque, Colón Province, Panamá. Silty mudstone. R. H. Stewart, J. L. Allen, and Anselmo Mena, 1968.
37a	23648	Top of Cerro Pelado, 1 km north-northwest of Gamboa, Canal Zone, altitude 223 m. Leached, soft sandstone. R. H. Stewart, 1964.

No. used in this report	USGS Cenozoic No.	Description of locality
		Culebra formation
112b	24502	Panama Canal, east side of Culebra Reach, northwest face of Gold Hill, near Core Hole ECB1, Canal Zone. Cliff face of sandstone. R. H. Stewart, 1967.
112c	24505	Panama Canal, east side of Culebra Reach, opposite Empire-Culebra slide, about Canal station 1730, Canal Zone. M. I. Goldman, 1912.
		Cucaracha formation
122c	----------	Panama Canal, west side of Cucaracha Reach, northeast slope of Cerro Escobar near Borinquin Highway, Canal Zone. Somewhat carbonaceous shale (coprolite bed) about 3 m above ash flow. J. L. Allen, 1965.
		La Boca formation
101a	23650	Panama Canal, west side of Las Cascadas Reach, Canal station 1627, Canal Zone. Basal echinoid-bearing limestone. R. H. Stewart and W. P. Woodring, 1965.
101b	23651	Panama Canal, west side of Las Cascadas Reach, Canal station 1631 plus 15 m, Canal Zone. Basal echinoid-bearing limestone. W. P. Woodring, 1965.
101c	23656	Panama Canal, west side of Las Cascadas Reach, Canal station 1622, Canal Zone. Unit 4 of measured section on p. 312. W. P. Woodring, 1965.
101d	23668	Panama Canal, west side of Las Cascadas Reach, Canal station 1622, Canal Zone. Unit 5 of measured section on p. 312. W. P. Woodring, 1965.
101e	23655	Panama Canal, west side of Las Cascadas Reach, Canal station 1628, Canal Zone. Poorly sorted, somewhat calcareous sandstone about 15 m below Emperador limestone member. W. P. Woodring, 1965.
101f	23653	Panama Canal, west side of Las Cascadas Reach, Canal station 1602, Canal Zone. Limestone at top of canal cliff. W. P. Woodring, 1965.
101g	23654	Panama Canal, west side of Las Cascadas Reach, Canal station 1601 plus 15 m, Canal Zone. Upper limestone in upper part of La Boca formation. W. P. Woodring, 1965.
101h	23652	Panama Canal, west side of Las Cascadas Reach, Canal stations 1608 to 1612 plus 23 meters, near top of canal cliff, Canal Zone. Somewhat calcareous silty sandstone, about 25 meters above Emperador limestone member. W. P. Woodring, R. H. Stewart and J. L. Allen, 1965.
101i	23658	Panama Canal, east side of Las Cascadas Reach, opposite measured section at Canal station 1622, Canal Zone. Upper part of La Boca formation, corresponding to unit 12 of measured section on p. 312. R. H. Stewart, 1964.

No. Used in this report	USGS Cenozoic No.	Description of locality
		Emperador limestone member of La Boca formation
117a	23662	Panama Canal, west side of Las Cascadas Reach, Canal station 1630, Canal Zone. Two beds of coralliferous limestone. R. H. Stewart and W. P. Woodring, 1965.
117b	23661	Panama Canal, west side of Las Cascadas Reach, Canal station 1630, Canal Zone. Upper noncoralliferous limestone. W. P. Woodring, 1965.
117c	23660	Panama Canal, east side of Las Cascadas Reach, Canal station 1626, Canal Zone. Coralliferous limestone. W. P. Woodring, 1965.
117d	23657	Panama Canal, west side of Las Cascadas Reach, Canal station 1622, Canal Zone. Unit 7b of measured section on p. 312. Coralliferous limestone. W. P. Woodring, 1965.
118	23659	West of Panama Canal, overgrown quarry about 250 m west of Borinquin Highway, in line with Canal station 1870, Empire Reach, Canal Zone. Same as USGS 6016. Type locality of Emperador limestone member. Incorrectly plotted on pl. 2, chap. A. R. H. Stewart, 1960.
		Lower part of Gatun formation
138f	23663	South side of Transisthmian Highway, hillside excavation at Colchonería Yero, about 450 m southwest of Cativa, Panamá. R. H. Stewart, W. P. Woodring, and others, 1965.
138g	23664	South side of Transisthmian Highway, about 35 m east of 23663, Panamá. R. H. Stewart, 1965.
		Middle part of Gatun formation
143a	24504	Panama Railroad, first cut southeast of Camp Totten, Canal Zone. [Near locality 143.] M. I. Goldman, 1912.
159d	24173	Gatun, Canal Zone. [Presumably Gatun Locks excavation.] M. I. Goldman and others, 1912.
160b	23665	South side of Río Chagres, 175 m below spillway of Gatun Dam, Canal Zone. Coralliferous conglomerate. W. P. Woodring, 1965.
160c	23666	Same locality as 23665. Silty sandstone underlying conglomerate. W. P. Woodring, 1965.
160d	24503	West end of Gatun Dam, Canal Zone. M. I. Goldman, 1912.
		Upper part of Gatun formation
177e	24174	Mount Hope borrow pits, Canal Zone. M. I. Goldman, 1912.

NEW GENERIC AND SUBGENERIC NAMES

The following new generic and subgeneric names are proposed.

Dolostoma, Turridae, Mangeliinae.

Type: *Dolostoma anorhepes* Woodring, n. sp., Gatun formation, Miocene, p. 398. Gender neuter.

Euglyphostoma, subgenus of *Glyphostoma*, Turridae, Mangeliinae.

Type: *Glyphostoma partefilosa* Dall, Gulf of California and west coast of Baja California, p. 401. Gender neuter.

Floribella, Philinidae.

Type: *Dolabella aldrichi* Dall, Miocene, Florida, Canal Zone, Cuba, p. 420. Gender feminine.

Lecallia, subgenus of *Averellia*, Helminthoglyptidæ, Xanthonycinae.

Type: *Averellia (Lecallia) stewarti* Woodring, n. sp., marine member of Bohio(?) formation, late Eocene or early Oligocene, p. 429. Gender neuter.

Paleocavolina, subgenus of *Cavolina*, Cavolinidae.

Type: *Cavolina (Paleocavolina) xenica* Woodring, n. sp., Caimito formation, Oligocene, p. 428. Gender feminine.

Rhiglyphostoma, subgenus of *Glyphostoma*, Turridae, Mangeliinae.

Type: *Glyphostoma xeston* Gardner, Miocene, Florida, p. 401. Gender neuter.

GASTROPOD FAUNAL SUMMARIES AND AGE OF FORMATIONS

EOCENE SERIES

GATUNCILLO FORMATION

As a result of Mr. Stewart's fieldwork and the core-drilling under his supervision the distribution of the Gatuncillo formation has been enlarged. Leached fossiliferous sandstone of that formation was found capping Cerro Pelado on the 227-meter peak (223 meters on the most recent map) of plate 1, a kilometer north-northwest of Gamboa (locality 37a). ECB core holes, drilled near the northwest foot of Gold Hill a few hundred meters northwest of the continental divide on the east side of the canal, revealed siltstone and mudstone of the Gatuncillo, containing abundant planktonic foraminifera, underlying the Culebra formation. Ruth Todd reports that the poorly preserved foraminifera include *Cassigerinella*, indicating a latest Eocene or early Oligocene age. Another subsurface locality (Core Hole CH–5), in the northern part of Gatun Lake, is recorded on page 61. These scattered occurrences and the reappearance of late Eocene deposits in the Río Bayano district, east of the area covered by plate 1, indicate that probably all of central Panamá was submerged in late Eocene time.

Flat-lying limestone of the Gatuncillo, resting on an irregular surface of the basement complex, was found along and near a tributary of Río Agua Sucia a kilometer west of locality 27 on the Transisthmian Highway, in an area shown as basement on plate 1. The limestone has a thickness of almost 60 meters, the greatest thickness now known for limestone in the Gatuncillo. It contains caves and deep, narrow sink holes. The stream disappears in the limestone and emerges at the contact with basement. The Agua Sucia and Río Gatun faults of plate 1 are misinterpretations.

The Gatuncillo formation has yielded 33 species of gastropods so far recorded, including two in the present chapter: *Persicula* cf. *P. semen* and *Conus* cf. *C. sauridens*, both silicified fossils from the Río Casaya area (locality 38). Fifteen of them, however, are not named at the specific level. Only four are unequivocally identified, three of which are endemic. About 20 additional species are represented in the recently acquired collection from locality 23b, for the most part species of genera not found at other localities.

The occurrence elsewhere of the same or related species is as follows:

Gastropods from Gatuncillo formation and occurrence elsewhere of same or related species

Species from Gatuncillo formation	Occurence elsewhere of same or related species
Velates perversus (Gmelin), subsp.?	*V. perversus*, early to late Eocene, principally Tethyan localities.
Turritella cf. *T. carinata* Lea	*T. carinata*, middle Eocene, southeastern U.S.
Turritella cf. *T. samanensis* Olsson.	*T. samanensis*, late Eocene, Perú.
Dirocerithium ame Woodring	*D. whitfieldi* (Heilprin), middle Eocene, southeastern U.S.
Hannatoma cf. *H. emendorferi* Olsson.[1]	*H. emendorferi*, late Eocene, or early Oligocene, Perú; late Eocene, Columbia, Venezuela.
Calyptraea cf. *C. aperta* (Solander).	*C. aperta*, Paleocene to Oligocene, western Europe, southeastern U.S., Miocene, Maryland.
Oostrombus aff. *O. chiraensis* (Olsson).	*O. chiraensis*, late Eocene or early Oligocene, Perú; *O. tournoueri* (Bayan), middle Eocene, Italy.
Terebellum (*Terebellum*) *procerum* Merian.[2]	Middle Eocene, Jamaica, Haiti, St. Bartholomew; late Eocene, Trinidad.
Terebellum (*Seraphs*) *belemnitum* (Palmer)?.	*T. belemnitum*, late Eocene, Florida.
Ectinochilus cf. *E. gaudichaudi* (d'Orbigny).	*E. gaudichaudi*, late Eocene, Perú.
Cypraedia aff. *C. subelegans* (Trechmann).	*C. subelegans*, middle Eocene, Jamaica.
Pachycrommium? solenaeum Woodring.	----------

See footnotes at end of table.

Gastropods from Gatuncillo formation and occurrence elsewhere of same or related species—Continued

Species from Gatuncillo formation	Occurrence elsewhere of same or related species
Galeodea? cf. *G. nodosa* (Solander).	*G. nodosa,* middle to late Eocene, western Europe.
Yasila aff. *Y. paytensis* Olsson	*Y. paytensis,* late Eocene, Perú.
Xancus cf. *X. peruvianus* (Olsson).	*X. peruvianus,* middle Eocene to late Eocene or early Oligocene, Perú.
Ctenilyria ctenista Woodring [1]	*C. coroni* (Morlet), middle to to late Eocene, western Europe.
Persicula (*Gibberula*) cf. *P. semen* (Lea).	*P. semen,* middle to late Eocene, southeastern U.S.
Conus cf. *C. sauridens* Conrad	*C. sauridens,* middle Eocene to early Oligocene, southeastern U.S.

[1] See following paragraph.
[2] Described on p. 192 as *Terebellum procerum?*.

Hannatoma cf. *H. emendorferi* was described on page 68 as *Hannatoma?* cf. *H. emendorferi*. Hundreds of specimens of this species from the new locality 23b show that it is indeed a *Hannatoma*, to be described in chapter E as a new species. *Hannatoma* is classified as a cerithid, not a thiarid. That it is a brackish genus is doubtful.

The Gatuncillo gastropods have Tethyan (*Velates, Terebellum* and its subgenus *Seraphs*), western European, southeastern United States, West Indian, and Peruvian affinities. Those with southeastern United States and Perú are preponderant. *Velates, Diroceri-thium, Hannatoma, Oostrombus, Seraphs, Ectinochilus, Cyprœdia, Pachycrommium, Yasila,* and *Ctenilyria* are extinct, and *Terebellum* survives only in the western Pacific Ocean.

Age.—No reasons are apparent for changing the age assignment in chapter A (p. 22), that is, that the bulk of the formation is of late Eocene age, but that it includes middle Eocene. Smaller foraminifera from locality 21 have been claimed to be of early Oligocene age (Jenkins, 1964), although at locality 23, practically along the strike, limestone yielded late Eocene larger foraminifera (p. 20). The Gatuncillo may include deposits of early Oligocene age, but the way to determine that is to examine a series of samples by trenching or augur-holing the upper part of the formation. With some effort that can be done. The Gatuncillo has been alleged to be of Aquitanian (early Miocene) age, with a liberal sprinkling here and there of reworked middle and late Eocene fossils (Eames and others, 1962, p. 36). As a matter of fact, the basis for that allegation—the occurrence of *Lepidocyclina pustulosa tobleri* (*Pliolepidina* of Eames and others)—has been repudiated (Eames and others, 1968, p. 302).

EOCENE OR OLIGOCENE SERIES

MARINE MEMBER OF BOHIO(?) FORMATION

The term "marine member of Bohio(?) formation" is a poor designation for this unit. Hill's casual designation "Vamos á Vamos [Vamos Vamos] beds" cannot be adopted, as it cannot be defined properly. His locality, on Río Chagres northwest of what is now Barro Colorado Island (locality 40), is now under the waters of Gatun Lake and the stratigraphic relations were uncertain before it was submerged. (See discussion p. 22–23.) If mapping can be carried out in the peninsula ending in Palenquilla Point (locality 41) and the peninsula to the west, it may be possible to define properly the strata containing this distinctive fauna.

Species in the families covered in chapter D are tabulated below. In that and other distribution tables the designation "sp." in the locality columns indicates an incomplete or poorly preserved species that may or may not be the same as that in the species column, and the designation "?sp." indicates that the species is questioned. Symbols for relative frequency are as follows:

Symbols used for relative frequency

Symbol	Number of specimens
R, rare	1–2
F, few	3–5
C, common	6–20
A, abundant	>20

Gastropods from marine member of Bohio(?) formation (Eulimidae, Turridae to Helminthoglyptidae

[R, rare; F, few; C, common]

	Localities				
	Vamos Vamos		Palenquilla Point		Trinidad Island
	40a	40d	41	41b	42
Eulima cf. *E. jacksonensis* Gregorio					F
Niso (*Niso*) *umbilicata* (Lea)?	R	R	F	R	
Zemacies? sp. a		R			
Turriculine? turrid	R				
Scaphander (*Scaphander*) cf. *S. jacksonensis* Palmer	F	C	R	C	
Retusa (*Cylichnina*) aff. *R. adamsi* (Palmer)				R	
Volvulella (*Volvulella*) aff. *V. conradiana* (Gabb)		R			?sp. R
Averellia (*Lecallia*) *stewarti* Woodring, n. sp				R	

If *Zemacies?* sp. a is indeed a species of *Zemacies*, it is a representative of a Paleocene to Pliocene New Zealand-Australian genus heretofore unknown in America. *Averellia stewarti*, the oldest land snail in Central America, is associated with 40 marine species

at locality 41b. It is the type of the subgenus *Lecallia*.

Thirty-seven species are so far recorded from the marine member of the Bohio(?) formation—a representation comparable to that for the Gatuncillo formation. Half of them are not named at the specific level. The seven unequivocally identified species are endemic. The affinities of those identified at the specific level and of one not so identified are as follows:

Gastropods from marine member of Bohio(?) formation and occurrence elsewhere of related species

Species from marine member of Bohio(?) formation	Occurrence elsewhere of related species
Tricolia calypta Woodring	*T. precursor* (Dall), early Miocene, Florida.
Turritella adela Woodring	*T. galvesia* Olsson, Oligocene, Perú.
Turritella cf. *T. caleta* Olsson [1]	*T. caleta*, Oligocene, Perú.
Architectonica (*Stellaxis*) aff. *A. alveata* (Conrad).	*A. alveata*, middle to late Eocene, southeastern U.S.
Architectonica cf. *A. fungia* (Conrad).	*A. fungia*, middle Eocene, southeastern U.S.
Eulima cf. *E. jacksonensis* Gregorio.	*E. jacksonensis*, middle to late Eocene, southeastern U.S.
Niso (*Niso*) *umbilicata* (Lea)?	*N. umbilicata*, early to late Eocene, southeastern U.S.
Neverita (*Glossaulax*) *bolivarensis tapina* Woodring.	*N. bolivarensis bolivarensis* Clark, late Eocene, Colombia.
Globularia (*Ampulella*) sp	*G. parisiensis* (d'Orbigny), middle Eocene to early Oligocene, western Europe.
Globularia (*Ampulella?*) *nana* Woodring.	*G. garzaensis* Vokes, middle Eocene, California.
Pachycrommium? proinum Woodring.	*P.? gabrielensis* (Clark), late Eocene, Colombia; *P.? jacksonensis* (Harris), late Eocene, southeastern U.S.
Morum (*Cancellomorum*) cf. *M. antiquum* (Bayan) [2].	*M. antiquum*, late Eocene, Italy.
Ficus cf. *F. mississippiensis* Conrad.	*F. mississippiensis*, Oligocene, southeastern U.S.
Typhis (*Laevityphis*) aff. *T. recurvirostris* Conrad.	*T. recurvirostris*, Oligocene, southeastern U.S.
Glyptostyla panamensis Dall	*G. striata* (Newton), middle or late Eocene, Nigeria.
Scaphander (*Scaphander*) cf. *S. jacksonensis* Palmer.	*S. jacksonensis*, late Eocene, southeastern U.S.
Retusa (*Cylichnina*) aff. *R. adamsi* (Palmer).	*R. adamsi*, middle Eocene, southeastern U.S.
Volvulella (*Volvulella*) aff. *V. conradiana* (Gabb).	*V. conradiana*, middle Eocene, southeastern U.S.
Averellia (*Lecallia*) *stewarti* Woodring, n. sp.	*A. coactiliata* (Férrusac), Holocene, northern México to Trinidad.

[1] Identified as *Turritella olssoni* Clark, a late Eocene Colombian species, by Allison (in Allison and Adegoke, 1969, p. 1254).
[2] Described on page 203 as *Morum* ("*Oniscidia*") cf. *M. antiquum*.

Age.—The gastropods from the marine member of the Bohio(?) formation have Eocene and Oligocene affinities, but the Eocene outweigh the Oligocene. Perhaps the most striking example of Eocene affinity is afforded by *Glyptostyla panamensis*, which is redescribed on page 434 and reillustrated on plate 48, figure 23. As a result of reappraisal, *Glyptostyla* is monotypic so far as America is concerned. A closely related species, however, *G. striata* (described as a species of *Strepsidura*), occurs in the Eocene of Nigeria. Newton (1922, p. 109) favored a middle Eocene age for the Nigerian deposits, but Eames (1957, p. 30) preferred late Eocene. Of the genera and subgenera in the preceding lists, *Stellaxis*, *Globularia*, *Pachycrommium*, *Glyptostyla*, *Zemacies?*, and *Lecallia* are extinct.

If the Eocene trend is continued by the pelecypods, a late Eocene age would be justified, presumably latest Eocene, younger than any known molluscan fauna in the Gatuncillo formation. It is possible that this Bohio(?) fauna represents an unusual biofacies in the upper part of the Gatuncillo. Stratigraphic relations, however, are unknown. A late Eocene age would agree with Cole's identification of the larger foraminifera, quoted on page 23.

OLIGOCENE SERIES

BOHIO FORMATION

The only mollusks from the Bohio formation are those in collections from the upper part of the formation on Barro Colorado Island. The following species, all collected at locality 42d, are covered in the present chapter:

Gastropods from upper part of Bohio formation on Barro Colorado Island (Marginellidae to Atyidae)

[R, rare; C, common; A, abundant]

	Locality 42d
Marginella (*Eratoidea*) aff. *M. mollitor* Dall	R
Conus cf. *C. sulculus* Dall	R
Conus aff. *C. chipolanus* Dall	C
Drillia? (*Neodrillia?*) sp	R
Strioterebrum listrotum Woodring, n. sp	R
Acteon (*Acteon*) aff. *A. tampae* Dall	R
Acteocina cf. *A. bullata* (Kiener)	A
Scaphander (*Scaphander*) *cryus* Woodring, n. sp	C
Atys (*Roxaniella*) *rhadina* Woodring, n. sp	R

Strioterebrum listrotum is the first unequivocal *Strioterebrum* from the Oligocene of the Caribbean region.

Of the 29 species from the upper part of the Bohio formation 10 are not named specifically. Seven of the eight unequivocally named species are endemic. The occurrence elsewhere and in other Canal Zone formations of the same or related species is tabulated below.

Age.—According to the tabulation, the Bohio fossils have Oligocene and Miocene affinities. The only species that occurs elsewhere *(Atys rhadina)* is found in the Oligocene Mint Spring marl member of the Marianna limestone in southeastern United States, which is generally assigned to the middle Oligocene. On the face of the table Miocene affinities far outweigh Oligocene. In the Caribbean region, however, Oligocene molluscan faunas are meager compared with those of Miocene age and for the most part consist of large, robust forms.

Gastropods from upper part of Bohio Formation on Barro Colorado Island and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from Bohio formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Solariella ephnidia Woodring	*S. altiuscula* Guppy, middle Miocene, Jamaica; *S. depressa* Dall, Holocene.
Turritella cf. *T. altilira* Conrad.	Subspecies of *T. altilira* range from late Oligocene to late Miocene.
Turritella listrota Woodring	*T. venezuelana* Hodson, early Miocene, Venezuela, Canal Zone.
Hemisinus (*Longiverena*) *oeciscus* Woodring.	*H. atriformis* Cooke, late Oligocene, Antigua.
Cerithium (*Thericium*) *mimeticum* Woodring.	----------
Orthaulax sp [1]	Possibly related to *O. pugnax* (Heilprin), late Oligocene, Georgia, early Miocene, Florida.
Globularia (*Globularia*) aff. *G. fischeri* (Dall).	*G. fischeri*, early Miocene, Florida. Also Caimito and La Boca formations.
Pachycrommium aff. *P. guppyi* (Gabb).	*P. guppyi*, middle Miocene, Jamaica; early to middle Miocene, Dominican Republic. Also Culebra and La Boca formations.
Gonysycon epomis Woodring	----------
Gonysycon cf. *G. epomis* Woodring.	----------
Mitrella epacta Woodring	*M. acanthodes* (Dall), early Miocene, Florida; *M. oxia* Gardner, early Miocene, Florida.
Marginella (*Eratoidea*) aff. M. *mollitor* Dall.	*M. mollitor*, early Miocene, Florida; *M. euancyla* Gardner, early Miocene, Florida. Also Caimito formation.
Conus cf. *C. sulculus* Dall	*C. sulculus*, early Miocene, Florida. Also Caimito formation.
Conus aff. *C. chipolanus* Dall	*C. chipolanus*, early Miocene, Florida. Also Caimito, Culebra, and La Boca formations.
Strioterebrum listrotum Woodring, n. sp.	*S. ischnum* Woodring, middle Miocene, Jamaica.
Acteon (*Acteon*) aff. *A. tampae* Dall.	*A. tampae*, early Miocene, Florida.
Acteocina cf. *A. bullata* (Kiener).	*A. bullata*, early Miocene to Holocene.
Scaphander (*Scaphander*) *cryus* Woodring, n. sp.	Doubtfully also La Boca formation.
Atys (*Roxaniella*) *rhadina* Woodring, n. sp.	Middle Oligocene, Mississippi.

[1] Described on page 191 as *Orthaulax* cf. *O. pugnax* (Heilprin).

The Suwannee limestone of Florida, of late Oligocene age, offers a more suitable biofacies, but its fauna shows little affinity with that from the Bohio formation. *Orthaulax*, *Globularia*, *Pachycrommium*, and *Gonysycon* are extinct.

The larger foraminifera from locality 42d (Cole, 1957) and the stratigraphic position below the Caimito formation are decisive for a late Oligocene age.

CAIMITO FORMATION

The Caimito formation includes two distinct biofacies: a shallow-water facies on the Panama Railroad north and south of the Bohio Peninsula (localities 56, 57, 57a) and in the Quebrancha syncline (locality 62); and a moderately deep-water facies on Barro Colorado Island (localities 54g to 54n) and Pato Horqueto Island (locality 55a). Locality 55b is a fossiliferous conglomerate interbedded with the moderately deep-water tuffaceous siltstone of locality 55a. The conglomerate evidently is a gravity slide, as its fossils are shallow-water forms. It therefore is grouped with the shallow-water facies. The two facies are so different that separate tables are presented for them. No species is found in both; in fact, only two genera (*Architectonica* and *Conus*) occur in both. (The *Architectonica* of the moderately deep-water facies is an unidentified species.) Chapter D covers the species in the next two tables.

Gastropods from shallow-water facies of Caimito formation (Marginellidae to Turridae)

[R, rare; F, few; C, common]

	Localities		
	55b	*56*	*57*
Marginella (*Eratoidea*) aff. *M. mollitor* Dall		R	----
Conus sp	R	----	----
Conus cf. *C. sulculus* Dall		C	R
Conus aff. *C. chipolanus* Dall		R	----
Gemmula cf. *G. amica* Casey		F	----
Pleurofusia sp		R	----

Gastropods from moderately deep-water facies of Caimito formation (Conidae to Cavolinidae)

[R, rare; C, common]

	Localities							
	54g	54h	54j	54k	54l	54m	54n	55a
Conus cf. *C. peruvianus* Olsson	------	R	------	------	------	------	------	------
"*Gemmula*" sp	R	------	R	------	------	------	------	------
Zemacies? sp. b	------	------	------	------	------	------	R	------
Cochlespira? sp	R	------	------	------	------	------	------	------
Clavine turrid	------	------	------	R	------	------	------	------
Scobinella aff. *S. morierei* (Cossmann)	------	R	------	------	------	R	------	------
Paraborsonia aff. *P. brassoensis* (Mansfield)	------	------	------	R	------	------	------	------
Strioterebrum sp	------	R	------	R	------	------	------	R
Ringicula (*Ringiculella?*) sp	------	------	------	------	------	------	------	R
Bulla? sp	------	------	------	------	------	------	R	------
Atys (*Aliculastrum*) sp	------	------	------	------	------	------	------	R
Vaginella lophota Woodring, n. sp	------	------	C	------	R	------	------	------
Cavolina (*Paleocavolina*) *xenica* Woodring, n. sp	------	R	R	------	------	------	------	------

The turrids and pteropods in the preceding list are noteworthy. *Cavolina xenica*, the oldest species of the genus, is the type of the subgenus *Paleocavolina*.

Forty-one species of gastropods are recorded from the Caimito formation. Half of them are not named at the specific level. Five of the seven unequivocally identified species are endemic. The next two tables show

the distribution elsewhere and in other Canal Zone formations of the same or related species.

Gastropods from shallow-water facies of Caimito formation and occurrence elsewhere and in other Canal Zone formations of the same or related species

Species from Caimito formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Turritella meroensis Olsson	Late Oligocene, Santiago area, Panamá, Ecuador, Perú.
Turritella (*Bactrospira*) *altilira* Conrad, subsp.[1]	Subspecies of *T. altilira* range from late Oligocene to late Miocene.
Architectonica (*Architectonica*) *rhicna* Woodring.	*A. nobilis* Röding, early Miocene to Holocene.
Trochita cf. *T. spirata* Forbes [2]	*T. spirata*, possibly middle Miocene to Holocene.
Orthaulax sp [3]	Possibly related to *O. pugnax* (Heilprin), late Oligocene, Georgia, early Miocene, Florida.
Cypraea cf. *C. chilona* Dall	*C. chilona*, early Miocene, Florida. Also Culebra and La Boca Formations.
Globularia (*Globularia*) aff. *G. fischeri* (Dall).	*G. fischeri*, early Miocene, Florida. Also Bohio and La Boca Formations.
Ampullinopsis spenceri (Cooke).	Late Oligocene, Antigua; possibly Puerto Rico, Santiago area, Panamá, Ecuador, Perú.
Semicassis (*Echinophoria*) *apenes* Woodring.	----------
Semicassis (*Echinophoria*) sp	*S. intermedia* (Brocchi) Miocene to Pliocene, Italy.
Cymatium (*Septa*) *ogygium* Woodring.	*C. nicobaricum* (Röding), Holocene.
Ficus cf. *F. pilsbryi* (B. Smith).	*F. pilsbryi*, middle Miocene, Jamaica, Dominican Republic.
Marginella (*Eratoidea*) aff. *M. mollitor* Dall.	*M. mollitor*, early Miocene, Florida; *M. euancycla* Gardner, early Miocene, Florida. Also Bohio formation.
Conus cf. *C. sulculus* Dall	*C. sulculus*, early Miocene, Florida. Also Bohio formation.
Conus aff. *C. chipolanus*	*C. chipolanus*, early Miocene, Florida. Also Bohio, Culebra, and La Boca formations.
Gemmula cf. *G. amica* Casey	*G. amica*, early Oligocene, Mississippi.

[1] Described on page 104 as *Turritella* (*Torcula*) *altilira* Conrad, subsp.
[2] Recorded on page 81 as *Trochita* cf. *T. trochiformis* (Born).
[3] Described on page 191 as *Orthaulax* cf. *O. pugnax* (Heilprin).

Age.—The Caimito gastropods, like those from the Bohio formation, have Oligocene and Miocene affinities. Numerically Miocene outweighs Oligocene. Nevertheless Oligocene affinities are more pronounced for the Caimito than for the underlying Bohio and the percentage of extinct genera is almost twice as high for the Caimito. The two unequivocally identified species that are not endemic (*Turritella meroensis* and *Ampullinopsis spenceri*) occur elsewhere in deposits of

Gastropods from moderately deep-water facies of Caimito formation and occurrence elsewhere and in other Canal Zone formations of related species

Species from Caimito formation	Occurrence elsewhere and in other Canal Zone formations of related species
Conus cf. *C. peruvianus* Olsson.	*C. peruvianus*, late Eocene, Perú.
Scobinella aff. *S. morierei* (Cossmann).	*S. morierei*, early to late Miocene.[1]
Paraborsonia aff. *P. brassoensis* (Mansfield).	*P. brassoensis*, middle Miocene, Trinidad.
Strioterebrum sp	*S. listrotum* Woodring, Bohio formation.
Vaginella lophota Woodring, n. sp.	*V. depressa* Daudin, Miocene, western Europe; *V. chipolana* Dall, early Miocene, Florida.
Cavolina (*Paleocavolina*) *xenica* Woodring, n. sp.	----------

[1] See page 373 for localities.

Oligocene age. Though *Ampullinopsis* (*Megatylotus* of much European literature) has an age range of late Eocene to early Miocene, it is especially characteristic of Oligocene throughout the Tethyan region, in the Rupelian (or Stampian) of western Europe, in southeastern United States, and in the Tertiary Caribbean province. The following genera and subgenera are extinct: *Orthaulax*, *Globularia*, *Ampullinopsis*, *Echinophoria*, "*Gemmula*," *Zemacies?*, *Scobinella*, *Paraborsonia*, and *Paleocavolina*.

The beautifully preserved planktonic and benthonic foraminifera in the moderately deep-water facies of the Caimito on Barro Colorado Island were identified by Bolli and assigned by him to the *Globorotalia kugleri* zone (Bolli, in Woodring, 1958, p. 22–23, 27). The smaller foraminifera, larger foraminifera (p. 29–30; Cole, 1957), and mollusks indicate a late Oligocene age.

As part of the sweeping allegation that no marine Oligocene is known in America, except in the Tampico area of México and Cuba, the Bohio and Caimito formations have been alleged to be of Aquitanian (early Miocene) age (Eames and others, 1962, p. 36–37). The sweeping allegation has been tacitly repudiated (Eames and others, 1968, p. 292–295).

CARABA FORMATION

On the recommendation of Mr. Stewart the name Caraba formation is adopted for strata formerly assigned to the Caimito formation. The name, in the form Caraba facies of the Caimito formation, was proposed by Jones (1950, p. 901). The thickest well-exposed section so far found is in the type region. It is located south of the Gamboa Reach of the Panama Canal, along a tributary of Río Mandinga, about 4 kilometers southwest of Gamboa and about 750 meters

east of Río Caraba. The section exposed along the stream, as recorded by Mr. Stewart and later by Woodring, is as follows:

Section of Caraba formation along stream in type region

	Approximate thickness (meters)
8. Andesitic lava	15
7. Agglomerate	60
6. Sandy siltstone	8
5. Hard, dense, buff limestone; *Clypeaster* fragments	3
4. Sandy siltstone and calcareous, pebbly sandstone; *Clypeaster concavus* and few mollusks (locality 60)	18
3. Hard, dense, buff limestone; *Clypeaster* fragments	8
2. Sandy siltstone and poorly sorted, silty sandstone; many *Heterostegina israelskyi*, also *Lepidocyclina asterodisca* (locality 59)	18
1. Conglomerate and coarse-grained, poorly sorted conglomeratic sandstone; boulders have maximum length of 60 cm, but cobbles having length of 3 to 6 cm more common than boulders; dacite prophyry conspicuous among clasts	70
Approximate thickness of section	200

These strata, characterized by the exceptional thickness of conglomerate and conglomeratic sandstone, presumably interfinger with the Caimito formation. The total thickness of the Caraba is unknown, even in the type region, as the base and top have not been recognized.

Where the Caraba formation reappears northeast of the Canal, it consists almost wholly of agglomerate, in which blocks and slabs of decite porphyry generally predominate, and agglomeratic tuff. North of Pedro Miguel the agglomerate is shown on the geologic map (pl. 1) as part of the Pedro Miguel agglomerate, and in the area straddling the part of Madden Highway south of the Transisthmian (or Boyd-Roosevelt) Highway overpass as part of the Caimito formation. Exposures may be seen at the falls on the east side of Madden Highway at the monument site four kilometers south of the overpass and on abandoned Army roads east of the highway. Lenses of dense marine limestone, containing calcareous algæ and larger foraminifera, have been found at locality 97, off Madden Highway, and six kilometers north-northwest of Pedro Miguel.

The fossils so far recorded from the Caraba formation and the occurrence of the same or related species elsewhere and in other Canal Zone formations are tabulated below.

Age.—The fossils other than larger foraminifera indicate a late Oligocene or early Miocene age. According to the larger foraminifera, however, the age is late Oligocene: the equivalent of part, or all, of the Caimito formation.

Fossils from Caraba formation and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from Caraba formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Larger foraminifera:	
Nummulites panamensis Cushman, near locality 97.[1]	Late Oligocene, Trinidad. Also Caimito formation.
Heterostegina israelskyi Gravell and Hanna, locality 59.[2]	Late Oligocene, Texas, Florida, México. Also Caimito formation.
Lepidocyclina asterodisca Nuttall, locality 59.	Early Oligocene, México; late Oligocene, Texas, Trinidad.
Lepidocyclina sp., near locality 97.	
Coral:	
Goniopora cf. *G. cascadensis* Vaughan, locality 61.[3]	*G. cascadensis*, La Boca formation; late Oligocene, Antigua; early Miocene, Auguilla.
Gastropods:	
Pachycrommium? aff. *P.? trinitatensis* (Mansfield), locality 60.	*P.? trinitatensis*, early Miocene, Trinidad. Also La Boca formation.
Ficus sp., group of *F. ventricosa* (Sowerby), locality 60.	Species of *F. ventricosa* group range from late Oligocene to Holocene. Possibly also Caimito formation.
Echinoid:	
Clypeaster concavus Cotteau, locality 60.[4]	Late Oligocene, Antigua; early Miocene, Anguilla.

[1] Across Madden Highway from locality 97; identification by K. N. Sachs, Jr.
[2] See p. 30; identifications by W. S. Cole.
[3] See p. 30; identification by J. W. Wells.
[4] See p. 31; identification by C. W. Cooke.

PANAMA FORMATION

The Panamá formation is redefined to include strata formerly assigned not only to the Panamá itself, but also to the Bohio and Caimito formations, and the Pedro Miguel agglomerate. As redefined the Panamá consists chiefly of agglomerate and tuff, extending from the Miraflores Lake area to Panamá City, and also northeastward across the continental divide and eastward in the Pacific coastal area to and beyond the limit of plate 1. The formation also includes tuffaceous sandstone, tuffaceous siltstone, lenses of stream deposits, and lenses of marine limestone.

Mr. Stewart showed many outcrops of agglomerate, including many new exposures resulting from highway construction and suburban development northeast of the main part of Panamá City and along the Transisthmian Highway. The agglomerate consists of angular to subrounded blocks, mostly andesitic, generally widely scattered in a matrix of fine-grained tuff. The

proportion of angular and subrounded blocks and the amount of tuff interbedded with, or overlying, agglomerate changes from place to place.

Stream deposits, made up of crudely bedded, tuffaceous sandstone containing scattered rounded, subrounded, and subangular boulders and cobbles, formerly assigned to the Bohio formation, are shown on plate 6. In the Pacific coastal area eastward from Río Abajo tuffaceous sandstone and fine-grained tuff make up a progressively larger part of the formation and in the Tocúmen Airport area farther east only fine-grained tuff was seen in excavations during construction.

The thickest lens of limestone was observed at locality 44, about 150 meters north of the Transisthmian Highway, where almost cylindrical stacks of algal limestone rise above the general surface to a maximum height of 6 meters. The lowest exposed part of the limestone contains scattered pebbles and sand grains.

Pectinids were found in algal limestone at localities 44 and 45, but no other mollusks. Larger foraminifera from algal limestone and their distribution elsewhere and in other Canal Zone formations are as follows:

Larger foraminifera from Panamá formation and their occurrence elsewhere and in other Canal Zone formations

[Identifications by W. S. Cole]

Species from Panamá formation	Occurrence elsewhere and in other Canal Zone formations
Heterostegina antillea Cushman, localities 43,[1] 45,[1] 95.[2]	Late Oligocene, Antigua, Trinidad. Also Bohio and Caimito formations.
Lepidocyclina giraudi R. Douvillé,[3] localities 43, 95.	Widespread in Oligocene, especially late Oligocene, of Caribbean region. Also Bohio, Caimito, and La Boca formations.
Lepidocyclina waylandvaughani Cole, locality 45.	Late Oligocene, Antigua, Trinidad, México. Also Bohio and Caimito formations.
Lepidocyclina yurnagunensis Vaughan,[4] localities 43, 45, 95.	Widespread in late Oligocene of Caribbean region. Also Caimito formation.
Lepidocyclina vaughani Cushman, localities 45, 95.	Late Oligocene, Antigua. Also Bohio and Caimito formations.
Lepidocyclina favosa Cushman, localities 43, 45.	Widespread in late Oligocene of Caribbean region. Also Bohio formation.
Lepidocyclina gigas Cushman, locality 43.	Widespread in late Oligocene of Caribbean region.
Miogypsina antillea Cushman, locality 95.	Late Oligocene, Trinidad; early Miocene, Anguilla. Also Bohio, Caimito, Culebra, and La Boca formations.

[1] See p. 27.
[2] See p. 33.
[3] Recorded on p. 27 and 33 as *Lepidocyclina parvula* Cushman.
[4] Includes *Lepidocyclina yurnagunensis morganopsis* Vaughan of p. 27 and 33.

Age.—The larger foraminifera in the preceding list are typical for a late Oligocene age in the Caribbean region. All except two occur also in the Caimito formation. Two range upward into the La Boca formation. Like the Caraba formation, the Panamá formation is inferred to be the equivalent of part, or all, of the Caimito. The early Miocene age formerly assigned to the Panamá was based on supposed stratigraphic relations to the La Boca, which have turned out to be erroneous.

Between Madden Highway and the Chiva Chiva road (the road extending from Miraflores Lake northeastward to the Transisthmian Highway) the Caraba and Panamá formations presumably interfinger. Much fieldwork, however, remains to be done in that heavily forested and other areas before the stratigraphic relations of the agglomerates of those formations and of the Las Cascadas agglomerate are properly known.

MIOCENE SERIES

CULEBRA FORMATION

As restricted on page 244, the Culebra formation is of limited extent along and near the Culebra Reach of the Canal, where it underlies the Cucaracha formation. Not only are fossil localities 98 to 101 to be transferred from the Culebra to the La Boca formation, as noted on page 244, but also localities 113 to 116a.

The Culebra was assumed to rest on the Las Cascadas agglomerate, but when the first core holes recently penetrated its base, it was found unexpectedly to rest directly on the Gatuncillo formation. The Culebra represents the early stage of a marine transgression culminating in the moderately deep-water siltstone in the upper part of the La Boca formation. In the Culebra Reach area the transgression was interrupted by deposition of a northwestward thinning wedge of nonmarine tuff, later altered to bentonitic clay, of the Cucaracha formation. The Culebra itself wedges out northwestward, as along the Empire and Las Cascadas reaches the La Boca overlies the Las Cascadas agglomerate; that is, as the marine transgression continued, it extended farther northward. During La Boca time doubtless the entire central Panamá area was submerged.

The present chapter covers five species from the Culebra formation, but none is specially noteworthy. On account of the transfer of fossil localities, the table on page 310 includes all of the Culebra gastropods: 32 species, about half of which are not named at the specific level.

Gastropods from Culebra formation (Neritidae to Terebridae) and occurrence in La Boca formation

[R, rare; F, few; C, common; A, abundant]

	Localities													La Boca formation
	102	103	104a	104b	106	107	108b	108c	110	110a	111a	111b	112	112a	
Neritina (Vitta?) sp.								F							
Littorina aff. *L. angulifera* (Lamarck)									R						
Turritella (Bactrospira?) amaras Woodring [1]						A	R	F	A	R	C	F	C	F	X
Turritella venezuelana Hodson						R			F		C		F	C	X
Potamides suprasulcatus (Gabb)		R	R		R		R	C	C						X
Terebralia dentilabris (Gabb)?									R						
Hipponix? sp.								R							
Calyptraea cf. *C. centralis* (Conrad)								R		R					X
Crucibulum sp.					R										
Strombus sp.					R								?R		
Orthaulax? sp.										R					
Cypraea cf. *C. chilona* Dall									R						X
Natica (Naticarius?) sp.									R						
Polinices? sp.					R										
Neverita? sp.					R								R		
Sinum sp.				R										R	
Pachycrommium? cf. *P. guppyi* (Gabb)													R		X
Semicassis? (Tylocassis?) cf. *S. aldrichi* (Dall)									R			R			
Ficus carbasea micronematica (Brown and Pilsbry)	R											R			X
Murex (Siratus) cf. *M. polynematicus* Brown and Pilsbry [2]									R						X
Metula sp.									R					R	
Cymatophos? cf. *C. veatchi* (Olsson)									F				R		X
Antillophos? (Antillophos?) cf. *A candei gatunensis* (Toula)	R				R						F		R		X
Melongena sp.								R	R	R					
Fusinus? sp.											R				
Mitra? (Cancilla?) sp. [3]													R		
Xancus cf. *X. validus* (Sowerby) [4]			R	R											X
Persicula (Rabicea venezuelana amydra Woodring, n. subsp.					R										X
Conus aff. *C. chipolanus* Dall				R											X
Gemmula sp.	F														
Terebra (Paraterebra) sp.												R			
Strioterebrum sp.											R				

[1] Described on page 101 as *Turritella (Torcula?) amaras.*
[2] Described on page 215 as *Murex (Murex?)* cf. *M. polynematicus.*
[3] Recorded on page 283 as *Mitra (Tiara)* sp.
[4] Described on page 286 as *Xancus* cf. *X. rex* Pilsbry and Johnson.

Though most of the species listed in the table lived in marine waters of normal salinity, *Neretina*, *Littorina* aff. *L. angulifera*, and *Terebralia dentilabris?* indicate brackish water, and *Potamides suprasulcatus* tolerated water of low salinity. These species are most abundant in the transition zone between the Culebra and the nonmarine Cucaracha formation (localities 108c, 110).

The following table shows the occurrence elsewhere and in other Canal Zone formations of the same or related species:

Gastropods from Culebra formation and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from Culebra formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Littorina aff. *L. angulifera* (Lamarck).	*L. angulifera*, late Miocene to Holocene.
Turritella (*Bactrospira?*) *amaras* Woodring.[1]	*T. caparonis* Maury, early Miocene, Trinidad. Also La Boca formation.
Turritella venezuelana Hodson	Early Miocene, Venezuela. Also La Boca formation.
Potamides suprasulcatus (Gabb).	Widespread in Caribbean region, late Oligocene to middle Miocene. Also La Boca formation.
Terebralia dentilabris (Gabb)?	*T. dentilabris*, Miocene, Dominican Republic.
Calyptraea cf. *C. centralis* (Conrad).	*C. centralis*, early Miocene to Holocene. Also La Boca formation.
Cypraea cf. *C. chilona* Dall	*C. chilona*, early Miocene, Florida. Also La Boca formation.
Pachycrommium? cf. *P. guppyi* (Gabb).	*P. guppyi*, middle Miocene, Jamaica; early to middle Miocene, Dominican Republic. Also Bohio and La Boca formations.
Semicassis? (*Tylocassis?*) cf. *S. aldrichi* (Dall).	*S. aldrichi*, early Miocene, Florida.
Ficus carbasea micronematica (Brown and Pilsbry).	Early Miocene, Perú. Also La Boca formation.
Murex (*Siratus*) cf. *M. polynematicus* Brown and Pilsbry.[2]	*M. polynematicus*, Gatun formation. Also La Boca formation.
Cymatophos? cf. *C. veatchi* (Olsson).	*C. veatchi*, Gatun formation; middle Miocene, Costa Rica. Also La Boca formation.
Antillophos? (*Antillophos?*) cf. *A. candei gatunensis* (Toula).	*A. candei gatunensis*, Gatun formation. Also La Boca formation.
Xancus cf. *X. validus* (Sowerby).[3]	*X. validus*, early to Middle Miocene, Dominican Republic. Also La Boca formation.
Persicula (*Rabicea*) *venezuelana amydra* Woodring, n. subsp.	*P. venezuelana venezuelana*, early Miocene, Venezuela. Also La Boca formation.
Conus aff. *C. chipolanus* Dall	*C. chipolanus*, early Miocene, Florida. Also Caimito and La Boca formations.

[1] Described on p. 101 as *Turritella* (*Torcula?*) *amaras*.
[2] Described on p. 215 as *Murex* (*Murex?*) cf. *M. polynematicus*.
[3] Described on p. 286 as *Xancus* cf. *X. rex* Pilsbry and Johnson.

Age.—Though the Culebra fauna is small, it has an unmistakable Miocene stamp—the earliest of the Miocene faunas in the Canal Zone. Moreover, the mollusks indicate the earliest part of the Miocene. All except three of the species in the preceding table occur also in the La Boca formation, an indication of the close age association of the two formations. *Orthaulax* and *Pachycrommium* are extinct, but both genera are doubtfully identified.

CUCARACHA FORMATION

Fresh-water snails of the genus *Hemisinus* (*H.* aff. *H. oeciscus*) are the only gastropods found in the Cucaracha formation.

Age.—The Cucaracha formation is bracketed by formations containing early Miocene marine fossils. Therefore the Cucaracha itself is of early Miocene age in terms of the marine succession. North American land mammals recently found in the Cucaracha are considered to be of middle Miocene age (Whitmore and Stewart, 1965, p. 182).

LA BOCA FORMATION, INCLUDING EMPERADOR LIMESTONE MEMBER

Gaillard Cut area.—Isolated outcrops of fine-grained rocks of the La Boca formation have been accessible along the Canal, and also outcrops of sandstone some distance from the Canal, as at the abandoned quarry south of Summit Gardens (locality 128). No outcrop localities showing a considerable thickness, however, were available until the excavation involved in the program of widening the Canal reached the Las Cascadas Reach in 1964–67. (The Las Cascadas Reach is the second reach southeast of Gamboa. Localities 99a, 99g, 100, 101, and 120 are plotted on the reach on plate 2.) The La Boca was exposed on the west side of the reach in a strip about 125 meters wide and a little more than a kilometer long from the major fault at Canal station 1598, which brings the underlying Las Cascadas agglomerate up above the level of Gaillard Cut, southeastward to station 1633. Many minor faults are apparent in the strip. The following section was exposed at station 1630, near the southeast end of the excavated strip:

Section of lower part of La Boca formation on west side of Las Cascadas Reach at Canal Station 1630

	Approximate thickness (meters)
6. Emperador limestone member:	
e. Noncoralliferous limestone; *Aequipecten canalis, Amusium, Spondylus, Clypeaster concavus* (locality 117b)	1.5
d. Poorly exposed sandy siltstone	3
c. Coralliferous limestone; corals, small *Spondylus*	1.5
b. Sandy siltstone	1.5

Section of lower part of La Boca formation on west side of Las Cascadas Reach at Canal Station 1630—Continued

	Approximate thickness (meters)
6. Emperador limestone member—Continued	
a. Coralliferous limestone; corals, *Turritella amaras* and other mollusks (locality 117a)	1.5
5. Greenish silty clay	1.5
4. Carbonaceous shale	.3
3. Siltstone, clay, silty sandstone, poorly sorted somewhat calcareous sandstone, and conglomeratic sandstone at foot of steep slope; mollusks in somewhat calcareous sandstone 30 meters to northwest (locality 101e)	10.5
2. Siltstone and clay, poorly exposed on bench	12
1. Lens of disintegrating echinoid-bearing limestone just beyond station 1632; mollusks and echinoids (*Echinolampas* cf. *E. lycopersicus, Clypeaster concavus*, identifications by P. M. Kier; locality 101b)	3
Las Cascadas agglomerate.	
Approximate thickness of section	36.3

At station 1627 another lens of basal echinoid-bearing limestone is represented by huge masses of hard, scabrous limestone. Mollusks and echinoids that weathered out of the hard rock were collected there (locality 101a). The echinoids, identified by P. M. Kier, are as follows: *Echinolampas* cf. *E. lycopersicus* and *Agassizia clevei*.

The Emperador limestone member was exposed on a bench at station 1626 (locality 117c). Corals, especially *Acropora* and *Porites*, and a few mollusks are strewn on the bench. The mollusks include five specimens of a big cerithid, *Campanile* cf. *C. herculeanus*.

Some 60 species of mollusks were collected from somewhat calcareous, silty sandstone on a bench extending from station 1608 to 23 meters beyond station 1612 (locality 101h). This fossiliferous bed, characterized by the abundance of a small *Aequipecten* and a small *Dimya*, was not seen elsewhere. It is about 25 meters above the Emperador limestone member. The collection contains also many well-preserved specimens of a small, heavily pillared *Lepidocyclina*, identified by K. N. Sachs, Jr., as *L. giraudi*.

The following section was measured at station 1622. The base is actually at the west end of a bench formed by the Las Cascadas agglomerate, 75 meters west of the Canal cliff at station 1622, and the top at the top of unweathered rock near the top of the steep slope at station 1621.

The samples listed in the following section are foraminiferal samples, which have been studied by Blacut and Kleinpell (1969). The section is shown in graphic form in their publication.

Section of La Boca formation on west side of Las Cascadas Reach at Canal station 1622

	Thickness (meters)
16. Thin-bedded, dark gray, sandy siltstone; sample • 410–10; overlain by weathered rock and residual clay	5.1
15. Thin-bedded, brownish, sandy siltstone	4.8
14. Silty sandstone and very sandy siltstone	.7
13. White vitric tuff, lenses out farther northwest than unit 11	.9
12. Silty sandstone and very sandy siltstone; crumbly *Lepidocyclina* and *Acila*	17.1
11. White vitric tuff, lenses out to northwest	1.3
10. Siltstone and sandy siltstone; sample 410–4, 2.8 m above base; 410–5, 4m; 410–6, 4.8 m; 410–7, 6 m; 410–8, 7.4 m; 410–9, 8.8 m	9.2
9. Claystone and mudstone, lower half dark gray, upper half chocolate brown	1.8
8. Soft mudstone and silty mudstone; leached foraminifera; includes two beds of calcareous silty sandstone, 30 to 60 cm thick	24.6
7. Emperador limestone member:	
d. Thin-bedded limestone, mat of broken branching corals	2.1
c. Thin-bedded, calcareous siltstone	.2
b. Thin-bedded limestone, mat of broken branching corals (locality 117d)	.6
a. Thin-bedded, calcareous, sandy siltstone	1.5
6. Sandstone, mudstone, and carbonaceous shale	.4
5. Mudstone and sandy siltstone; many *Bittium scotti* and molds of other small mollusks (locality 101d); sample 410–1, 1.1 m above base	3.3
4. Sandy siltstone; mollusks, for most part fragments: *Cypraea, Anadara, Trachycardium, Tagelus* (locality 101c)	.5
3. Carbonaceous shale	.6
2. Mudstone, black calcareous nodules; ostracodes, fragmentary mollusks	1.2
1. Bentonitic clay	1.3
Las Cascadas agglomerate.	
Thickness of section	77.2

Half a kilometer farther northwest a lens of dense limestone crops out in the upper part of exposed strata, as shown in the following section:

Section of La Boca formation on west side of Las Cascadas Reach from Canal station 1605 to 1601

	Approximate thickness (meters)
8. Silty sandstone and sandy siltstone; scattered foraminifera and mollusks	15
7. Lens of white vitric tuff	3
6. Silty sandstone and sandy siltstone	6
5. Lens of dense limestone; *Pachycrommium?* cf. *P.? trinitatensis, Aequipecten canalis, Amusium*, echinoids (*Echinolampas semiorbis, Clypeaster concavus*, identified by P. M. Kier; locality 101g)	4.5
4. Sandy siltstone and silty sandstone, few thin calcareous beds	20

Section of La Boca formation on west side of Las Cascadas Reach from Canal station 1605 to 1601—Continued

	Approximate thickness (meters)
3. Poorly exposed sandy and silty beds	7. 5
2. Emperador limestone member:	
e. Lenticular limestone, many *Amusium*	6
d. Alternating siltstone and limestone in beds 30 to 60 cm thick	2
c. Limestone	3
b. Siltstone	. 3
a. Coralliferous limestone near level of Canal	3
1. Carbonaceous clay and tuffaceous siltstone	. 5
Approximate thickness of section	70. 8

Immediately south of the major fault at station 1598 the base of the La Boca, overlying the Las Cascadas agglomerate, consists of variegated clay overlain by fine-grained vitric tuff.

Core hole LBW 149, located 250 meters west of the top of the measured section at station 1622, penetrated strata higher than the measured section. On the assumption that a 2.3-meter bed of vitric tuff penetrated in the core hole corresponds to unit 13 of the measured section, the combined outcrop and subsurface thickness of the La Boca is 137 meters, and the top of the formation is not represented.

Madden basin.—As mentioned on page 300, the agglomerate on the south side of Madden basin, exposed on the Transisthmian Highway immediately north of the intersection with Madden Highway, is identified by Mr. Stewart as the Las Cascadas agglomerate and the overlying fine-grained rocks as the La Boca formation. Both were formerly grouped as the pyroclastic-clay member of the Caimito formation (p. 32). The fine-grained rocks are poorly exposed or unexposed. Molds of foraminifera, including *Siphogenerina*, were observed in calcareous mudstone on a tributary of Río Chilibre (Quebrada Ancha, not shown on plate 1) about 500 meters east-northeast of the Transisthmian Highway bridge across Río Chilibre. Other streams, however, in that and adjoining areas have not been traversed.

The lenses of limestone, on which localities 71, 72, and 73 are plotted on plate 1 evidently represent outcrops of different parts of a limestone unit, now identified as the Emperador limestone member of the La Boca. In unpublished reports it has been designated informally as the Chilibre limestone.

Gastropods, Gaillard Cut area.—Seventeen species from the La Boca formation in the Gaillard Cut area are described or recorded in the present chapter. *Floribella aldrichi* is the most noteworthy of these species. It is considered to be a remarkable philinid, by far the largest fossil or living species. *Ellobium* aff. *E. pellucens* is the first American fossil representative of the salt-marsh pulmonate genus *Ellobium*. *Terebra dicheres* is the earliest known species of the subgenus *Oreoterebra*.

The La Boca fauna has been greatly enlarged by the collections from localities 101h and 116a (some 60 and some 90 species of mollusks respectively). As for the Culebra formation, all the gastropods from the La Boca formation of the Gaillard Cut area are listed in the table on pages 314–315. The table lists 78 species, half of which are not named at the specific level. Three of those not so named, chiefly from localities 101h and 116a, are to be described in chapter E. No mollusks have been recovered in Madden basin, except from the Emperador limestone member. (See table, p. 314.)

The occurrence elsewhere and in other Canal Zone formations of the same or related species is as follows:

Gastropods from La Boca formation of Gaillard Cut area and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from La Boca formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Turritella cf. *T. collazica* Maury.	*T. collazica*, late Oligocene, Puerto Rico.
Turritella (*Bactrospira?*) *amaras* Woodring.[1]	*T. caparonis* Maury, early Miocene, Trinidad. Also Culebra formation.
Turritella (*Bactrospira*) *altilira* Conrad, subsp.[2]	Subspecies of *T. altilira* range from late Oligocene to late Miocene.
Turritella subgrundifera Dall [3]	Early Miocene, Florida.
Turritella venezuelana Hodson	Early Miocene, Venezuela. Also Culebra formation.
Turritella cf. *T. berjadinensis cocoditana* Hodson.	*T. berjadinensis cocoditana*, middle Miocene, Venezuela.
Hemisinus (*Longiverena*) aff. *H. oeciscus* Woodring.	*H. oeciscus*, Bohio formation.
Potamides suprasulcatus (Gabb).	Widespread in Caribbean region, late Oligocene to middle Miocene. Also Culebra formation.
Bittium scotti Brown and Pilsbry.	*B. permutabile*, early Miocene, Florida.
Architectonica (*Architectonica*) *nobilis* Röding, subsp.[4]	*A. nobilis*, early Miocene to Holocene.
Calyptraea cf. *C. centralis* (Conrad).	*C. centralis*, early Miocene to Holocene. Also Culebra formation.
Orthaulax gabbi, Dall	Early Miocene, Florida.
Cypraea cf. *C. chilona* Dall	*C. chilona*, early Miocene, Florida. Also Culebra, and Caimito formations.
Globularia (*Globularia*) aff. *G. fischeri* (Dall).	*G. fischeri*, early Miocene, Florida. Also Caimito and Bohio formations.
Pachycrommium? cf. *P.? trinitatensis* (Mansfield).	*P.? trinitatensis*, early Miocene, Trinidad.
Pachycrommium? cf. *P. guppyi* (Gabb).	*P. guppyi*, middle Miocene, Jamaica; early to middle Miocene, Dominican Republic. Also Culebra and Bohio formations.
Morum (*Cancellomorum*) cf. *M. chipolanum* Maury.[5]	*M. chipolanum*, early Miocene, Florida.
Ficus carbasea micronematica (Brown and Pilsbry).	Early Miocene, Perú. Also Culebra formation.

Continued on page 316, with footnotes.

Gastropods from La Boca formation of Gaillard

[R, rare; F, few;

	Localities										
	98	99a	99b	99c	99d	99e	99f	99g	99h	100	100a
Acmaea? sp											
Liotia sp											
Nerita sp											
Neritina (Vitta?) sp											
Cyclophorid, genus?											
Rissoina (Zebinella?) sp			R								
Turritella cf. *T. collazica* Maury											
Turritella (Bactrospira?) amaras Woodring [1]	R		A								
Turritella (Bactrospira) altilira Conrad,[2] subsp											
Turritella subgrundifera Dall [3]					R						
Turritella venezuelana Hodson			R								
Turritella cf. *T. berjadinensis cocoditana* Hodson											
Serpulorbis sp					?R			?R			
Hemisinus (Longiverena) aff. *H. oeciscus* Woodring											
Potamides suprasulcatus (Gabb)											
Cerithium (Thericium) sp											
Campanile? sp											
Bittium scotti Brown and Pilsbry			C							C.	A
Modulus sp											
Architectonica (Pseudotorinia?) sp											
Architectonica (Architectonica) nobilis Röding, subsp			R	R						R	
Epitonium sp						R					
Cirsotrema sp											
Hipponix cf. *H. pilosus* (Deshayes)											
Calyptraea cf. *C. centralis* (Conrad)			C	F						R	
Trochita sp.[4]											
Crepidula sp			R							R	
Xenophora sp								R			
Strombus sp				R	C		R	F	F		
Orthaulax gabbi Dall					?sp.R			sp.R			sp.R
Cypraea cf. *C. chilona* Dall		?sp.R						R			
Natica sp., operculum											
Polinices? sp					R					F	
Neverita? sp		R	A	F	R		R				
Sinum sp				F	F						
Globularia (Globularia) aff. *G. fischeri* (Dall)		R									
Pachycrommium? cf. *P.? trinitatensis* (Mansfield)									R		
Pachycrommium? cf. *P. guppyi* (Gabb)											
Cassis sp											
Semicassis (Echinophoria) sp											
Semicassis (Tylocassis) sp											
Morum (Cancellomorum) cf. *M. chipolanum* Maury [5]											
Ficus carbasea micronematica (Brown and Pilsbry)				R	R		R	F	R		
Murex (Siratus) cf. *M. polynematicus* Brown and Pilsbry [6]											
Mitrella? sp			R								R
Strombina cf. *S. quirosana* Hodson											
Cymatophos? cf. *C. veatchi* (Olsson)											
Antillophos? (Antillophos?) sp. (small)											
Antillophos? (Antillophos?) cf. *A. candei gatunensis* (Toula)											
Northia? cf. *N. northiae* (Gray)											
Nassarius (Uzita?) praeambiguus (Brown and Pilsbry)			C							C	C
Melongena sp		R	R		R						
Fasciolaria sp											
Fusinus? sp			R								
Oliva (Oliva) sp			?F							?C	
Olivella sp			?F							?C	
Agaronia sp											
Xancus cf. *X. validus* (Sowerby) [7]											
Lyria? sp					R						
Marginella (Eratoidea) sp			R								
Prunum (Microspira) aff. *P. apalachee* (Gardner)			?R								
Prunum (Microspira) sp											
Persicula (Rabicea) venezuelana amydra Woodring, n. subsp											
Cancellaria? sp											
Conus cf. *C. planiceps* Heilprin											
Conus aff. *C. chipolanus* Dall											
Gemmula cf. *G. vaningeni* (Brown and Pilsbry)				F							
Pleuroliria (Polystira?) sp				R							
Pleurofusia? sp					R						
Crassispira (Crassispirella) sp											

See footnotes at end of table.

Cut area (Acmaeidae to Ellobiidae)

C, common; A, abundant]

Localities—Continued																			
100b	101	101a	101b	101c	101d	101e	101g	101h	101i	114	115	115a	115b	116	116a	119	119a	120	125	130
															R					
															R					
															C					
															C					
															R					
															R					
R															R					
								A						R	R					
								R							F			R		
								C												
										R					C					
													R							
												?F			R					
															R					
										F		F	C		F					
															F					
								R												
	A																			
								R												
										R										
								A						R	R					
								R												
															F					
															C					
												R	R	F	A					
															F				R	
								R												
										R		F	F	R	C		R	R		
R			R	sp.R				R				sp.R				sp.R		sp.R		
								R							F	R				
															R					
								C	C			R	R		R					
		F	R					F	F	R		F			R		R	R		R
										R					R					
R																				
							R	R												
												R								
								R												
								A												
								C												
								R		R										
								A	C	R		R			R			R		
										R										
										R										
										R	R	R								
									C	R										
									R	R										
	R											R								
			?R					C												
								?C							R					
	?F									F	R				F					
	?F									F	R				F					
								R							F					
															R					
															R					
								R												
										R			R		A					
								R												
								C				F	C		R					
								R				R			C					
									sp.R											
									R											
									R											
															R					

Gastropods from La Boca formation of Gaillard

	Localities										
	98	99a	99b	99c	99d	99e	99f	99g	99h	100	100a
Clathrodrillia sp											
Terebra (Oreoterebra) dicheres Woodring, n. sp											
Strioterebrum cf. *S. clethra* (Maury)											
Acteocina sp											
Scaphander (Scaphander) cryus Woodring, n. sp.?			R								
Atys? sp											
Retusa? (Cylichnina?) sp											F
Floribella aldrichi (Dall)											
Ellobium aff. *E. pellucens* (Menke)											

[1] Described on page 101 as *Turritella (Torcula?) amaras.*
[2] Recorded on page 103 as *Turritella (Torcula) altilira,* subsp.
[3] Described on page 105 as *Turritella* cf. *T. subgrundifera.*
[4] Recorded on page 81 as *Trochita* cf. *T. trochiformis* (Born).
[5] Described on page 203 as *Morum* ("*Oniscidia*") cf. *M. chipo anum.*
[6] Described on page 215 as *Murex (Murex?)* cf. *M. polynematicus.*
[7] Described on page 286 as *Xancus* cf. *X. rex* Pilsbry and Johnson.

Gastropods from La Boca formation of Gaillard Cut area and occurrence elsewhere and in other Canal Zone formations of same or related species.—Continued from p. 313

Species from La Boca formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Murex (Siratus) cf. *M. polynematicus* Brown and Pilsbry.[6]	*M. polynematicus,* Gatun formation. Also Culebra formation.
Strombina cf. *S. quirosana* Hodson.	*S. quirosana,* early Miocene, Venezuela.
Cymatophos? cf. *C. veatchi* (Olsson).	*C. veatchi,* Gatun formation; middle Miocene, Costa Rica. Also Culebra formation.
Antillophos? (Antillophos?) cf. *A. candei gatunensis* (Toula).	*A. candei gatunensis,* Gatun formation. Also Culebra formation.
Northia? cf. *N. northiae* (Gray).	*N. northiae,* Holocene.
Nassarius (Uzita?) praeambiguus (Brown and Pilsbry).	Also Gatun formation.
Xancus cf. *X. validus* (Sowerby).[7]	*X. validus,* early Miocene, Dominican Republic. Also Culebra formation.
Prunum (Microspira) aff. *P. apalachee* (Gardner).	*P. apalachee,* early Miocene, Florida.
Persicula (Rabicea) venezuelana amydra, Woodring, n. subsp.	*P. venezuelana venezuelana,* early Miocene, Venezuela. Also Culebra formation.
Conus cf. *C. planiceps* Heilprin.	*C. planiceps,* early Miocene, Florida.
Conus aff. *C. chipolanus* Dall	*C. chipolanus,* early Miocene. Also Culebra and Caimito formations.
Gemmula cf. *G. vaningeni* (Brown and Pilsbry).	*G. vaningeni,* Gatun formation.
Terebra (Oreoterebra) dicheres Woodring, n. sp.	*T. odopoia* Gardner, early to middle Miocene, Florida.
Strioterebrum cf. *S. clethra* (Maury).	*S. clethra,* early Miocene, Brazil.
Scaphander (Scaphander) cryus Woodring?, n. sp.	Perhaps same species as *S. cryus,* Bohio formation.
Floribella aldrichi (Dall)	Early Miocene, Florida, Cuba.
Ellobium aff. *E. pellucens* (Menke).	*E. pellucens,* Holocene.

[1] Described on p. 101 as *Turritella (Torcula?) amaras.*
[2] Recorded on p. 104 as *Turritella (Torcula) altilira* Conrad, subsp.
[3] Described on p. 105 as *Turritella* cf. *T. subgrundifera.*
[4] Described on p. 165 as *Architectonica (Architectonica)* cf. *A. nobilis* Roding.
[5] Described on p. 203 as *Morum* ("*Oniscidia*") cf. *M. chipolanum.*
[6] Described on p. 215 as *Murex (Murex?)* cf. *M. polynematicus.*
[7] Described on p. 286 as *Xancus* cf. *X. rex.*

Gastropods, Emperador limestone member.—The Emperador limestone member yielded the gastropods tabulated below. Aside from species identified only at the generic level, *Campanile* cf. *C. herculeanus* is the only one not in the preceding table. The Emperador species and *C. herculeanus,* from the early Miocene Anguilla formation of Anguilla, are the last American species of the genus, younger than any in Europe.

Gastropods from Emperador limestone member of La Boca formation

	Localities							
	Gaillard cut area						Madden basin	
	117a	117c	118	121	123	129a	71	73
Turritella cf. *T. collazica* Maury			R		R			
Turritella (Bactrospira?) amaras Woodring	R		R					
Turritella (Bactrospira) altilira Conrad, subsp			R					
Campanile cf. *C. herculeanus* (Cooke)		F						
Strombus sp						R		R
Orthaulax sp			R				R	
Cypraea cf. *C. chilona* Dall				R			R	
Ficus cf. *F. carbasea micronematica* (Brown and Pilsbry)							R	R
Fusinus? sp							R	
Xancus sp							R	

Age.—The La Boca fossils have marked early Miocene affinities. They suggest correlation with the Chipola formation of Florida. Nevertheless, the La Boca is considered to be older than the Chipola, chiefly on the grounds that *Lepidocyclina* and *Nemocardium* sur-

Cut area (Acmaeidas to Ellobiidae)—Continued

Localities—Continued																			
100b	101	101a	101b	101c	101d	101e	101g	101h	101i	114	115	115a	115b	116	116a	119	119a	120	125	130
									R											
												R								
													R		sp.F					
					C															
												R			R					
															R					
												R								
															R					

vived in La Boca time. To be sure *Lepidocyclina* is unknown in southeastern United States later than Oligocene. Aside from the survival of *Nemocardium* in the Tampa limestone (Mansfield, 1937, p. 258; recorded as *Protocardia*) the La Boca fossils show little resemblance to those of the Tampa, although they are thought to be of the same age. *Orthaulax*, *Globularia*, *Pachycrommium?*, and *Floribella* are extinct.

The smaller benthonic foraminifera from the La Boca indicate correlation with the early Miocene Saucesian stage of California (Blacut and Kleinpell, 1969, p. 5). In addition to *Lepidocyclina giraudi* from locality 101h, a collection from the east side of Las Cascadas Reach (locality 101i), at a horizon corresponding to unit 12 of the measured section on the west side of the reach, contains many well preserved specimens identified by K. N. Sachs, Jr., as *Lepidocyclina miraflorensis*. Those two species are the last representatives of the genus in the Canal Zone.

The large, high-domed echinoid, *Echinolampas semiorbis*, is conspicuous in the Emperador limestone member in the Gaillard Cut and Madden basin areas. It occurs in the Anguilla formation of Anguilla, which is correlated with the La Boca.

ALHAJUELA FORMATION

The Alhajuela formation is defined to include the calcareous sandstone member and Alhajuela sandstone member of the Caimito formation in Madden basin, as used in chapter A (p. 32–33). It is the youngest formation in Madden basin, which is the type region. The base is tentatively selected as the base of conglomerate formerly exposed on the Transisthmian Highway at locality 74, 1.5 kilometers south of Río Chilibrillo bridge.

The formation is divided into a lower member and an upper member. The lower member consists of the former calcareous sandstone member of the Caimito formation and includes the lens of sandy limestone formerly designated the Chilibrillo limestone member of the Caimito (p. 32). The upper member is the former Alhajuela sandstone member of the Caimito. The thickness of the formation is estimated to be 115 to 145 meters.

Gastropods are rare in the Alhajuela formation and with few exceptions are represented by molds. The following species are recorded in earlier chapters:

Gastropods from Alhajuela formation

	Localities									
	Lower member					Upper member				
	77	79	80	82	82a	85	85a	88	89	92
Turritella (Bactrospira) altilira altilira Conrad [1]	cf. R		cf. R					?	C	?
Turritella gatunensis Conrad?				R						
Vermetid?						R				
Crucibulum sp.								R		
Malea sp.		R			?R		?R			
Ficus carbasea carbasea (Guppy)	sp. R							R		

[1] Described on p. 102 as *Turritella (Torcula) altilira altilira*.

Age.—The upper member contains the typical form of *Turritella altilira* and the typical form of *Ficus carbasea*—the earliest known occurrence of those forms, which are found in the Gatun formation. That the age of the entire Alhajuela formation is late early Miocene, rather than middle Miocene, is indicated by the pelecypods.

GATUN FORMATION

The present chapter covers 135 species and subspecies from the Gatun formation and two unnamed ones are

Gastropods from Gatun formation (Eulimidae, Marginellidae to

[R, rare; F, few;

	Localities																																
	Lower part														Middle part																		
															Eastern area																		
	136	136a	137	137a	138	138a	138b	138c	138d	138e	138f	138g	139	139b	139c	139d	139e	139f	139g	140	141	142	144	146	147	147b	147e	147f
Turritella abrupta Spieker								R	R	C							R		R									
Petaloconchus sculpturatus H. C. Lea								R		R					F													
Hemisinus amaras Woodring, n. sp																												
Eulima nobilis Guppy					R	F	R	C	R					R	C											R		
Eulima acuta Sowerby																												
Eulima sarissiformis (Pilsbry and Johnson)					F			R	R																			
Balcis (Balcis) jacululum (Maury)			R		R			?R						R	R											R		
Balcis (Balcis) lipara Woodring, n. sp					F	F		F							R											R		
Balcis (Balcis) aulaca Woodring, n. sp					R																							
Balcis (Balcis) cetia Woodring, n. sp								F	F	R	R			R	R													
Niso (Niso) mesata Woodring, n. sp			F			R		A	F													R			C		
Colubraria obscura (Reeve)																												
Pterynotus (Subpterynotus) textilis (Gabb)								R																				
Typhis (Talityphis) eucteanus Woodring, n. sp											F																	
Volvarina leander (Brown and Pilsbry)														C			?R							A		A		C
Prunum (Microspira) gatunense (Brown and Pilsbry)								C	R						C	R												
Persicula (Rabicea) couviana stenygra Woodring, n. subsp						?R		R																				
Cancellaria (Cancellaria) anomoia Woodring, n. sp								F																				
Cancellaria (Cancellaria) aff. *C. macneili* Mansfield	R		R																									
Cancellaria (Cancellaria) tapeina Woodring, n. sp																												
Cancellaria (Cancellaria) epistomitera dariena Toula	F	C	R		F	R	R	A	A	F	C				C		R	C		R					?F			?R
Cancellaria (Cancellaria) epistomifera lipara Woodring, n. subsp																												
Cancellaria (Cancellaria) apimela Woodring, n. sp																												
Cancellaria (Pyruclia) cibarcola cibarcola Anderson		R	R	F	R	F	R	A	C	F	C																	
Cancellaria (Pyruclia) diadela Woodring, n. sp																												
Cancellaria (Euclia) codazzii Anderson	A	C	R	R		R	R	A	A	C	C				F		R	R										
Cancellaria (Euclia) dinota Woodring, n. sp	F	C		R	R	R		A	C		C																	
Cancellaria acalypta Woodring, n. sp	R	R													R													
Cancellaria nancellaria Woodring, n. sp																								R		C		
Cancellaria (Narona) barystoma Woodring, n. sp			R		R	R	R	R	F						R													
Cancellaria (Narona) decaptyx Brown and Pilsbry																												
Cancellaria (Charcolleria) terryi Olsson								C	R									R		R								
Aphera islacolonis (Maury)						R		R			R																	
Trigonostoma cf. *T. scalatella* (Guppy)										R					R													
Trigonostoma cf. *T. insulare* (Pilsbry and Johnson)																												
Conus recognitus Guppy																												
Conus musaensis Olsson																												
Conus spurius Gmelin																												
Conus bravoi Spieker	F	C		R				C		C	R																	
Conus acolus Woodring, n. sp	R	F						F																				
Conus molis Brown and Pilsbry		R		R				C	R								R	R						R		?R		R
Conus aemulator aemulator Brown and Pilsbry		R			R	R		R	R	F	R				R		F	R										
Conus cf. *C. catenatus* Sowerby																												
Conus consobrinus consobrinus Sowerby								R								R												
Conus symmetricus Sowerby																												
Conus taphrus Woodring, n. sp																												
Conus imitator imitator Brown and Pilsbry		R	F	F				C	R		R																	
Conus multiliratus multiliratus Böse								C	R						C		R											
Conus burckhardti burckhardti Böse																							R		?R			
Conus burckhardti harrisi Olsson	R	R				R		C	R						F		F											
Conus tortuosostriatus Toula																												
Gemmula vaningeni (Brown and Pilsbry)								R																		R		
Gemmula machapoorensis (Maury)								R																				
Pleuroliria (Polystira) tenagos (Gardner)	R				R	R		A	C	F	F				C	R	C	R				R		R		C		
Pleuroliria (Polystira) sp																												
Pleurofusia acra Woodring, n. sp																												
Pleurofusia (Cruziturricula) fusinus fusinus (Brown and Pilsbry)				R	C	F		A	C	R	F			R	R							R		F		C		R
Leucosyrinx xenica Woodring, n. sp																												
Cochlespira (Ancistrosyrinx) cedonulli (Reeve)																										R		
Scobinella morierei (Cossmann)						R																						
Drillia (Neodrillia) riogurabonis eurysoma Gardner								R						F														
Carinodrillia (Carinodrillia) zooki (Brown and Pilsbry)						R								R			R							R		F		R
Carinodrillia (Carinodrillia) cf. *C. elocata* (Pilsbry and Johnson)															R													
Crassispira (Crassispira) henekeni leptalea Woodring, n. subsp																												
Crassispira (Hindsiclava) consors consors (Sowerby)						R		C	F	R	R				F		R							R		C		R
Crassispira (Crassispirella) cymation Woodring, n. sp																												
Crassispira (Crassispirella) tyloessa Woodring, n. sp															R													
Clathrodrillia gatunensis (Toula)								C	F		R			F	F		R	R										R
Clathrodrillia saavedrai Woodring, n. sp																										R		

Cavolinidae and a few species of other families)

C, common; A, abundant]

Localities—Continued

Middle part—Continued

Eastern area—Continued

147g | 147h | 147i | 151 | 153 | 153a | 154 | 155 | 155a | 155b | 155c | 156 | 157 | 158 | 159 | 159a | 159b | 159d | Other collections

Western area

160 | 160c | 160d | 161 | 161a | 161b | 161c | 161d | 162 | 162a | 164 | 170 | 170a

Upper part

Eastern area

163 | 171 | 172 | 173 | 173a | 174 | 175 | 176 | 176a | 177 | 177a | 177b | 177c | 177d | 177e | 178 | Other collections

Western area

179 | 182 | 182a | 183 | 185

Gastropods from Gatun formation (Eulimidae, Marginellidae to

	Localities																											
	Lower part													Middle part — Eastern area														
	136	136a	137	137a	138	138a	138b	138c	138d	138e	138f	138g	139	139b	139c	139d	139e	139f	139g	140	141	142	144	146	147	147b	147e	147f
Clathrodrillia aff. *C. saavedrai* Woodring, n. sp.																												
Clathrodrillia aff. *C. lelandi* (Olsson)		R																										
Clathrodrillia cf. *C. islalindae* (Maury)									F		R																	
Agladrillia (*Agladrillia*) *characta* Woodring, n. sp.						?R		F	?R					R										R		F		
Agladrillia (*Agladrillia*) *enneacyma enneacyma* (Brown and Pilsbry)														R	R									C		A		F
Agladrillia (*Agladrillia*) *enneacyma* (Brown and Pilsbry), subsp.			R		R			R																				
Agladrillia (*Agladrillia*) *phengoides* Woodring, n. sp.																								F		A		F
Agladrillia (*Agladrillia*) *acaria ectypha* Woodring, n. subsp.			C		F	C		C	F	R				C	C	R	R											
Agladrillia (*Eumetadrillia*) *isthmica* (Brown and Pilsbry)					F			F	R		R				F													
Agladrillia (*Eumetadrillia*) *acidna* Woodring, n. sp.																												
Microdrillia trina Mansfield					R			R						R	F									R		A		C
Lepicythara heptagona (Gabb)						R																						
Ithycythara defuniak Gardner								R																		R		
Ithycythara cf. *I. elongata* (Gabb)								R																				
Cytharella? cf. *C. compsacosta* (Gardner)								R																				
Kurtziella (*Kurtziella*) *pagella* Woodring, n. sp.			R			F		C	R	R				C	F									F		A		
Kurtziella (*Kurtziella*) *stenotella* Woodring, n. sp.																								R		A		R
Kurtziella (*Cryoturris*) *habra* Woodring, n. sp.						R																						
Kurtziella (*Cryoturris*) sp.									R																			
Nannodiella rintriada (Mansfield)															R											A		
Nannodiella cf. *N. melanitica* (Dall)														R														
Euclathurella (*Euclathurella*) *vendryesiana* (Dall)																												
Euclathurella (*Miraclathurella*) *eucharis* Woodring, n. sp.				R	F	R		C	R					C	C									R		C		R
Dolostoma anorhepes Woodring, n. sp.			R		F		R	R	R						R									F		A		
Dolostoma dinota Woodring, n. sp.																												
Glyphostoma (*Glyphostoma*) *dentiferum* Gabb								R		?R					R													
Glyphostoma (*Glyphostoma*) *pyrgota* Woodring, n. sp.																												
Glyphostoma (*Euglyphostoma*) *olssoni* Woodring, n. sp.																												
Glyphostoma (*Rhiglyphostoma*) *allodapum* Woodring, n. sp.									R																	R		
Daphnella pagera Woodring, n. sp.																												
Daphnella sp.						R																						
Daphnella? sp.					R																							
Terebra (*Oreoterebra*) *subsulcifera subsulcifera* Brown and Pilsbry					F	R		C	R	F					R			R										
Terebra (*Oreoterebra*) *subsulcifera cembra* Olsson	R							C	R	?R	R																	
Terebra (*Oreoterebra*) *isaacpeiti* Maury															F													
Terebra (*Paraterebra*) aff. *T. taurina* (Lightfoot)																												
Terebra (*Panaterebra*) *cucurrupiensis* Oinomikado		F		R	C	C		A	F		C	R			F		F			R								
Strioterebrum spiriferum (Dall)	F	C	?R		C	C	R	A	A	C	A	C	?R		R						R							
Strioterebrum wolfgangi (Toula)	F																											
Strioterebrum gausapatum (Brown and Pilsbry)			F		C	C																		R				
Strioterebrum indocayapum Olsson			F		A	C	F	A	A	R	C	F		R	F									F		A		C
Strioterebrum oresignum oresignum Olsson															C		F	C										
Strioterebrum oresignum hadrum Woodring, n. subsp.	C	A		R																								
Strioterebrum sp.																												
Strioterebrum monidum (Woodring)								R	R																			
Strioterebrum aff. *S. raptum* (Gardner)								R																				
Acteon (*Acteon*) *punctostriatus* (C. B. Adams)						F		C						F	F											R		
Acteon (*Lissacteon*?) sp.																										F		
Rictaxis oryza (Gabb)								R		R				R	F				R									
Ringicula (*Ringiculella*) *semistriata* d'Orbigny						F		F	R	R		R		F	C				C							R		
Acteocina bullata (Kiener), small form														R												R	R	
Acteocina elachista Woodring, n. sp.					F	C				R	R															C		
Acteocina rusa Gardner								R						R														
Cylichnella atacata stibara Woodring, n. subsp.			R		C	A		A	C	F				A	A			R	R					C		A		F
Roxania chipolana (Dall)								R							R									R		A		
Bulla umbilicata Röding, small form	R																											
Atys (*Aliculastrum*) *eurys* Woodring, n. sp.																												
Atys (*Weinkauffia*) *cadus* Woodring, n. sp.														F														
Retusa (*Cylichnina*) *quercinensis biforis* Pilsbry and Johnson														R												A		
Sulcoretusa sulcata lipara (Woodring)						R								F	R				R					R		C		
Volvulella (*Volvulella*) *oxytata* (Bush)			R		F	C		C		R		R		C	F											A		
Volvulella (*Volvulella*) *micratracta* Brown and Pilsbry																												
Volvulella (*Volvulella*) *cylindrica parallela* (Pilsbry and Johnson)																												
Volvulella (*Volvulella*) *phoinicoides* (Gardner)								R						C	F											F		
Spiratella inflata elevata (Collins)		F																										
Vaginella undulata (Gabb)																												
Cavolina (*Cavolina*) *triaspis* Woodring, n. sp.																												
Cavolina (*Cavolina*) cf. *C. ventricosa* (Guppy)																												

Cavolinidae and a few species af other families)—Continued

Localities—Continued

Middle part—Continued

Eastern area—Continued

147g | 147h | 147i | 151 | 153 | 153a | 154 | 155 | 155a | 155b | 155c | 156 | 157 | 158 | 159 | 159a | 159b | 159d | Other collections

Western area

160 | 160c | 160d | 161 | 161a | 161b | 161c | 161d | 162 | 162a | 164 | 170 | 170a

Upper part

Eastern area

163 | 171 | 172 | 173 | 173a | 174 | 175 | 176 | 176a | 177 | 177a | 177b | 177c | 177d | 177e | 178 | Other collections

Western area

179 | 182 | 182a | 183 | 185

mentioned. Two other species, described in earlier chapters, are redescribed on the basis of better material in recently acquired collections.

The Gatun fossils embrace 18 cancellarids (including a species of the subgenus *Charcolleria* and of the genus *Aphera*), 16 conids, 50 turrids (including two species of the new mangeline genus *Dolostoma*, and a species each of *Euglyphostoma* and *Rhiglyphostoma*, new subgenera of the mangeline genus *Glyphostoma*), and 13 terebrids (including five large species and subspecies of *Terebra*, assigned to the subgenera *Oreoterebra*, *Paraterebra*, and *Panaterebra*).

The distribution of the species and subspecies in the formation is shown in the table on pages 318–321.

The Gatun gastropod fauna now totals 293 species and subspecies (plus eight others not formally described). To that total should be added 5 that remain to be described and 10 undescribed pyramidellids. For the purpose of tabulation the arbitrarily separated eastern and western areas of the middle part (p. 46) are consolidated, but the geographically isolated eastern and western areas of the upper part are retained. The number of species and subspecies in the three parts of the formation, and the largest collections are tabulated below.

Gastropods from Gatun formation

Part	Number of species and subspecies	Largest collection	
		Number of species and subspecies	Locality
Lower	145	125	138c
Middle	181	104	139c
Upper, eastern	82	35	177b
Upper, western	53	25	185

Ninety-five of the 230 unequivocally identified species and subspecies are endemic. The occurrence elsewhere of the other 135 is shown in the table on pages 323–324.

Age.—The distribution elsewhere supports a middle Miocene age for the Gatun formation, even for the upper part in the western area, which was formerly considered to be late Miocene. The closest similarity is with unrecorded middle Miocene faunas from Darién Province and Chiriqui Province, both on the Pacific side of Panamá, and also with the middle Miocene of southeastern Costa Rica.

For some unknown reason the small fauna of 53 species from the upper part in the western area is unique in biofacies, although 30 of the species occur elsewhere in the Gatun.

Diarecallus, *Apiocypraea*, *Strombinophos*, *Strombinella*, *Subterynotus*, *Panamurex*, *Pilsbrytyphis*, *Calophos*, *Rhipophos*, *Nicema*, *Nanarius*, *Psilarius*, *Charcolleria*, *Scobinella*, and *Dolostoma* are extinct.

Taxa that formerly lived in the western Atlantic part of Tertiary Caribbean province, but now are extinct there and survive in eastern Pacific waters, have been designated paciphiles (Woodring, 1966, p. 426). The following paciphile genera and subgenera are represented in the gastropod fauna of the Gatun formation:

Paciphile genera and subgenera in gastropod fauna of Gatun formation

Teinostoma (*Aepystoma*)
Solariorbis (*Hapalorbis*)
Heliacus (*Astronacus*)
Rhinoclavis (*Ochetoclava*)
Trochita
Neverita (*Glossaulax*)
Neverita (*Hypterita*)
Malea
Thais (*Vascula*)
Strombina (*Sincola*)
Solenosteira [1]
Metula
Cymatophos
Oliva (*Strephonella*)
Mitra (*Cancilla*) [2]
Cancellaria (*Pyruclia*)
Cancellaria (*Euclia*)
Cancellaria (*Narona*)
Aphera
Pleurofusia (*Cruziturricula*)
Agladrillia (*Agladrillia*)
Glyphostoma (*Euglyphostoma*)
Terebra (*Panaterebra*)
Rictaxis

[1] Described on p. 256 as *Hanetia*.
[2] Described on p. 283 as *Tiara*.

A few paciphiles, listed below, are at the specific level:

Paciphile species in gastropod fauna of Gatun formation

Trochita spirata Forbes? [1]
Neverita (*Glossaulax*) *reclusiana xena* Woodring
Neverita (*Hypterita*) *helicoides* Gray
Distorsio (*Rhysema*) *decussata gatunensis* Toula
Cochlespira (*Ancistrosyrinx*) *cedonulli* (Reeve)
Volvulella (*Volvulella*) *cylindrica parallela* (Pilsbry and Johnson)

[1] Described on p. 81 as *Trochita trochiformis* (Born).

Still fewer species survive on both sides of the Panamá land bridge, as follows:

Gastropod species of Gatun formation that survive on both sides of Panamá land bridge

Architectonica (*Architectonica*) *nobilis* Röding
Colubraria obscura (Reeve)
Murex (*Murex*) *recurvirostris* Broderip

CHAGRES SANDSTONE, INCLUDING TORO LIMESTONE MEMBER

Locality 208 yielded the following gastropods described or mentioned in the present chapter. All are rare; that is, represented by one or two specimens.

Gastropods from Chagres sandstone at locality 208 (Cancellaridæ to Terebridæ)

Cancellaria (*Cancellaria*) aff. *C. epistomifera dariena* Toula
Cancellaria (*Cancellaria*) sp.
Cancellaria (*Pyruclia*) *diadela* Woodring, n. sp.?
Trigonostoma n. sp.
Conus imitator Brown and Pilsbry?
Conus tortuosostriatus Toula
Pleuroliria (*Polystira*) *ecuadoriana* (Olsson)

Occurrence elsewhere of gastropods from Gatun formation

	Gatun formation				Early Miocene		Middle Miocene						Late Miocene		Early Pliocene		Late Pliocene	Holocene
	Lower part	Middle part	Upper part, eastern area	Upper part, western area	Chipola formation, Florida	Other [1]	Southeastern Costa Rica	Cercado formation, Dominican Republic	Gurabo formation, Dominican Republic	Bowden formation, Jamaica	Shoal River formation, Florida	Other [2]	Limón formation, Costa Rica	Other [3]	Caloosahatchee formation, Florida	Other [4]	Moín formation, Costa Rica	
Teinostoma (Pseudorotella) pycnum (Woodring)	×	×								×								
Cyclostremiscus (Ponocyclus) pentagonus (Gabb)	×	×	×	×				×	×	×								
Turritella (Bactrospira) altilira altilira Conrad [5]	×	×	×									×						
Turritella (Bactrospira) altilira praecellens Pilsbry and Brown [5]	×	×				×												
Turritella abrupta Spieker	×	×										×						
Turritella matarucana Hodson	×	×										×		×				
Turritella gatunensis gatunensis Conrad	×	×	×			×	×					×	×					
Serpulorbis papulosus (Guppy)		×					×	×	×	×		×		×				
Petaloconchus sculpturatus H. C. Lea [6]	×	×										×		×				
Alabina asperoides asperoides (Gabb)	×							×										
Alabina asperoides canaliculata (Gabb)	×	×						×	×	×								
Architectonica (Architectonica) nobilis nobilis Röding	×	×	×	×				×	×	×		×	×	×	×	×	×	×
Heliacus (Astronacus) stonemanae (Maury)	×					×		×				×						
Scalina pseudoleroyi (Maury)		×	×							×								
Eulima nobilis Guppy	×	×					×	×	×	×	×							
Eulima acuta Sowerby		×			×		×	×	×					×	×			×
Eulima sarassiformis (Pilsbry and Johnson)	×											×						
Balcis (Balcis) jacululum (Maury)	×	×						×										
Calyptraea centralis (Conrad)	×					×						×		×	×	×		×
Trochita spirata Forbes? [7]	×															?		×
Crucibulum (Crucibulum) chipolanum Dall		×			×													
Crucibulum (Dispotaea) springvaleense Rutsch	×	×		×								×		×				
Crepidula plana Say	×	×				×						×	×		×			×
Xenophora delecta (Guppy)			×					×	×	×				×				
Strombus gatunensis Toula	×	×		×								×	×					
Siphocypraea (Muracypraea) henekeni (Sowerby) [8]	×	×		×		×	×	×	×	×		×		×				
Atlanta (Atlantidea) lissa Woodring			×							×								
Natica (Natica?) bolus Brown and Pilsbry	×	×	×					×	×					×				
Stigmaulax guppiana (Toula)	×	×	×	×							×	×		×				
Polinices brunneus subclausus (Sowerby)		×					×	×	×	×		×						
Polinices stanislasmeunieri Maury	×	×	×	×			×		×			×		×				
Neverita (Hypterita) helicoides (Gray)	×	×					?									×		×
Sinum eurybedra Woodring	×									×								
Semicassis (Tylocassis) reclusa (Guppy)	×	×					×	×	×	×		×						
Sconsia laevigata sublaevigata (Guppy)		×	×				×			×		×	×					
Colubraria obscura (Reeve)		×																×
Distorsio (Rhysema) decussata gatunensis Toula	×	×	×	×								×	?					
Bursa (Colubrellina) caelata amphitrites Maury	×	×						×	×					×				
Malea camura Guppy	×	×	×	×			×	×	×	×			×					
Ficus carbasea carbasea (Guppy)		×		×		×						×		×				
Murex (Murex) recurvirostris recurvirostris Broderip	×	×	×			×	×	×		×				×		×	×	×
Pterynotus (Subpterynotus) textilis (Gabb)	×				×							×		×	×			
Paziella (Panamurex) gatunensis (Brown and Pilsbry)		×	×									×						
Eupleura thompsoni Woodring	×	×										×		×				
Typhis (Talityphis) alatus obesus Gabb		×	×		×					×		×	×					
Mitrella limonensis (Gabb)		×	×														×	
Anachis (Costoanachis) mira mira (Dall)	×	×	×	×			×											
Anachis (Costoanachis) mira fugax Brown and Pilsbry	×	×	×									×						
Strombina (Strombina) lessepsiana Brown and Pilsbry	×	×	×	×			×											
Strombina (Sincola) chiriquiensis Olsson		×	×									×	×					
Solenosteira dalli dalli Brown and Pilsbry [9]	×	×	×									×						
Solenosteira dalli medioamericana Olsson [9]				×			×						×					
Cymatophos veatchi veatchi (Olsson)	×	×					×					×						
Cymatophos subsemicostatus (Brown and Pilsbry)		×	×				×											
Antillophos (Antillophos) candei gatunensis (Toula)	×	×	×									×				×		
Antillophos (Antillophos) mexicanus (Böse)				×			×					×	×					
Nassarius (Uzita) cecadensis (Maury)		×	×					×	×	×		×						
Psilarius leptus (Woodring) [10]		×										×						
Melongena melongena consors (Sowerby)	×	×				×	×	×	×			×						
Fasciolaria gorgasiana Brown and Pilsbry	×	×					×											
Fasciolaria gorgasiana Brown and Pilsbry, subsp				×										×				
Oliva (Strephonella) colpotus Woodring, n. name [11]		×								×		×						
Ancilla (Eburna) pinguis (Guppy)		×								×								
Olivella (Niteoliva) terryi Olsson	×	×					×											
Olivella (Toroliva) goliath Olsson		×					×											
Agaronia testacea mancinella (Olsson)	×	×					×											
Mitra (Pleioptygma?) limonensis Olsson		×	×										×					
Mitra (Cancilla) longa longa Gabb [12]	×	×	×					×	×									
Mitra (Cancilla) dariensis Brown and Pilsbry [12]	×	×										×	×					
Xancus falconensis Hodson [13]	×	×										×						
Voluta eurytera Woodring [14]				×								×						
Prunum (Microspira) gatunense (Brown and Pilsbry)	×	×	×				×					×						
Cancellaria (Cancellaria) epistomifera dariena Toula	×	×	×				×					×	×					
Cancellaria (Cancellaria) epistomifera lipara Woodring, n. subsp				×									×					
Cancellaria (Pyruclia) cibarcola cibarcola Anderson	×											×						
Cancellaria (Euclia) codazzii Anderson	×	×										×						
Cancellaria (Charcolleria) terryi Olsson	×	×										×		×		×		
Aphera islacolonis (Maury)	×	×				×		×				×						

See footnotes at end of table.

Occurrence elsewhere of gastropods from Gatun formation—Continued

	Gatun formation				Early Miocene		Middle Miocene						Late Miocene		Early Pliocene		Late Pliocene	Holocene
	Lower part	Middle part	Upper part, eastern area	Upper part, western area	Chipola formation, Florida	Other [1]	Southeastern Costa Rica	Cercado formation, Dominican Republic	Gurabo formation, Dominican Republic	Bowden formation, Jamaica	Shoal River formation, Florida	Other [2]	Limón formation, Costa Rica	Other [3]	Caloosahatchee formation, Florida	Other [4]	Moín formation, Costa Rica	
Conus recognitus Guppy				×		×	×	×	×	×		×						
Conus musaensis Olsson		×					×											
Conus spurius Gmelin		×					×	×	×	×		×	×			×		×
Conus bravoi Spieker	×	×										×						
Conus molis Brown and Pilsbry	×	×	×	×			×					×	×					
Conus aemulator aemulator Brown and Pilsbry	×	×		×		×		×	×			×	×					
Conus consobrinus consobrinus Sowerby	×	×	×	×					×	×		×						
Conus symmetricus Sowerby		×																
Conus imitator imitator Brown and Pilsbry	×	×	×	×			×	×	×	×		×	×					
Conus multiliratus multiliratus Böse	×	×	×					×	×	×		×	×					
Conus burckhardti burckhardti Böse		×	×	×			×					×	×	×				
Conus burckhardti harrisi Olsson	×	×					×							×				
Conus tortuosostriatus Toula		×	×										×					
Gemmula vaningeni (Brown and Pilsbry)	×	×	×			×					×	×						
Gemmula machapoorensis (Maury)	×											×						
Pleuroliria (Polystira) tenagos (Gardner)	×	×	×	×							×							
Pleurofusia (Cruziturricula) fusinus fusinus (Brown and Pilsbry)	×	×	×									×						
Cochlespira (Ancistrosyrinx) cedonulli (Reeve)		×	×				×			×		×		×		×		×
Scobinella morierei (Cossmann)	×		×			×						×	×	×				
Drillia (Neodrillia) riogurabonis eurysoma Gardner	×	×									×							
Crassispira (Hindsiclava) consors conscrs (Sowerby)	×	×	×	×		×	×		×			×	×	×		×		
Clathrodrillia gatunensis (Toula)	×	×	×				×					×				×		
Agladrillia (Agladrillia) acaria ectypha Woodring, n. subsp	×	×										×						
Microdrillia trina Mansfield	×	×	×									×						
Lepicythara heptagona (Gabb)	×	×		×			×	×	×			×						
Ithycythara defuniak Gardner	×	×									×							
Nannodiella rintriada (Mansfield)		×	×									×						
Euclathurella (Euclathurella) vendryesiana (Dall)		×						×	×	×								
Euclathurella (Miraclathurella) eucharis Woodring, n. sp	×	×		×								×						
Dolostoma anorhepes Woodring, n. sp	×	×										×						
Glyphostoma (Glyphostoma) dentiferum Gabb	×	×										×						
Terebra (Oreoterebra) subsulcifera subsulcifera Brown and Pilsbry	×	×	×				×					×						
Terebra (Oreoterebra) subsulcifera cembra Olsson	×											×						
Terebra (Oreoterebra) isaacpetiti Maury		×	×	×					×			×						
Terebra (Panaterebra) cucurrupiensis Olnomikado	×	×										×						
Strioterebrum spiriferum (Dall)	×	×	×	×		×		×				×		×				
Strioterebrum wolfgangi (Toula)	×	×	×										×					
Strioterebrum gausapatum (Brown and Pilsbry)	×	×								×		×						
Strioterebrum indocayapum Olsson	×	×	×				×					×	×					
Strioterebrum oresignum oresignum Olsson		×										×						
Strioterebrum monidum (Woodring)	×	×						×		×								
Acteon (Acteon) punctostriatus (C. B. Adams)	×	×						×		×					×			×
Rictaxis oryza (Gabb)	×	×										×						
Ringicula (Ringiculella) semistriata d'Orbigny	×	×	×						×	×							×	×
Acteocina bullata (Kiener)		×	×			×	×			×		×	×					×
Acteocina rusa Gardner	×	×									×							
Cylichnella atacata stibara Woodring, n. subsp	×	×	×	×					×									
Roxania chipolana (Dall)	×	×	×		×													
Bulla umbilicata Röding, small form	×	×				×	×	×	×									
Retusa (Cylichnina) quercinensis biforis Pilsbry and Johnson		×	×									×						
Sulcoretusa sulcata lipara (Woodring)	×	×								×								
Volvulella (Volvulella) oxytata (Bush)	×	×			×	×	×	×	×	×			×		×			×
Volvulella (Volvulella) micratracta Brown and Pilsbry		×											×					
Volvulella (Volvulella) cylindrica parallela (Pilsbry and Johnson)		×					×					×						
Volvulella (Volvulella) phoinicoides (Gardner)	×	×	×								×							
Spiratella inflata elevata (Collins)	×											×						
Vaginella undulata (Gabb)		×										×						

[1] Early Miocene part of Uscari shale, southeastern Costa Rica; Baitoa formation, Dominican Republic; Thomonde formation, Haiti; Aymamón limestone, Puerto Rico; deposits of early Miocene age in Sinú area, Colombia; Las Perdices shale, Colombia; outcrop La Rosa formation, Venezuela; Subibaja formation, Ecuador; lower part of Zorritos formation, Perú.

[2] Presumably Cercado or Gurabo formation, Dominican Republic (Gabb's stratigraphically unallocated species); Tubará formation, Colombia; subsurface La Rosa formation, Venezuela; middle Miocene part of Brasso formation, Trinidad; San José calcareous silt member of Manzanilla formation, Trinidad; Agueguexquite formation, México; middle Miocene deposits in Chiriquí Province and Darién province, Panamá; middle Miocene deposits in valley of Río San Juan, southwestern Colombia; Angostura, Picaderos, Progreso, and Daule formations, Ecuador; Upper part of Zorritos formation, and Cardalitos and Montera formations, Perú.

[3] Deposits of late Miocene age, Colombia; Punta Gavilán formation, Venezuela; Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation, Trinidad; deposits of late Miocene age (Spencer's Coatzacoalcos formation), Tehuantepec area, México; deposits of late Miocene age, including Olsson's Pinecrest beds and Mansfield's *Cancellaria* zone, Florida; Duplin marl, North Carolina; Esmeraldas formation, Ecuador.

[4] Deposits of early Pliocene age, Bocas Isla id, Panamá; Mare and Playa Grande formations, Venezuela; deposits of early Pliocene age in Cumaná area, Venezuela; Matura formation, Trinidad; Charco Azul formation, southeastern Costa Rica and southwestern Panamá.

[5] Assigned to subgenus *Torcula* on p. 102 and 105, respectively.

[6] Described on p. 161 as *Petaloconchus* aff. *P. floridanus*.

[7] Described on p. 81 as *Trochita trochiformis*.

[8] Described on p. 194 as *Cypraea (Muracypraea) henekeni*.

[9] Assigned to genus *Hanetia* on p. 256 and 257, respectively.

[10] Described on p. 272 as *Leptarius leptus*.

[11] Described on p. 278 as *Oliva (Strephonella) plicata*.

[12] Assigned to subgenus *Tiara* on p. 283 and 284, respectively.

[13] Described on p. 286 as *Xancus validus falconensis*.

[14] Described on p. 287 as *Voluta alfaroi eurytera*.

Pleurofusia cf. *P. fenimorei* (Bartsch)
Scobinella ecuadoriana Olsson
Carinodrillia (*Carinodrillia*) sp.
Darbya? (*Buridrillia?*) sp.
Grassispira (*Hindsiclava*) *pyrgoma* Woodring, n. sp.
Clathrodrillia? sp.
Strioterebrum sp.

The gastropod fauna of the Chagres sandstone proper is meager, like that of the early Tertiary faunas under consideration: 30 species, seven of which are not named at the specific level. Seven of the unequivocally identified species are endemic and four others evidently are. The occurrence elsewhere and in the Gatun formation of the same or related species is tabulated below.

Gastropods from Chagres sandstone and occurrence elsewhere and in Gatun formation of same or related species

Species from Chagres sandstone	Occurrence elsewhere and in Gatun formation of same or related species
Calliostoma (*Calliostoma*) *metalium* Woodring.	*C. aurora* Dall, Holocene.
Architectonica (*Architectonica*) *nobilis karsteni* Rutsch.	Middle Miocene, Ecuador; late Miocene, Venezuela, Panamá, México.
Epitonium ("*Depressiscala*") *eucteanum* Woodring.	*E. scipio* (Dall). Holocene.
Sthenorytis toroensis euthynta Woodring.	*S. toroensis toroensis* (Dall), Toro limestone member.
Scalina weigandi (Böse)	Late Miocene, Tehuantepec area, México.
Bathygalea (*Miogalea*) *hadra* Woodring and Olsson.	*B. andersoni* (Abbott),[1] early Miocene, Colombia.
Stigmaulax guppiana (Toula)	Middle to late Miocene. Also Gatun formation.
Distorsio (*Rhysema*) *decussata gatunensis* Toula.	Middle to late(?) Miocene. Also Gatun formation.
Ficus carbasea carbasea (Guppy).	Early to late Miocene. Also Gatun formation.
Solenosteira dalli Brown and Pilsbry, subsp.[2]	Subspecies of *S. dalli* range from middle to late Miocene.
Cymatophos? acolus Woodring	
Amarophos bothrus Woodring	*A. dentalis* (Olsson), early Miocene, Costa Rica.
Latirus (*Polygona*) *anapetes* Woodring.	*L. taurus* Olsson, late Miocene, Panamá.
Voluta eurytera Woodring [3]	*V. alfaroi* Dall, middle Miocene, Costa Rica. Also Gatun formation.
Cancellaria (*Cancellaria*) aff. *C. epistomifera dariena* Toula.	*C. epistomifera dariena*, middle to late Miocene.
Cancellaria (*Pyruclia*) *diadela* Woodring, n. sp.?	Possibly *C. diadela*, Gatun formation.
Conus imitator Brown and Pilsbry?	Possibly *C. imitator*, middle to late Miocene.
Conus tortuosostriatus Toula	Middle to late Miocene. Also Gatun formation.
Pleuroliria (*Polystira*) *ecuadoriana* (Olsson).	Late Miocene, Panamá, Ecuador.
Pleurofusia cf. *P. fenimorei* (Bartsch).	*P. fenimorei*, Holocene.
Scobinella ecuadoriana Olsson	Late Miocene, Ecuador.
Crassispira (*Hindsiclava*) *pyrgoma* Woodring, n. sp.	*C. consors* (Sowerby), early Miocene to late Pliocene.

[1] Recorded on p. 198 as *Bathygalea dalli*.
[2] Assigned to genus *Hanetia* on p. 258.
[3] Described on p. 287 as *Voluta alfaroi eyrytera*.

Though the Chagres formerly was considered to be of early Pliocene age, a late Miocene age is justified. Three species occur elsewhere exclusively in formations of that age and the age range of four others includes late Miocene. Five and possibly two others occur in the Gatun formation. None is exclusively Pliocene and the age range of none, except a related species, includes Pliocene. So far as known, however, three species are closely related only to living species. *Miogalea*, *Amarophos*, and *Scobinella* are extinct.

Two of the Chagres turrids are found in the Esmeraldas formation of northern Ecuador, although the outcrop areas are 800 kilometers apart. Olsson (1964, p. 12) designated a late Neogene age for the Esmeraldas, but late Miocene is preferable. Perhaps in suggesting a correlation between the Chagres and Esmeraldas a comparable moderately deep-water facies rather than age is being correlated. Nevertheless both formations overlie middle Miocene deposits. In three widely separated areas—the Tehuantepec region of México, northern Panamá and northern Ecuador—moderately deep-water formations seem to be of late Miocene age.

Only eight gastropods have been recovered from the Toro limestone member, the shallow-water basal part of the Chagres. Six, represented by molds, are aragonite-shelled, one of which is identified as *Turritella altilira*. The other two are calcite-shelled epitonids: *Sthenorytis pernobilis?* (a living species) and *S. toroensis toroensis*, which may occur in Pliocene deposits on Montserrate Island, in the Gulf of California.

HOLOCENE SERIES

INFORMALLY DESIGNATED ATLANTIC AND PACIFIC MUCK

The informally designated Atlantic and Pacific muck is described on page 50. The following radiocarbon dates on black organic muck and wood were measured in the USGS laboratory:

Radiocarbon dates on muck and wood from Atlantic and Pacific muck

Lab. No.	Location of sample	Age (years before present)
W–958	Core Hole BBR 53, west side of Pacific entrance to Panama Canal, 9 kilometers west-northwest of Point Farfan; depth 10 meters, 4.2 meters below top of muck, which is 9.9 meters thick. Black organic muck.	6,720±300
W–959	Core Hole BBR 128, east side of Pacific entrance to Panama Canal, 0.5 kilometer east of terminus of Thatcher Ferry; depth 22 meters, 9 meters below top of muck, which is 10.5 meters thick. Black organic muck.	7,680±300
W–960	Core Hole Mindi 2, Mindi Dairy Farm, 6.4 kilometers south of Colón; depth 10.6 meters, 1.5 meters below top of muck, which is 3 meters thick. Wood.	7,240±300

The muck formerly was thought to be of Pleistocene age, but according to the radiocarbon dates it was deposited during the postglacial rise of sea level.

Dall (1912) and Brown and Pilsbry (1913a) described a few species of mollusks from marine layers in the muck near Mount Hope on the Caribbean side of the Canal. Three of them are now known to be living off Payardi Island, 8 kilometers northeast of Colón: *Minioliva myrmecoon* (Dall), *Strioterebrum spei* (Brown and Pilsbry), and *Adrana perprotracta* (Dall). As pointed out by Altena (1968), *A. newcombi* (Angas) is an earlier name for Dall's species.

Mr. Stewart called my attention to a construction-period map based on some 200 shallow drill holes along and near the alinement of Gatun Dam. Contours drawn on the top of bedrock show a channel, filled with muck, west of the present channel of Río Chagres, sloping northwestward to a depth of −300 feet (91.4 meters). Major (later Major General) W. L. Sibert, the engineer in charge of the construction of Gatun Dam, Spillway, and Locks described the bedrock surface as follows: "The rock surface under the Gatun Locks was very uneven, being composed of hills and valleys; in the valleys the softest of mud was found, corroborating the statements of the geologists that a subsidence of more than 300 feet occurred at one time at Gatun" (Sibert, 1916, p. 392–393).

Other radiocarbon dates for muck in the Gatun Lake area, ranging in age from about 11,300 to 1,275 years before the present, have been published in a recent account that describes the core occurrence of wild maize pollen and at a higher level cultivated maize (Bartlett, Barghoorn, and Berger, 1969).

DESCRIPTION OF TERTIARY MOLLUSKS—CONTINUED FROM CHAPTER C

GASTROPODS—CONTINUED FROM CHAPTER C

Family EULIMIDAE

The family Eulimidæ was omitted in its proper place.

Genus Eulima Risso

Risso, Histoire naturelle des principales productions de l'Europe méridionale, v. 4, p. 123, 1826.

Type (logotype, Herrmannsen, Indicis generum malacozoorum, v. 1, p. 431, 1847): *Turbo subulatus* Donovan (=*Strombiformis glaber* da Costa), living, eastern Atlantic Ocean.

Eulima cf. E. jacksonensis Gregorio

Plate 48, figure 8

Very small, slender, 9-whorled. Protoconch acute, tip slightly bulging. Post-protoconch whorls practically flat-sided. Suture indistinct. Aperture elongate, narrow, ovate.

Height (incomplete) 3.1 mm (estimated restored height 4 mm), diameter 1.1 mm (figured specimen).

The marine member of the Bohio(?) formation on Trinidad Island yielded five small specimens of *Eulima*. They resemble *E. jacksonensis* Gregorio (Palmer *in* Harris and Palmer, 1946–47, p. 224, pl. 26, fig. 16, 1947; middle and late Eocene, southeastern U. S.), but are about half as large, even when specimens having the same number of whorls are compared.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 42.

Eulima nobilis Guppy

Plate 49, figure 1

Eulima (*Liostraca*) *nobilis* Guppy, *in* Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 315, pl. 30, fig. 9, 1896 (Miocene, Jamaica).

Melanella (*Eulima*) *cercadica* Maury, Bull. Am. Paleontology, v. 5, no. 29, pl. 25, fig. 1, 1917 (Miocene, Dominican Republic).

Strombiformis prælubrica Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 183, 1917 (Miocene, Dominican Republic). Pilsbry, Idem, v. 73, p. 395, pl. 35, fig. 10), 1922 (Miocene, Dominican Republic).

Strombiformis ischna Gardner, U.S. Geol. Survey Prof. Paper 142, p. 573, pl. 55, fig. 17 (misprinted 16), 1947 (Miocene, Fla.).

Small, slender, 11- or 12-whorled. Protoconch acute, tip slightly bulging. Post-protoconch whorls practically flat-sided. Suture indistinct. Aperture elongate, narrow, ovate.

Height 5.9 mm, diameter 1.7 mm (figured specimen).

Type: Lectotype, herewith designated, USNM 107071.

Type locality: Bowden, Jamaica, Bowden formation.

Eulima nobilis, represented by 35 specimens, is fairly widely distributed in the lower and middle parts of the Gatun formation, but is nowhere abundant. The Gatun shells are smaller than those from Jamaica, the Dominican Republic, and Costa Rica, which reach a height of 9.5, 10, and 8.5 millimeters, respectively.

The type lot of Guppy's misnamed species consists of four specimens. The lectotype is the largest and was illustrated. Maury's synonomy and discussion indicate that she intended *Melanella cercadica* to be a substitute name for Gabb's *Eulima acicularis*, a homonym, although she did not have access to Gabb's type. Nevertheless, her expression "n. sp.", whether intentional or not, is the basis for accepting her name as the name for the species she illustrated. Two weeks after her name appeared, a properly proposed substitute name for Gabb's species was published. It is not the same as Maury's. (See the second following species.)

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 147b, 147h, 153a, 155 (identification doubtful), 159d. Cercado and Gurabo (USGS 8735) formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Middle Miocene deposits, Costa Rica (USGS 5882f and other localities). Shoal River formation (middle Miocene), Florida.

Eulima acuta Sowerby

Plate 51, figure 13

Eulima acuta Sowerby, Zool. Soc. London Proc., p. 8, 1834 (living, eastern Pacific Ocean).

Leiostraca acuta (Sowerby), Sowerby, Thesaurus conchyliorum, p. 803, pl. 170, fig. 11 (misprinted 25 in text), 1854 (living, eastern Pacific Ocean).

Strombiformis acuta (Sowerby), Bartsch, U.S. Natl. Mus. Proc., v. 53, p. 347, pl. 47, fig. 2 (enlargement of Sowerby's illustration), 1917 (Sowerby's record).

Eulima scotti Maury, Bull. Am. Paleontology, v. 4, no. 21, p. 30, pl. 7, fig. 21, 1910 (Miocene, Florida).

Strombiformis scotti (Maury), Gardner, U.S. Geol. Survey Prof. Paper 142, p. 573, pl. 55, fig. 16 (misprinted 17), 1947 (Miocene, Florida).

Strombiformis ischnon Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 183, 1917 (Miocene, Dominican Republic). Pilsbry, Idem, v. 73, p. 395, pl. 35, fig. 8, 1922 (Miocene, Dominican Republic).

Small, very slender, 12-whorled. Protoconch acute, tip slightly bulging. Post-protoconch whorls practically flat-sided. Suture indistinct. Aperture elongate, narrow, ovate.

Height 7.3 mm, diameter 1.2 mm (figured specimen).

Type: Presumably in British Museum (Natural History).

Type locality: Living, Montijo Bay, Pacific Coast of Panamá.

A small, very slender *Eulima* from the middle part of the Gatun formation is identified as the species ranging from North Carolina to the West Indies, for which the name *E. acuta* has been used, for example by Dall and Simpson (1901, p. 413). Though no eastern Pacific specimens are available, that name is adopted. In any event, the fossil and living species is not *E. auricincta* (Abbott) (1958, p. 106, fig. 5; Grand Cayman Island), which is less slender.

The type of *E. ischnon* and specimens from the Cercado formation at USGS locality 8525 are smaller and more slender than the Gatun fossil, but others from both the Cercado (USGS 8521) and Gurabo (USGS 8734) formations closely resemble that fossil.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area locality 159d. Chipola formation (early Miocene), Florida. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Middle Miocene deposits, Costa Rica (USGS 5882 m). Deposits of late Miocene age, Florida. Caloosahatchee formation (Pliocene), Florida. Living, North Carolina to West Indies; Pacific coast of Panamá.

Eulima sarissiformis (Pilsbry and Johnson)

Plate 49, figure 2

Eulima acicularis Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 227, 1873 (Miocene, Dominican Republic). Not *Eulima acicularis* A. Adams, 1861.

Strombiformis sarissiformis Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 183, 1917 (Miocene, Dominican Republic); new name for *Eulima acicularis* Gabb. Pilsbry, Idem, v. 73, p. 394, pl. 35, fig. 9, 1922 (Miocene, Dominican Republic).

Relatively large, slender. Protoconch and early post-protoconch whorls missing. Remaining post-protoconch whorls practically flat-sided. Suture distinct or moderately distinct. Aperture elongate, narrow ovate.

Height (incomplete) 11.5 mm (estimated restored height 14 mm), diameter 2.7 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3010.

Type locality: Dominican Republic, Miocene.

This relatively large species is represented by five specimens from the lower part of the Gatun formation. The protoconch and early post-protoconch whorls are missing on all. Comparable, but smaller, species are living in both western Atlantic and eastern Pacific waters: *Eulima rectiuscula* (Dall) (1890–1903, p. 160, 1890) and *E. towensendi* (Bartsch) (1917, p. 340, pl. 46, fig. 4), respectively.

An incomplete, partly corroded shell from the upper part of the Gatun formation in the western area is listed as *Eulima* sp.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 138, 138c, 138d. Miocene (presumably Cercado or Gurabo formation), Dominican Republic.

Genus Balcis Leach

Leach, Annals and Mag. Nat. History, v. 20, p. 271, 1847.

Type (monotype): *Balcis montagui* Leach (= *Strombiformis albus* da Costa), eastern Atlantic Ocean.

The western Atlantic species of the genus in the collections of the U.S. National Museum are not satisfactorily identified and the eastern Pacific species are overnamed.

Subgenus Balcis s.s.

Balcis (Balcis) jacululum (Maury)

Plate 51, figures 1, 2

Melanella (Eulima) jacululum Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 143, pl. 25, fig. 3, 1917 (Miocene, Dominican Republic).

Eulima robusta Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 227, 1873 (Miocene, Dominican Republic). Not *Eulima robusta* A. Adams, 1861.

Melanella astuta Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 182, 1917 (Miocene, Dominican Republic); new name for *Eulima robusta* Gabb. Pilsbry, Idem, v. 73, p. 394, pl. 35, fig. 7, 1922 (Miocene, Dominican Republic).

Small, slender, about 8-whorled. Protoconch missing. Post-protoconch whorls practically flat-sided. Suture fairly distinct. Body whorl rounded. Penult whorl practically flat or faintly angulated just above body-whorl suture. Aperture short, ovate.

Height (not quite complete) 3.3 mm, diameter 1.1 mm (figured specimen).

Type: Cornell University.

Type locality: Bluff 3, Cercado de Mao, Río Mao, Dominican Republic, Cercado formation.

Six small, slender fossils in five lower and middle Gatun collections are identified as *Balcis jacululum*. They are considerably smaller than topotypes of that species, which reach a height of 5.5 mm. Maury emphasized the "overhanging whorls," that is, the faint angulation of the penult whorl just above the body-whorl suture. That feature, however, is not consistently shown by topotypes or Gatun shells. The trivial name evidently is a noun in apposition.

Three additional specimens that have a wider apical angle are doubtfully identified (localities 138c and 139c). They may represent *B. maoica* (Maury, 1917, p. 142, pl. 25, fig. 2), should that be a valid species.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138c (identification doubtful). Middle part, eastern area, localities 139b, 139c (identification doubtful), 147b, 159d. Cercado formation (middle Miocene), Dominican Republic.

Balcis (Balcis) lipara Woodring, n. sp.

Plate 51, figure 14

Of medium size, slender, about 12-whorled. Outline of spire faintly concave. Protoconch acute. First two or three and last two post-protoconch whorls slightly bulging, remainder practically flat-sided. Suture distinct. Aperture short, ovate.

Height (not quite complete) 8.3 mm, diameter 2.5 mm (type).

Type: USNM 646076.

Type locality 138 (USGS 16909, North and south sides of Transisthmian Highway, 1.6 kilometers northeast of Canal Zone boundary, Panamá), lower part of Gatun formation.

Balcis lipara is represented by 13 specimens from the lower and middle parts of the Gatun formation. It is characterized by its faintly concave spire and slightly bulging last two whorls. Those features distinguish it from *B. jamaicensis* (C. B. Adams) (Clench and Turner, 1950, p. 296, pl. 36, fig. 5; living, Jamaica) and a similar species in USNM collections from localities between Massachusetts and Florida. This Atlantic coast species seems to be the same as that named *B. bartschi* (Gardner and Aldrich) (1919, p. 37, pl. 2, fig. 1) for late Miocene fossils and *B. calkinsi* (Olsson and Harbison) (1953, p. 332, pl. 59, fig. 5) for Pliocene fossils.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c. Middle part, eastern area, localities 139c, 147b, 147g.

Balcis (Balcis) aulaca Woodring, n. sp.

Plate 51, figure 12

Of medium size, slender, about 12-whorled. Protoconch and earliest post-protoconch whorls missing. Suture deeply impressed. Early whorls practically flat-sided; remaining whorls slightly bulging. Base of all except first few spire whorls beveled adjoining suture. Aperture short, ovate; outer lip broken back. Columellar lip thin.

Height (not quite complete) 7.8 mm, diameter (not quite complete) 2.2 mm (type).

Type: USNM 646077.

Type locality: 138 (see preceding species), lower part of Gatun formation.

Though the outer lip of the type—the only specimen—is defective, *Balcis aulaca* is a distinctive species. In suture and beveling adjoining the suture it is similar to the next species, but the shell is smaller and more slender, and the whorl height is greater.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138.

Balcis (Balcis) cetia Woodring, n. sp.

Plate 49, figure 8

Very large, slender, about 18-whorled, whorl height low. Protoconch missing. Post-protoconch whorls slightly bulging. Suture deeply impressed. Base of all except first few spire whorls beveled adjoining suture. Aperture short, ovate. Columellar lip thick.

Height (not quite complete) 28.3 mm, diameter 8.7 mm (type).

Type: USNM 646078.

Type locality: 138f (USGS 23663, South side of Transisthmian Highway, hillside excavation at Colchonería Yero, about 450 meters southwest of Cativa, Panamá), lower part of Gatun formation.

Fourteen specimens of this large *Niso*-like species were found in the lower and middle parts of the Gatun formation. It is a representative of a closely knit group of Miocene species that are characterized by their large size, low whorl height, and deeply impressed suture. This group of four species left no known descendants. The earliest and smallest (height 20 mm) of these species occurs in the Thomonde formation of Haiti (USGS 9946), the last and largest in the Savaneta glauconitic sandstone member and Melajo clay member of the Springvale formation of Trinidad, both of late Miocene age: *Balcis egregia* (Guppy) (Jung, 1969, p. 465, pl. 47, figs. 1, 2; height 50 mm). The fourth species, *B. makista* (Gardner) (1926–47, p. 574, pl. 72, figs. 6-8, 1947), occurs in the middle Miocene of Florida. Like *B. cetia*, it is of intermediate size (estimated height 23 mm). It is, however, more slender than the Gatun species and the base of its spire whorls is not bevelled.

B. dalli (Bartsch) (1917, p. 302, pl. 35, fig. 5; Gulf of California) is a large species (height 20 mm), but its outline, suture, and whorl height are like those of smaller species.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139b, 139c.

Genus Niso Risso

Risso, Histoire naturelle des principales productions de l'Europe méridionale, v. 4, p. 218, 1826.

Type (monotype): *Niso eburnea* Risso, Pliocene, France and Italy.

Subgenus Niso s.s.

Niso (Niso) umbilicata (Lea)?

Plate 48, figure 7

Of medium size, moderately inflated, about 10-whorled. Protoconch missing. Spire whorls low, practically flat-sided to slightly bulging. Body whorl rounded to faintly angulated. Umbilicus partly exposed, apparently narrow. Peristome missing.

Height (incomplete 11.2 mm (estimated restored height 15 mm), diameter 5.5 mm.

The marine member of the Bohio(?) formation at the submerged Vamos Vamos locality and Palenquilla Point yielded eight specimens doubtfully identified as *Niso umbilicata*. The identification is doubtful only because these fossils are defective. So far as observable features go they closely resemble that species, which ranges through the Eocene in southeastern United States (Palmer, 1937, p. 66, pl. 6, figs. 22–25; Palmer *in* Harris and Palmer, 1946-47, p. 225, pl. 26, fig. 17, 1947). No comparable Oligocene species is known in that area.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), localities 40a, 40d, 41, 41b.

Niso (Niso) mesata Woodring, n. sp.

Plate 49, figure 5, plate 51, figure 3

Large, moderately inflated, about 15-whorled. Protoconch acute. Post-protoconch whorls low, first few slightly bulging, later whorls practically flat-sided, last few slightly bulging. Intermediate whorls weakly angulated at base adjoining suture, angulation fainter or absent on last few whorls, including corresponding part of body whorl. Occasional microscopic axial threads on some specimens. Umbilicus moderately wide, bordering ridge subdued. Basal lip missing.

Height (incomplete) 14 mm (estimated restored height 18 mm), diameter (incomplete) 6.4 mm (type). Height (not quite complete) 21.1 mm, diameter (not quite complete) 8 mm (paratype).

Type: USNM 646079; paratype USNM 646080.

Type locality: 138c (USGS 21956, About 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

Locality of paratype: 142 (Stanford Univ. 2698, Northeast of Fort Gulick, latitude 9° 20′ N., longitude 79° 52′ W., plus 1,010 feet [310 meters], middle part of Gatun formation.

Though 61 specimens of *Niso mesata* are in collections from the three parts of the Gatun formation, 80 percent are immature, including all from six localities. The early and intermediate whorls of the paratype—the largest specimen—are worn. The type shows the angulation of intermediate whorls.

Several similar species, differing chiefly in apical angle, are found in the Miocene of the Caribbean region. *N. grandis* Gabb (Pilsbry, 1922, p. 394, pl. 34, fig. 17; Dominican Republic) and its probable synonym, *N. striatula* Böse (*in* Bose and Toula, 1910, p. 227, pl. 12, fig. 7; Tehuantepec area) have the widest apical angle, and a species from the Cercado farmation of the Dominican Republic (USGS 8534) the narrowest. (The type of *N. grandis* is a fragment of four whorls. A 10-whorled specimen, lacking a few early whorls (height 23.8 mm) has been found in the Gurabo formation at USGS locality 8519.) The apical angle of *N. mesata* is of intermediate width; wider, however, than that of a smaller species from the Bowden formation of Jamaica and the Limón formation of the Bocas del Toro area.

N. mesata is more closely related to the Panamic *N. excolpa* Bartsch (1917, p. 348, pl. 48, fig. 4) than to

any western Atlantic species. The whorl height of the Panamic species is greater, and its late spire whorls and body whorl are angulated.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 138a, 138c, 138d. Middle part, eastern area, localities 142, 147b, 147g, 147h, 159d; western area, locality 161. Upper part, eastern area, locality 175.

Family MARGINELLIDAE

Unlike most of the families of gastropods under consideration, the family Marginellidæ has a richer representation in the Carribbean Sea than in eastern Pacific waters.

In addition to the species described or mentioned, unidentified marginellids, or probable marginellids, are in collections from the Caimito and Culebra formations.

Genus Marginella Lamarck

Lamarck, Soc. Histoire Nat. Paris Mém., p. 70, 1799.
Type (monotype): *Voluta glabella* Linné, living, west Africa.

Subgenus Eratoidea Weinkauff

Weinkauff, Systematisches Conchylien-Cabinet von Martini und Chemnitz, v. 5, pt. 4, p. 140, 1879.
Type (logotype, Cossmann, Essais paléoconchologie compareé, pt. 3, p. 87, 1899): *Marginella margarita* Kiener, living, West Indies.

Classification of the numerous fossil and living marginellids still is unsatisfactory. *Eratoidea* seems to be better than *Serrata* (Jousseaume, 1875, p. 167, 230-232; type (tautotype): *Marginella serrata* Gaskoin, living, Mauritius) for high-spired Caribbean species, although *Serrata* was used in 1928 (Woodring, 1928, p. 239). Should the objective be smaller groups, the recently proposed name *Eburnospira* (Olsson and Harbison, 1953, p. 201; type (orthotype): *Marginella eburneola* Conrad, Miocene, Virginia, and North Carolina) is available.

Marginella (Eratoidea) aff. M. mollitor Dall

Plate 48, figures 15, 16

Small, slender or moderately inflated. Spire high, about 2/5 of height of shell. Later half of body whorl slightly shouldered. Outer lip greatly thickened, sharply limited. Inner edge of outer lip coarsely denticulate. Space between posteriormost denticle and insertion of lip relatively wide. Columella bearing four folds.

Estimated restored height 10.5 mm, diameter 5.7 mm (figured specimen). Estimated restored height 11 mm, diameter 6 mm (largest specimen).

Three damaged specimens are referred to this species: one from the upper part of the Bohio formation on Barro Colorado Island and two from the Caimito formation of the Gatun Lake area. The Bohio specimen, the best of the lot, is illustrated. One of the Caimito specimens is mature. It is a little larger and a little more inflated than the Bohio specimen, and has also a wider outer lip.

The greatly thickened outer lip is the most distinctive feature of this unnamed species. Otherwise it is similar to early Miocene species from Florida: *Marginella mollitor* Dall (1915, p. 52, pl. 12, fig. 1; Tampa formation) and *M. euancycla* Gardner (1926–47, p. 388, pl. 46, fig. 20, 1938; Chipola formation). *M. hematita* Kiener (1834-41, p. 11, pl. 7, fig. 31, 1834) is the most similar of the living Caribbean species. Aside from its thinner outer lip, it tends to have a lower spire and a more distinctly shouldered body whorl than the Panamá fossils. No comparable living Panamic species has been recognized.

Two poorly preserved small specimens reveal the presence of a species of *Eratoidea* in the La Boca formation (locality 99b). It has a lower spire than *M.* aff. *M. mollitor.*

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d. Caimito formation, Gatun Lake area (late Oligocene), locality 56.

Genus Volvarina Hinds

Hinds, Zool. Soc. London, Proc., pt. 12, p. 75, 1844.
Type (logotype, Redfield, Am. Jour. Conchology, v. 6, p. 221, 1870): *Marginella nitida* Hinds, living, locality unknown.

Hinds' statement that *Marginella avena* Valenciennes is a typical species of *Volvarina* is not a type designation, although it has been accepted doubtfully as such (Woodring, 1928, p. 236). *Marginella nitida* was based on a specimen (or specimens) of unknown habitat in the Cuming collection. Sowerby's (1847, p. 389, pl. 76, fig. 131) illustration of that species presumably represents the type. Tomlin (1917, p. 284) thought that *M. nitida* is the Mediterranean species *M. mitrella* Risso. In any event, according to Sowerby's illustration, *Volvarina* is properly used for a small group of slender species that have an exposed spire, slightly or moderately thickened, nondenticulate or faintly denticulate outer lip, and four columellar folds. *Hyalina* (Schumacher, 1817, p. 234; type (monotype): *H. pellucida* Schumacher, living, locality unknown) is also in use for that group of species. Without type material or an illustration of the type, however, *Hyalina* is considered a nomen dubium. Despite statements to the contrary (Tomlin, 1917, p. 288; Woodring, 1928, p. 237), Schumacher's species was based on a specimen. Though he cited an illustration in Martini's Conchylien-Cabinet, he went on to remark that Martini's illustration is

smaller than his shell, but is much better depicted than by an illustration in a publication by Schröter.

Volvarina leander (Brown and Pilsbry)

Plate 51, figures 4–6

Marginella leander Brown and Pilsbry, Acad. Nat Sci. Phila. Proc., v. 63, p. 347, pl. 24, fig. 13, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 98, pl. 6, fig. 22, 1922 (Miocene, Canal Zone).

Marginella aff. *nitida* Hinds, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 504, pl. 31, fig. 18, 1911 (Miocene, Canal Zone).

Of medium size, slender. Spire low, thinly glazed. Outer lip somewhat thickened, sharply bordered. Inner edge of outer lip smooth or faintly denticulate. Aperture narrow. Columellar lip bearing four slender folds. Parietal callus moderately thick.

Height 8 mm, diameter 3.7 mm (small figured specimen). Height 9 mm, diameter 4.4 mm (figured specimen of intermediate size), height 11.4 mm, diameter 5.2 mm (large figured specimen).

Type: Acad. Nat. Sci. Phila. 1708.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

This marginellid is widespread in the middle and upper parts of the Gatun formation, including the upper part in the western area, but was not found in the lower part. It is most abundant in old collections from the middle part along the Panama Railroad south and southeast of Gatun; for example, some 150 specimens were collected at locality 147b. None from that locality and nearby has a height greater than about 8 millimeters. One of these small fossils is shown on plate 51, figure 6. A specimen of average size has a height of 9 millimeters (pl. 51, fig. 5). The largest (pl. 51, fig. 4) is in a collection from the upper part of the Gatun near Mount Hope. With the exception of a relatively inflated shell in the same collection (height 8.2 mm, diameter 4.2 mm), the range of variation in degree of inflation is very slight. Toula's *Marginella* aff. *M. nitida* is a typical example of *Volvarina leander*.

V. collina (Olsson) (1922, p. 97, pl. 7, figs. 26, 27), a middle Miocene Costa Rican species, is a little larger, a little more slender, and has a slightly higher, more thickly glazed spire. The living Caribbean species *V. avena* (Valenciennes) (*in* Kiener, 1834–41, p. 17, pl. 6, fig. 24, 1834) is a little larger than *V. collina*, has a higher spire, and lacks the sharply bordered outer lip of *V. collina* and *V. leander*. *V. avena* has been recognized in deposits of late Miocene age in Costa Rica (Olsson, 1922, p. 97, pl. 7, figs. 21, 28). *V. tæniolata* Mörch (Coan and Roth, 1966, p. 287, pl. 50, figs. 48–55), which ranges from southern California to Costa Rica, has the outline of *V. leander*, but its outer lip is not sharply bordered.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139b, 139e (identification doubtful), 146, 147b, 147f, 147g, 147h, 151, 153a (identification doubtful), 155 (identification doubtful), 155b, 155c, 157; western area, locality 161a. Upper part, eastern area, localities 173, 177, 177b, 177c, 177d, 178 (identification doubtful); western area, localities 183, 185 (identification doubtful).

Genus Prunum Herrmannsen

Herrmannsen, Indicis generum malacozoorum, v. 2, supplement, p. 113, 1852.

Type (monotype and tautotype): *Voluta prunum* Gmelin, living, West Indies.

At the present time it is appropriate to use *Prunum* at the generic level for a large group of maginellids, the largest group of fossil species in the Caribbean region. The species assigned to *Prunum* in the unrestricted sense are of medium to large size, more or less inflated, and low-spired. Their aperture is narrow or wide; the outer lip is sharply bordered and is smooth or denticulate. The parietal wall and the ventral face of the spire are free of callus or covered with callus. The columellar lip bears four folds.

The subgenus *Prunum* s.s. is a small group. The species have a wide aperture and nondenticulate outer lip. The spire and parietal wall have the usual glaze of marginellids, but are not callused. The thickened outer lip tapers off abruptly toward the posterior end. The type species has a distinct notch, formed by the thinned continuation of the lip.

Subgenus Microspira Conrad

Conrad, Am. Jour. Conchology, v. 4, p. 66, 1868.

Type (monotype): *Volutella* (*Microspira*) *oviformis* Conrad, Miocene, Virginia.

The type specimen of the type species was illustrated by Gardner (1926-47, p. 397, pl. 48, figs. 11, 12, 1938). It has a very low spire, denticulate outer lip, and thin parietal callus. *Egouena* (Jousseaume, 1875, p. 167, 192-214; type (tautotype); *Egouena egouen* Jousseaume = *Marginella amygdala* Kiener, living, west Africa) is available for species that have a nondenticulate outer lip and callus completely encircling the aperture. *Leptegouana* (Woodring, 1928, p. 237; type (orthotype): *Voluta guttata* Dillwyn, living, West Indies) was proposed for species characterized by no callus on the spire except in line with the weakly denticulate outer lip. Both names, however, can be suppressed without any great loss.

Prunum (Microspira) aff. P. apalachee (Gardner)

Plate 48, figure 25

Relatively small, moderately inflated, spire relatively high. Outer lip moderately thickened, relatively narrow, its inner edge smooth. Parietal callus thin.

Height 10.2 mm, diameter 5.9 mm (figured specimen).

The La Boca formation at locality 116a near Paraiso yielded a small specimen of *Prunum*. Though it is not well preserved, it evidently represents a small species allied to *P. apalachee* (Gardner) (1926-47, p. 395, pl. 47, fig. 5, 1938), of the early Miocene Chipola formation of Florida. The spire of the La Boca species is a little lower and its outer lip is narrower.

P. aff. *P. apalachee* is doubtfully recognized at locality 99b.

Occurrence: La Boca formation (early Miocene), localities 99b (identification doubtful), 116a.

Prunum (Microspira) gatunense (Brown and Pilsbry)

Plate 51, figures 10, 11

Marginella gatunensis Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 347, pl. 24, fig. 10, 1911 (Miocene, Canal Zone).

Marginella coniformis Sowerby, Brown and Pilsbry, Idem, p. 348, pl. 24, fig. 12, 1911 (Miocene, Canal Zone).

Marginella (Bullata) mindiensis Cossmann, Jour. Conchyliologie, v. 61, p. 61, pl. 5, figs. 13–15, 1913 (Miocene, Canal Zone).

Marginella mindiensis Cossmann, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 96, pl. 6, figs. 16, 23, 1922 (Miocene, Canal Zone).

Marginella latissima pilsbryi Olsson, Idem, p. 96, pl. 10, fig. 2, not fig. 1, 1922 (Miocene, Canal Zone, Costa Rica).

Of medium size, moderately to strongly inflated, spire extending well above posterior end of outer lip. Aperture very narrow. Outer lip strongly thickened, its inner edge weakly denticulate. Callus extending from outer lip over much, or exceptionally all, of ventral face of spire, thickly covering parietal wall and thinning somewhat on columellar lip. Outer edge of callus generally fading out on parietal wall and columellar lip, exceptionally sharply defined.

Height 17.8 mm, diameter 12 mm (larger figured specimen).

Type: Acad. Nat. Sci. Phila. 1706.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Unfortunately the type of *Marginella gatunensis* is immature (height 11.4 mm), whereas the type of *M. mindiensis* is mature.

Though *Prunum gatunense* is of modest size, it is the largest marginellid in the Gatun formation. It occurs in the lower, middle, and upper parts, but is represented by a total of only 23 specimens. The outline is variable. The type of *P. mindiense* and Olsson's illustrated specimens referred to that species are moderately inflated, like the immature type of *P. gatunense* and the immature shell shown on plate 51, figure 10. Brown and Pilsbry's *P. coniformis* is mature and inflated. Olsson's illustrated *P. latissima pilsbryi* from the middle part of the Gatun in the western area is strongly inflated, but not as strongly inflated as the illustrated specimen from Río Banana, Costa Rica, which is herewith designated the lectotype. Other specimens from the western area are not so strongly inflated.

According to Crossmann's illustrations, the type of *P. mindiense* has exceptionally thick and sharply limited callus. A moderately inflated specimen (height 20.3 mm, diameter 12 mm) from locality 157 has such callus. Not only is it thick and sharply limited, it extends to the tip of the spire and covers the entire apertural face of the spire, as on Cossmann's type.

Prunum coniforme (Sowerby) (Pflug, 1961, p. 55, pl. 15, figs. 2-6, 8, 9: Miocene, Dominican Republic, Jamaica) is larger, less inflated, less heavily callused, and has a lower spire. *P. precursor* (Dall) (1890-1903, p. 47, pl. 5, fig. 4, 1890; Pliocene, Florida) also has a lower spire. *P. latissimum* (Dall) (*in* Guppy and Dall, 1896, p. 308, pl. 29, fig. 11; Miocene, Dominican Republic; Pliocene, Costa Rica) is smaller, more inflated, and its aperture is dilated near the base of the outer lip. *P. storerium* (Couthouy) (1837, p. 440, pl. 9, figs. 1, 2), now living along the Caribbean coast of Panamá, is less inflated and its outer lip is smooth. Coan and Roth's (1966, p. 280, pl. 48, figs. 7, 8) illustrations of an unnamed shell dredged off Costa Rica indicate that a species similar to *P. gatunense* is living in eastern Pacific waters. As they noted, the inner edge of the outer lip of Brown and Pilsbry's *Marginella coniformis* (that is, *P. gatunense*) is straighter than that of their species.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d. Middle part, eastern area, localities 139c, 139d, 157, 160d; western area, localities 161, 161b. Upper part, eastern area, localities 171, 175 (immature). Middle Miocene, Costa Rica. Middle Miocene, Chiriquí area, Panamá (USGS 7955).

Genus Persicula Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 235, 1817.

Type (monotype and tautotype): *Persicula variabilis* Schumacher (= *Voluta persicula* Linné), living, west Africa.

Subgenus Gibberula Swainson

Swainson, A treatise on malacology, p. 323, 1840.

Type (monotype): *Gibberula zonata* Swainson (= *Volvaria oryza* Lamarck), living, west Africa.

Gibberula is low-spired, whereas *Persicula* s.s. has no spire; in fact, the type has a slight apical depression.

Persicula (Gibberula) cf. P. semen (Lea)

Plate 48, figure 3

Small, inflated or moderately slender, spire low. Aperture very narrow. Outer lip thickened, but not sharply bordered. Inner edge of outer lip finely denticulate. Siphonal canal notched. Columellar lip bearing five or six folds.

Height 6.5 mm, diameter 4 mm (figured inflated specimen). Restored height about 6.7 mm, diameter 3.6 mm (moderately slender specimen).

Two silicified small marginellids from the Gatuncillo formation are similar to *Persicula semen*, a middle and late Eocene species of southeastern United States (Palmer, 1937, p. 422, pl. 67, figs. 13, 14, 16–19). They have a slightly higher spire and narrower aperture than *P. semen*. One of the fossils from the Canal Zone is inflated and the other is fairly slender. The preservation of both is poor, as the granular silica is too coarse for satisfactory preservation of such small fossils.

Occurrence: Gatuncillo formation (middle Eocene), locality 38.

Sugenus Rabicea Gray

Gray, Guide to the systematic distribution of Mollusca in the British Museum, pt. 1, p. 37, 1857.

Type (monotype): *Persicula interrupta* (Lamarck) (*Marginella interrupta* Lamarck=*Voluta interruptolineata* Megerle), living, west Africa and Caribbean Sea.

The heavy, more or less bifid second (from anterior end) fold on the columellar lip, callus spread over the entire parietal wall, and absence of an apical depression distinguish *Rabicea* from *Persicula* s.s.

Persicula (Rabicea) venezuelana amydra Woodring, n. subsp.

Plate 48, figure 26

Small, strongly inflated, apex slightly below level of posterior end of outer lip. Aperture very narrow. Outer lip wide, weakly bordered by low ledge. Inner edge of outer lip finely denticulate. Siphonal canal notched. Five folds visible on columellar lip; second (from anterior end) widest, heaviest, indistinctly bifid, extending out on body whorl beyond lip. Parietal callus moderately thick. Corroded shells showing 20 to 22 narrow, closely spaced spiral bands, representing color bands that have lost their color, or the spaces between color bands.

Height 7.6 mm, diameter 4.9 mm (type).

Type: USNM 645860.

Type locality: 116a (USGS 20956, east bank of Panama Canal at Canal station 1870 near Paraiso, Canal Zone; 700 feet (213 meters) southeast of locality 116), La Boca formation.

This marginellid is identified in three collections from the La Boca formation and one from the Culebra. It is abundant only at the type locality, which yielded 30 specimens. Most of these fossils from all four localities are more or less corroded and show the spiral bands mentioned in the description. Faint color bands and corresponding false sculpture of corroded shells are not unusual in fossil species of *Persicula*. They have been observed on shells of the Eocene species *P. semen* (Lea) (Palmer, 1937, p. 423) and on shells of *P. venezuelana venezuelana* (F. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 77).

P. venezuelana amydra agrees with *P. venezuelana venezuelana* (F. Hodson) (*in* Hodson, Hodson, and Harris, 1927, p. 77, pl. 40, figs. 13, 14) in essential features, but is less inflated and a little smaller. The nominate subspecies occurs in strata of early Miocene age in Venezuela. A larger middle and late Miocene subspecies in Venezuela has been named *P. venezuelana lavelana* (F. Hodson) (*in* Hodson, Hodson, and Harris, 1927, p. 78, pl. 40, figs. 3, 10, 11; Rutsch, 1934, p. 91, pl. 6, figs. 9–11, 12).

P. venezuelana is more inflated and has a less distinctly bordered outer lip than *P. interruptolineata* (Megerle) (Kiener, 1834–41, p. 25, pl. 5, fig. 21, 1834; as *Marginella interrupta* Lamarck), the type of *Rabicea*. Though those two species are similar, *P. cercadensis* (Maury) (1917, p. 73, pl. 11, fig. 7), a small, slender middle Miocene species from the Dominican Republic, perhaps more closely resembles the type species. Despite its small size (height 7 mm), *P. cercadensis* has a wide, sharply bordered outer lip, like the type species. *P. interruptolineata* is living in both west African and Caribbean waters. A comparable, if not identical, species, *P. imbricata* (Hinds) (Coan and Roth, 1966, p. 283, pl. 48, fig. 18, pl. 49, figs. 19–33), is found in the Panamic region.

Occurrence: Culebra formation (early Miocene), locality 106. La Boca formation (early Miocene), localities 114, 115b, 116a.

Persicula (Rabicea) couviana stenygra Woodring, n. subsp.

Plate 51, figure 7

Of medium size, strongly inflated, apex about at level of posterior end of outer lip. Aperture moderately narrow. Outer lip narrow, weakly bordered by a low ledge. Denticles on inner edge of outer lip fairly strong. Siphonal canal notched. Columellar lip bearing seven

folds; second (from anterior end) widest, heaviest, weakly bifid, extending out on body whorl; fifth to seventh progressively fainter in that order. Parietal callus thick. Faint spiral color bands visible on later half of body whorl under glaze of enamel.

Height 10 mm, diameter 6.8 mm (type).

Type: USNM 645711.

Type locality: 138c (USGS 21958, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

The type, found in the lower part of the Gatun formation, is the only mature specimen of this marginellid. Four minute immature shells, one of which is associated with the type, presumably are to be assigned to it. Nevertheless they are doubtfully identified, as a growth series is unavailable. Two of the immature specimens, both from the middle part of the Gatun, are corroded and show about 12 spiral bands.

Persicula couviana stenygra is less inflated and a little smaller than *P. couviana couviana* (Maury) (1925, p. 202, pl. 34, fig. 11), and has a narrower outer lip. The outer lip of both subspecies is weakly bordered. The nominate subspecies occurs in the late Miocene Savaneta glauconitic sandstone member of the Springvale formation of Trinidad. The outer lip of the type of *P. couviana couviana*, and also of the type of its junior synonym *P. propeobesa* (Mansfield) (1925, p. 41, pl. 6, fig. 10) is broken back beyond the thickened margin.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138a (immature, identification doubtful), 138c. Middle part, western area, locality 170 (immature, identification doubtful).

Family CANCELLARIIDAE

Cancellarids present a great array of form and sculpture. Classification of such diverse species is difficult and so far unsatisfactory. Ample precedent is available for both conservative treatment and more narrowly restricted genera and subgenera.

The cancellarid fauna of the Panamic region is much richer than that of the Caribbean region. As in many other families, the roots of the present Panamic cancellarid fauna lie in the enlarged Miocene Caribbean province, which embraced western Atlantic and eastern Pacific waters. *Perplicaria clarki* M. Smith (1947, p. 55, pl. 2, fig. 9; Olsson and Bergeron, 1967) and the loosely coiled *Trigonostoma milleri* Burch (1949) are perhaps the most remarkable Recent cancellarids. Both are Panamic species and both have Miocene predecessors in the present Caribbean region or in Florida. The fossil species of *Perplicaria* have been reviewed by Wilson (1948). His upper Miocene collections from peninsular Florida include a loosely coiled *Trigonostoma* allied to *T. milleri*, recently described as *T. hœrlei* (Olsson, 1967, p. 24, pl. 8, figs. 6, 6a).

The Gatun formation contains 18 species and subspecies of cancellarids in nine genera and subgenera. Four of the genera and subgenera (*Pyruclia*, *Euclia*, *Narona*, and *Aphera*) are no longer living in the present Caribbean region, but survive in the Panamic region. Unidentified cancellarids, or doubtful cancellarids, are represented by poorly preserved material in the marine member of the Bohio(?) formation, the upper part of the Bohio formation of Barro Colorado Island, the Caimito formation of the Gatun Lake area, and the La Boca formation.

Genus Cancellaria Lamarck

Lamarck, Soc. Histoire Nat. Paris Mém., p. 71, 1799.

Type (monotype): *Voluta reticulata* Linné, living, Cape Hatteras to Caribbean Sea.

Subgenus Cancellaria s. s.

Cancellaria (Cancellaria) anomoia Woodring, n. sp.

Plate 52, figures 1, 2

Small, moderately inflated, spire distinctly turreted. Protoconch relatively large, naticoid, 3¼-whorled, end marked by abrupt appearance of sculpture. First sculptured whorl bearing 11 axial ribs and seven relatively wide, closely spaced, flat spiral threads. Sculpture of late whorls consisting of axial ribs, basically narrow or of moderate width (18 to 21 on body whorl), and closely spaced, flat spiral threads or narrow cords (seven on penult). On shoulder of body whorl and near base a secondary spiral thread in some of the spaces between primary threads. A widened varix-like rib or two present on body whorl; present or absent on preceding two whorls. Outer lip broken back; ribs and growth lines showing a shallow notch near base.

Height 19.1 mm, diameter 11.7 mm (type). Height (not quite complete) 19.8 mm, diameter 13.6 mm (largest specimen).

Type: USNM 645712.

Type locality: 138c (USGS 21956, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

The type of *Cancellaria anomoia* was found in the lower part of the Gatun formation at locality 138c. The same locality yielded a minute shell, consisting of the protoconch and 2¼ sculptured whorls, and three imperfect shells, one of which is a little larger than the

type. That the type is immature is indicated by its size and also by the narrow space between the edge of the columellar lip and the siphonal fasciole.

The sculpture, consisting of closely, and essentially uniformly, spaced flat spiral threads (or narrow cords) and axial ribs, which are basically narrow or of moderate width, gives this species a characteristic appearance. The spiral sculpture suggests that of *C. rowelli* Dall, which is discussed under the next heading. Both spiral and axial sculpture of *C. anomoia*, however, continue with undiminished strength beyond the stage when they are subdued on *C. rowelli*. *C. anomoia* is more similar to *C. defuniak* Gardner (1926-47, p. 365, pl. 44, figs. 1, 2, 1938), a middle Miocene species from Florida, but is not as slender and has less sharply chiseled spiral sculpture.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c.

Cancellaria (Cancellaria) aff. C. macneili Mansfield

Plate 52, figures 3, 4

Small, moderately inflated, spire distinctly turreted. Protoconch worn, naticoid, 2½-whorled, end marked by abrupt appearance of sculpture. First sculptured whorl somewhat worn, bearing 10 axial ribs, a spiral thread (later two) on upper part of whorl, and three low, flat spiral threads on main part of whorl. Early half of penult whorl sculptured with 15 narrow axial ribs, a doubled spiral thread adjoining suture, another spiral thread on upper part of whorl, and four closely spaced, low, flat spiral threads (or narrow cords) on main part of whorl. On later part of penult and on body whorl axial ribs greatly subdued. At same stage spiral sculpture disappears, except in narrow band in sutural area and in wider band adjoining siphonal fasciole. Sculptured spire whorls, except first, bearing a widened varixlike rib.

Height 19 mm, diameter 12 mm (figured specimen).

The lower part of the Gatun formation yielded a small weakly sculptured *Cancellaria* and a fragment of a somewhat larger specimen, also weakly sculptured. Both of these fossils doubtless are immature. The outline and strong suppression of sculpture suggest relationship to *C. macneili* (Mansfield, 1937a, p. 609, pl. 85, figs. 1, 4; middle Miocene, Florida), if not that species. The early sculpture of *C. lævescens* Guppy (Woodring, 1928, p. 220, pl. 12, figs. 7, 8; middle Miocene, Jamaica), is reticulate and stronger than that of *C. macneili*, whereas *C. rowelli* Dall (*in* Guppy and Dall, 1896, p. 307, pl. 29, fig. 1; middle Miocene, Dominican Republic) is more slender and its sculpture is not as strongly suppressed on late whorls.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 137.

Cancellaria (Cancellaria) tapeina Woodring, n. sp.

Plate 51, figures 8, 9

Of medium size, moderately inflated, spire distinctly turreted. Protoconch missing, early sculptured whorls worn. Earliest preserved sculpture consisting of axial ribs and eight low, flat spiral threads. On later part of penult whorl and on body whorl axial ribs more closely spaced and subdued; spiral threads (or narrow cords) subdued, and an intervening secondary spiral thread appearing. Penult whorl bearing 29 axial ribs and 12 primary spiral threads. Slightly widened ribs, which appear on last three whorls, take the place of varices. Outer lip broken back; ribs and growth lines showing a shallow notch near base.

Height (almost complete) 34.7 mm, diameter 20.5 mm (type).

Type: USNM 645714.

Type locality: 182a (USGS 8488, Caribbean coast east of San Miguel [Río Miguel], station 25 plus 400 feet (120 meters), Panamá), upper part of Gatun formation.

Cancellaria tapeina is based on a somewhat worn specimen, found in the upper part of the Gatun formation in the western area. Though the weak sculpture suggests *C. rowelli*, this cancellarid evidently is not a form of that species. The low, flat spiral threads of *C. tapeina* are separated by wider spaces, in which a secondary thread appears on the last whorl and a half. The body-whorl axial ribs of the Gatun fossil also are less subdued.

C. anomoia, *C.* aff. *C. macneili* and *C. tapeina* are more similar to *C. reticulata* than the other cancellarids of the Canal Zone and adjoining parts of Panamá. Nevertheless the relationship is not close.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), locality 182a.

Cancellaria (Cancellaria) epistomifera dariena Toula

Plate 52, figures 11–18

Cancellaria dariena Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 703, pl. 28, fig. 2, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 345, pl. 24, figs. 3, 4, 1911 (Miocene, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32 (list), 1917 (Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 80, pl. 6, fig. 8, 1922 (Miocene, Canal Zone, Panamá, Costa Rica). Weisbord, Idem, v. 14, no. 54, p' 50, pl. 6, fig. 8, 1929 (Miocene, Colombia). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 115, 1929 (Miocene, Colombia). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 549, pl. 75, fig. 4, 1965 (Miocene, Canal Zone).

Cancellaria dariena n. sp., var., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 704, pl. 28, fig. 1, 1909 (Miocene, Canal Zone).

Cancellaria dariena trachyostraca Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 345, pl. 24, figs. 1, 2, 1911 (Miocene, Canal Zone).

Cancellaria darienensis Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 51, pl. 4, figs. 9, 10, 1913 (Miocene, Canal Zone).

Cancellaria epistomifera Guppy, Cossmann, Idem, p. 53, pl. 4, figs. 5, 6, 1913 (Miocene, Canal Zone).

Uxia miocœnica Cossmann, Idem, p. 54, pl. 4, figs. 11, 12, 1913 (Miocene, Canal Zone).

Cancellaria (Cancellaria) dariena Toula, Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 118, 1964 (Miocene, Ecuador).

?Cancellaria (Cancellaria) dariena Toula, Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 623, pl. 29, fig. 19, 1939 (Miocene, Colombia).

Not *Cancellaria?* cf. *C. dariena* n. sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, pl. 25, fig. 13, 1909 (Miocene, Canal Zone); = *Antillophos candei gatunensis* (Toula).

Of medium size, inflated to moderately slender, spire slightly to strongly turreted. Protoconch naticoid, 3-whorled, end marked by gradual appearance of sculpture. First sculptured whorl bearing four or five spiral threads and generally 10 or 11 (exceptionally 14) widely spaced axial ribs. Terminal varix of varying strength present or absent on mature shells. Body whorl of mature shells generally bearing one or two earlier varices (exceptionally none or as many as three). One or two varices exceptionally present on penult whorl or even on antepenult. Penult whorl of mature shells sculptured with four or five spiral cords (exceptionally six) and 23 to 25 axial ribs (exceptionally as many as 28). Spiral cord adjoining suture narrower and closer to adjoining cord than others. Width of spiral cords and spacing of axial ribs variable. Narrow cords and widely spaced ribs most common. A secondary spiral thread generally present in at least some of spaces between spiral cords, especially on and above periphery. Basal part of outer lip flaring and bearing a shallow notch. Siphonal fasciole strongly inflated. Parietal callus moderately thick.

Height 34 mm, diameter (including strong terminal varix) 21.5 mm (figured inflated specimen). Height 31 mm, diameter (including weak terminal varix) 16.5 mm (figured slender specimen).

Type material: Lectotype (herewith designated), Tech. Hochschule, Vienna.

Type locality: Presumably Gatun Locks site, Canal Zone, middle part of Gatun formation.

Cancellaria epistomifera dariena is the most widely distributed cancellarid in the Gatun formation and is locally abundant, especially in the lower part of the formation at locality 138c, where about 100 specimens were collected. Its distribution in the middle and upper Miocene deposits of the western part of the present Caribbean province is fairly wide. Though it was not found in the upper part of the Gatun in the western area, two incomplete worn shells, listed as *C.* aff. *C. epistomifera dariena*, were found in the Chagres sandstone.

A pronounced range of variation, in outline and sculpture, is shown by the fossils referred to *C. epistomifera dariena*. The greatest range in outline is afforded by the samples from the lower part of the Gatun. An inflated specimen (pl. 52, figs. 17, 18), a slender specimen (pl. 52, figs. 15, 16), and a distinctly turreted specimen (pl. 52, figs. 13, 14), were selected from the large collection just mentioned. That collection includes 13 distinctly turreted shells. A strongly turreted specimen (pl. 52, figs. 11, 12), in a Stanford University collection from the lower part of the Gatun, is associated with six slightly turreted shells. No other shell is so strongly turreted. It is so different from the ordinary run of *C. epistomifera dariena* that it suggests a different species and is perhaps to be treated as such. It represents, however, only a step from the distinctly turreted form. One distinctly turreted shell was found in the middle part of the formation and none in the upper part. The illustrated slender specimen (pl. 52, figs. 15, 16) is exceptionally slender. The lectotype (the specimen shown on Toula's plate 28, figure 2) is moderately inflated and slightly turreted. It has a height of 27 mm and a diameter of 15.2 mm. Its flat siphonal fasciole and slender columellar folds indicate that it is not quite mature.

The range of variation in spacing of axial ribs, in width of spiral cords, and in strength of secondary spiral threads (or their absence) is too great to show with a reasonable number of illustrations. Some of the range is shown on plate 52 for specimens from the lower part of the Gatun. Toula's and Brown and Pilsbry's illustrations serve the same purpose for the middle part, and Cossmann's for the upper part in the eastern area. Five of some 250 shells in the collections at hand lack secondary spiral threads. At the other extreme, one (locality 138c) has exceptionally strong secondary threads.

C. epistomifera epistomifera Guppy occurs in the Cercado and Gurabo formations of the Dominican Republic. A lectotype, presumably from the Gurabo formation, was selected and illustrated by Pflug (1961, p. 52, pl. 14, figs. 1, 2, 9). Its protoconch is not preserved. Maury (1917, p. 63) pointed out that two types of protoconch and first post-protoconch whorl are represented in her collections: (1) protoconch small, axial ribs appearing at beginning of first post-protoconch whorl; (2) protoconch large, axial ribs appear-

ing after first third of first post-protoconch whorl. According to collections in the U.S. National Museum, her first type is shown by specimens from the Cercado formation and her second type by specimens from the Gurabo formation. *C. epistomifera dariena* shows the first type, although some variation in the size of the protoconch is apparent. The contrast in the two types of protoconch is shown in illustrations of a specimen from the Gurabo formation and one from the Gatun formation (Jung, 1965, pl. 75, figs. 3, 4, respectively).

The chief difference between *C. epistomifera dariena* and the nominate subspecies lies in the greater range of variation, in outline and sculpture, of the Canal Zone subspecies.

The subgenus *Cancellaria* s.s. is an appropriate assignment for *C. epistomifera*, although that species formerly (Woodring, 1928, p. 221) was referred to the subgenus later named *Bivetiella* by Wenz (1943, p. 1356; type (orthotype: *Cancellaris similis* Sowerby, living, west Africa).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 138, 138a, 138b, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139c, 139e, 139f, 140, 147 (identification doubtful), 147f (identification doubtful), 154 (identification doubtful), 155, 155a, 155b, 155c, 157, 159, 159b, 159d; western area, localities 161, 161a, 161c, 170 (identification doubtful). Upper part, eastern area, localities 172, 175, 176, 176a, 177 (identification doubtful), 177b, 178. Middle Miocene, Costa Rica, Colombia, Darién area (USGS 8477), Chiriqui area (USGS 7955). Limón formation (Late Miocene), Bocas del Toro area, Panamá. Miocene, Ecuador. Chagres sandstone (late Miocene), locality 208 (*C.* aff. *C. epistomifera dariena*).

Cancellaria (Cancellaria) epistomifera lipara Woodring, n. subsp.

Plate 52, figures 7, 8

Smaller than *Cancellaria epistomifera dariena*, inflated, spire somewhat turreted. Axial ribs closely spaced, 25 to 33 on penult whorl. Secondary spiral threads absent. Terminal varix and a nearby earlier varix subdued, or both absent. Notch on basal part of outer lip very shallow or absent.

Height 28 mm, diameter 17.5 mm (type). Estimated restored height 30 mm, diameter 18 mm (largest specimen).

Type: USNM 645719.

Type locality: 183 (USGS 8487, Caribbean coast east of Rio San Miguel [Río Miguel], station 4 plus 40 feet (12 meters), Panamá), upper part of Gatun formation.

Cancellaria epistomifera lipara is represented by 17 specimens from the type locality and one from locality 182a. Both localities are in the upper part of the Gatun formation in the western area. In marked contrast to the diversity shown by *C. epistomifera dariena*, these 18 cancellarids are fairly uniform. The combination of relatively small size, closely spaced axial ribs, absence of secondary spiral threads, subdued varices (or their absence), and very shallow notch (or its absence) on the outer lip distinguish them from *C. epistomifera dariena* and *C. epistomifera epistomifera*. Despite their small size, the largest specimens of *C. epistomifera lipara*, like the small form of *C. epistomifera epistomifera* in the Gurabo formation of the Dominican Republic, have a swollen siphonal fasciole and heavy columellar folds, indicating that they are mature.

The Limón formation, of late Miocene age, on Cayo de Toro, in the Bocas del Toro area of northwestern Panamá (USGS 8326), yielded one specimen of *C. epistomifera lipara* (height 31 mm), associated with four of *C. epistomifera dariena*.

The axial ribs of an immature shell (height 16.3 mm) in the large collection from the lower part of the Gatun formation at locality 183c are even more closely spaced than those of *C. epistomifera lipara*, and so are the spiral cords. This fossil is doubtfully identified as an aberrant form of *C. epistomifera dariena*.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), localities 182a, 183. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Cancellaria (Cancellaria) apimela Woodring, n. sp.

Plate 52, figures 5, 6

Small, slender, spire distinctly turreted. Protoconch missing, early sculptured whorls corroded. Earliest preserved sculpture consisting of axial ribs and eight low, flat spiral cords. Axial ribs strong and widely spaced on last two whorls. Penult whorl bearing 12 or 13 axial ribs and nine low, flat spiral cords, separated by narrow grooves. Spiral sculpture subdued on main part of body whorl. One or two axial ribs on last two whorls wider and lower than others.

Height 22.6 mm, diameter 13 mm (type).

Type: USNM 645720.

Type locality: 182a (USGS 8488, Caribbean coast east of San Miguel [Río Miguel] station 25 plus 400 feet (120 meters), Panamá, upper part of Gatun formation.

This distinctive species is based on two specimens from the upper part of the Gatun formation in the western area. Part of both shells—the part exposed when they were collected—is corroded.

Though the low flat spirals, which are separated by narrow grooves and are subdued on the body whorl, recall those of *Cancellaria rowelli*, the combination of such spiral sculpture with strong, widely spaced axial ribs and slender outline is unusual.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), localities 182, 182a.

Cancellaria (Cancellaria) species

An incomplete and badly damaged specimen of *Cancellaria* was found in the Chagres sandstone at locality 208. It is small and slender, like *C. apimela*. Also like that species, it has strong, widely spaced axial ribs. Unlike that species, however, the spiral cords are widely spaced and are strong even on the body whorl. The penult whorl is sculptured with 10 axial ribs and six spiral cords.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Subgenus Pyruclia Olsson

Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 160, 1932.
Type (orthotype): *Cancellaria solida* Sowerby, living, Gulf of California to Perú.

The earliest species of *Pyruclia* are of middle Miocene age and the survivors live in the eastern Pacific Ocean. Miocene representatives are found along or near the south border of the present Caribbean Sea—in Panamá, Colombia, Venezuela, and Trinidad—and also in the Darién area, Ecuador and Perú. The latest species in the present Caribbean region occur in deposits of late Miocene age.

Cancellaria (Pyruclia) cibarcola cibarcola Anderson

Plate 52, figures 9, 10; plate 53, figures 8, 10–12

Cancellaria cibarcola Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 116, pl. 14, figs. 1–3, 1929 (Miocene, Colombia). Barrios, Colombia Servico Geol. Nac. Bol. Geol., v. 6, nos 1–3 (Informe 1082), p. 290, pl. 11, fig. 7, 1960 (Miocene, Colombia).

Not *Cancellaria cibarcola* Anderson, Rutsch, Naturforsch. Gesell. Basel Verh., v. 54, p. 163, pl. 9, figs. 6a, 6b, 1942 (Miocene, Trinidad); =*C. auriculaperta* Vokes.

Of medium size to large, slightly to moderately shouldered. Spire of varying height, slightly to distinctly turreted, strongly inflated. Protoconch naticoid, 2½-whorled. Early sculpture consisting of closely spaced axial ribs and low spiral threads. Sculpture gradually disappearing on third to fifth whorl later than protoconch, except faint spiral threads in sutural area and weak spiral threads on basal part of body whorl. Ribbed whorls later than first generally bearing a rib (exceptionally two) wider than others. Growth lines showing shallow notch on lower part of outer lip.

Height (practically complete) 49.2 mm, diameter (incomplete) 30 mm (exceptionally large, high-spired, figured specimen). Height (practically complete) 35.7 mm, diameter (incomplete) 25 mm (moderately large, relatively low-spired, figured specimen).

Type: Calif. Acad. Sci. 4643.

Type locality: Between Chorrera and Cibarco, Dept. of Atlántico, Colombia, Tubará formation.

Cancellaria cibarcola cibarcola is fairly widespread in the lower part of the Gatun formation and is rare in the middle part. It is abundant at locality 138c, where 40 specimens were collected. The collection from that locality is unique in including 11 high-spired shells and exceptionally large shells. The largest, which is also high-spired, is illustrated (pl. 53, figs. 10, 12). The largest of 22 specimens in eight other collections is a little larger than that shown on plate 53, figures 8, 11, and all are relatively low-spired. The type and other available shells from Columbia also are relatively low-spired. On at least some of the Colombian fossils the space between the edge of the columellar lip and the siphonal fasciole is a little wider than on Gatun specimens. These Colombian fossils have also a slightly more abruptly inflated siphonal fasciole and a slightly channeled suture. Specimens from the Darién area closely resemble those from the Gatun formation.

C. pycta Olsson (1964, p. 122, pl. 21, figs. 3, 3a) is considered to be a middle Miocene Ecuadoran subspecies of *C. cibarcola*, distinguished by the persistence of sculpture to a slightly later stage.

A late Miocene species from Trinidad, *C. auriculaperta* Vokes (1938, p. 22, figs. 19, 20), is the most similar described species in the present Caribbean region. *C. cibarcola* is less distinctly turreted, and has an unchanneled or less distinctly channeled suture, and narrower axial ribs on early whorls. Rutsch, however, thought that *C. auriculaperta* is *C. cibarcola*. In general features *C. cibarcola* is similar to *C. solida* (Keen, 1958, p. 441, fig. 704), the type of *Pyruclia*, but is more distinctly shouldered and has a higher spire.

Occurrence: Lower and possibly middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 137a, 138, 138a, 138b, 138c, 138d, 138e, 138f. Middle part, eastern area, locality 159d; western area, locality 161c (identification doubtful). Middle Miocene, Colombia, Darién area (USGS 8433, 8476, 8493), Panamá.

Cancellaria (Pyruclia) diadela Woodring, n. sp.

Plate 53, figures 7, 9

Moderately large, pyriform, broadly and strongly shouldered, strongly inflated, low-spired. Suture deeply channeled on late whorls. Early sculpture not well pre-

served, but consisting of axial ribs and spiral threads. Sculpture of late whorls reduced to faint spiral threads in sutural area and weak spiral threads on basal part of body whorl. Basal part of outer lip bearing a shallow notch.

Height (practically complete) 39.5 mm, diameter 33 mm (type).

Type: USNM 645724.

Type locality: 182 (USGS 8408, Caribbean coast east of San Miguel [Río Miguel], station 25 plus 600 feet 150 meters, Panamá), upper part of Gatun formation.

The broadly and strongly shouldered, pyriform outline, and low spire of *Cancellaria diadela* distinguish it from other species of the subgenus *Pyruclia*. *C. scheibei* Anderson (1929, p. 115, pl. 10, figs. 1–4), from the middle and upper(?) Miocene of Columbia, is the most similar described species, but is not as strongly shouldered or as pyriform.

Unfortunately, like another species of *Cancellaria* from the upper part of the Gatun formation in the western area (*C. tapeina*), *C. diadela* is based on only one specimen. A fragmentary shell from the Chagres sandstone is doubtfully referred to it.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), locality 182. Chagres sandstone (late Miocene), locality 208 (identification doubtful).

Subgenus Euclia H. and A. Adams

H. and A. Adams, The genera of Recent Mollusca, v. 1, p. 277, 1854.

Type (logotype, Cossmann, Essais de paléoconchologie comparée, pt. 3, p. 10, 1899): *Cancellaria cassidiformis* Sowerby, living, Gulf of California to Perú.

Euclia, like *Pyruclia*, occurs in the Miocene deposits of the present Caribbean region, but survives in eastern Pacific waters. The Miocene distribution has the same pattern as that of *Pyruclia:* Panamá, Colombia, Venezuela, Trinidad, Darién area, Ecuador, and Perú. The survival pattern in the present Caribbean region also is like that of *Pyruclia*. The latest species there are of late Miocene age.

Cancellaria (Euclia) codazzii Anderson

Plate 54, figures 3, 4, 7, 8, 11, 12

Cancellaria codazzii Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 116, pl. 14, figs. 4–7, March 29, 1929 (Miocene, Colombia). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 291, pl. 11, fig. 5, 1960 (Miocene, Colombia).

Cancellaria karsteni Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 114, pl. 10, figs. 7–9, 1929 (Miocene, Colombia).

Cancellaria hettneri Anderson, Idem, p. 114, pl. 10, figs. 5, 6, 1929 (Miocene, Colombia).

Cancellaria (Euclia) maldonadoi Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 122, pl. 21, figs. 5, 5a, 1964 (Miocene, Ecuador).

Of medium size, moderately slender to moderately inflated. Body whorl angulated to subrounded at shoulder. Protoconch naticoid, 2½–to 3–whorled, end marked by gradual appearance of sculpture. First sculptured whorl bearing 10 to 12 axial ribs and three or four spiral threads. First sculptured whorl or two angulated or subangulated at shoulder; remaining spire whorls up to penult rounded; penult gradually angulated or remaining rounded; body whorl sharply angulated to subrounded. Spire sculpture in general coarsely reticulate. Penult bearing six or seven spiral threads. Thread at shoulder almost invariably stronger than others. With few exceptions, axial ribs more widely spaced on later part of penult and body whorl; 7 to 16 (generally 10 to 13) on body whorl and as many as 20 to 24 to a whorl at stage preceding wide spacing. Subduing of ribs on body whorl exceptional. Ribs drawn out into spines of varying length at shoulder on body whorls that are angulated. Secondary spiral thread appearing in some of spaces between primary threads, especially near shoulder and near siphonal fasciole. A widened rib present or absent on body whorl and preceding sculptured whorls.

Height (practically complete) 33 mm, diameter 20.7 mm (figured slightly angulated, slightly spinose specimen). Height (practically complete) 35.6 mm, diameter 24 mm (figured moderately angulated, moderately spinose specimen).

Type: Calif. Acad. Sci. 4645.

Type locality: Between Chorrera and Cibarco, Dept. of Atlántico, Colombia, Tubará formation.

This variable species is widespread and locally abundant in the lower part of the Gatun formation and rare in the middle part. Some 140 specimens, including 54 from locality 138c, are available in 10 collections from the lower part and 11 in four collections from the middle part. Among mature shells those that have a slightly or moderately angulated body whorl and slightly or moderately spinose ribs (pl. 54, figs. 3, 4, 7, 8) are most abundant; those that are sharply angulated and strongly spinose (pl. 54, figs. 11, 12) are less abundant; and those characterized by a subrounded outline and nonspinose ribs are rare. None of the few specimens in the third group is suitable for illustrating. Ribs on mature body whorls are almost invariably widely spaced and the spiral thread at the shoulder is almost invariably stronger than the others, invariably so on angulated whorls. It should be noted that the three forms Anderson named were found in strata of middle Miocene age in Colombia and two of them

occur together (*Cancellaria karsteni* and *C. hettneri*). *C. codazzii* is given preference, as the other two names were used for extreme forms. In the Darién area the range of variation is not as great as in Colombia and in the Gatun formation.

C. maldonadoi represents the subrounded, nonspinose form of *C. codazzii*. The spire whorls of *C. werenfelsi* Jung (1965, p. 552, pl. 75, figs. 9–11; middle Miocene, Venezuela) are more distinctly turreted.

A middle Miocene Venezuelan species, *C. venezuelana* H. K. Hodson (Hodson and Hodson, 1931, p. 45, pl. 23, figs. 1, 4), is more inflated than *C. codazzii* and has coarser spiral sculpture. *C. montserratensis* Maury (Rutsch, 1942, p. 163, pl. 9, figs. 7a, 7b), a late Miocene Trinidad species, also has coarser spiral sculpture and includes distinctly tabulated shells. In general features *C. codazzii* is similar to the type of *Euclia*, the living Panamic *C. cassidiformis* Sowerby (Keen, 1958, p. 439, fig. 693), which is larger, invariably spinose, and its spire whorls are angulated, like the body whorl. The fossil species, however, is much more similar to another species living in Panamá Bay: *C. balboæ* Pilsbry (1931, p. 439, pl. 41, figs. 7, 8). The type of *C. balboæ* is lost or misplaced and the paratype is immature. Twenty-two specimens were collected recently from dredge dumpings at Fort Amador, Canal Zone, by R. H. Stewart, Joanne L. Allen, and Douglas Allen. According to this sample, *C. balboæ* is similar to the slightly or moderately angulated form of *C. codazzii*, but has fewer axial ribs on spire whorls. The type of *C. balboæ* (height 45 mm) evidently is exceptionally large.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 134, 136, 136a, 137, 137a, 138a, 138b, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139c, 139e, 139f, 155. Middle Miocene, Colombia, Darién area (USGS 8429, 8430, 8453, 8476, 8477), Panamá. Angostura formation (middle Miocene), Ecuador.

Cancellaria (Euclia) dinota Woodring, n. sp.

Plate 54, figures 1, 2; plate 56, figures 5, 6

Of medium size, moderately inflated. Body whorl rounded at shoulder. Protoconch naticoid, 2½–whorled. End of protoconch marked by appearance of sculpture. First sculptured whorl or two angulated or subangulated at shoulder; remaining whorls rounded. First sculptured whorl bearing 10 to 12 axial ribs and three or four spiral threads. Axial ribs narrow, except on body whorl; more widely spaced on entire body whorl, or crowded and somewhat subdued on last third of whorl; 16 to 21 (generally 18 or 19) ribs on penult, 13 to 18 (generally 17) on body whorl of specimens that have ribs of essentially uniform spacing. Spiral threads narrow; low and subdued on late whorls; six to eight (generally seven) on penult. Spiral thread at shoulder and those between shoulder and suture rarely a little stronger than others. Secondary spirals appearing on penult; those on main part of body whorl almost as strong as primaries. One or two (generally two) widened ribs on body whorl and preceding two whorls.

Height (practically complete) 29.9 mm, diameter 18 mm (type). Height 34.9 mm, diameter 21 mm (exceptionally large figured specimen).

Type: USNM 645728.

Type locality: 138c (USGS 21956, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

In marked contrast to the diversity shown by *Cancellaria codazzii*, *C. dinota* is fairly uniform. The spacing of axial ribs on the last third of the body whorl, however, is not uniform. Also on a few specimens the spiral thread at the shoulder and those between the shoulder and the suture are slightly emphasized. The size of the exceptionally large specimen shown on plate 56, figures 5, 6, is the most conspicuous exception to uniformity. Many of the shells, including the type, are somewhat worn.

C. dinota is most similar to *C. harpiformis* Pilsbry and Olsson (1941, p. 23, pl. 3, figs. 1, 2), a Pliocene species from Ecuador. That species is larger (height 43 mm), its spire is lower, and its sculpture is coarser.

C. dinota occurs in association with *C. codazzii* in the lower part of the Gatun formation, but has not been found in the middle or upper parts. It is abundant only at the type locality, where 61 specimens were collected. Immature shells may be distinguished from immature shells of *C. codazzii* by the finer sculpture of *C. dinota*.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 136a, 137a, 138, 138a, 138c, 138d, 138f.

Subgenus?

The following species is distinguished by its small size, slightly inflated spire whorls, narrowly reticulate sculpture, strong columellar folds, widely swinging siphonal fasciole and accompanying relatively wide umbilicus. The general facies of form and sculpture and the strong columellar folds suggest *Cancellaria* s.s., whereas the widely swinging siphonal fasciole suggests *Bivetopsia* Jousseaume (1887, p. 193; type (logotype, Cossmann, 1899, p. 9): *Cancellaria chrysostoma* Sowerby, living, Panamá to Perú) and *Bivetiella* Wenz (1943, p. 1,356; type (orthotype): *Cancellaria similis* Sowerby, living, west Africa). Contrary to the view

expressed in 1928 (Woodring, 1928, p. 221), when *Bivetopsis* was inadvertently used for *Bivetopsia*, *Bivetopsia* and *Bivetiella* are scarcely distinguishable, except on a basis of sculptural plan. *Bivetiella* Marks (1949, p. 456) is not only a junior homonym of *Bivetiella* Wenz, it is also an objective junior synonym of that name.

Cancellaria acalypta Woodring, n. sp.

Plate 53, figures 1, 2

Small, moderately inflated, spire whorls slightly and uniformly inflated. Protoconch 2½-whorled, end marked by abrupt appearance of sculpture. Sculpture narrowly reticulate. Axial ribs wider than spiral threads and for most part a little more widely spaced. First sculptured whorl bearing nine axial ribs and four spiral threads. Body whorl sculptured with 20 to 22 axial ribs and 13 or 14 spiral threads. Third sculptured whorl and later whorls bearing one or two slightly widened ribs. Aperture ovate, tapering to a very short siphonal canal. Columella bearing three folds, progressively stronger from first (basal) to third. Columellar folds, liræ on interior of outer lip, and ridges at upper end of parietal wall strong for size of shell. An elongate denticle alined with outer end of third columellar fold; a denticle near edge of columellar lip between second and third folds; and an elongate denticle extending obliquely from outer end of second fold. Siphonal fasciole moderately inflated, swinging far from outer edge of columellar lip, forming a relatively wide umbilicus.

Height: 15.6 mm, diameter 10.2 mm (type).

Type: USNM 645730; paratype, Stanford University.

Type locality 136a (Stanford University 2611, Transisthmian Highway, lat 9° 21′ N. plus 1,100 feet (335 meters), long 79° 49′ W., Panamá; same as USGS 16912), lower part of Gatun formation.

Three specimens of this small cancellarid were found in the lower part of the Gatun formation and one in deposits near the base of the middle part. All are of approximately the same size. Despite the small size, the apertural features are strong, especially on the shell from the middle part of the formation. The body-whorl sculpture of that specimen is also for the most part more evenly reticulate than that of the others. The basal part of the outer lip of the type is missing and the lip of the other specimens is damaged.

The axial ribs of *Cancellaria laqua* Mansfield (1935, p. 26, pl. 2, fig. 5; middle Miocene, Florida), *C. lavelana* H. K. Hodson (*in* Hodson and Hodson, 1931, p. 44, pl. 24, fig. 12; middle Miocene, Venezuela), and an unnamed late Miocene Mexican species (USGS 18687) are closely spaced. The third columellar fold of these three species is wider than that of *C. acalypta*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a. Middle part, eastern area, locality 139c.

Subgenus?

Cancellaria nancellaria Woodring, n. sp.

Plate 53, figures 3, 4

Small, moderately slender, whorls rounded. Protoconch large for size of shell, naticoid, 3-whorled, end marked by appearance of first axial rib. First sculptured whorl bearing eight to ten axial ribs and four or five spiral threads. Sculpture throughout consisting of narrow axial ribs (nine or ten on penult, 11 to 13 on body whorl) and narrower spiral threads (five or six on penult, 11 to 13 on body whorl). Aperture of moderate width, tapering to a short siphonal canal. Columella bearing three fairly strong columellar folds. Denticle near outer edge of columellar lip between second and third (from base) folds present or absent. Interior of outer lip bearing moderately strong liræ. Siphonal fasciole slightly inflated, swinging some distance from outer edge of columellar lip, forming a narrow umbilicus.

Height 7.6 mm, diameter 4.5 mm (type). Height 8.9 mm, diameter 5 mm (largest specimen).

Type: USNM 645731.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

Twenty-eight specimens, collected at five localities (four in the middle part of the Gatun formation and one in the upper part in the eastern area) are referred to *Cancellaria nancellaria*. As usual, the lower part of the outer lip of the type and other specimens, except some of the smallest, is imperfect. The largest of these fossils has a height under 9 mm and almost half of them consist of only the protoconch and one or two later whorls. The type locality, as already mentioned (p. 69, 74, 75, 88, 103, 274), is noteworthy for its many small specimens, both mature small species and immature shells. Small specimens are fairly common also at two of the other localities at which *C. nancellaria* was found (146 and 147g), both near the type locality. Nevertheless these three collections include moderately large fossils. Despite their small size, perhaps the largest shells of this species are mature. If they are mature, *C. nancellaria* is a minute species. The columellar folds, the short siphonal canal, and the position of the siphonal fasciole suggest *Cancellaria* s.s.,

but the outline and the widely spaced axial ribs are more similar to those of *Narona*, the subgenus under the next heading. At all events no close allies of *C. nancellaria* are recognized.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 146, 147b, 147g, 153a. Upper part, eastern area, locality 175.

Subgenus Narona H. and A. Adams

H. and A. Adams, The genera of Recent Mollusca, v. 1, p. 277, 1854.

Type (logotype, Jousseaume, Le Naturaliste, 2d ser., année 9, p. 222, 1887): *Cancellaria clavatula* Sowerby, living, México to Perú.

Narona, like *Pyruclia* and *Euclia*, formerly lived in the present Caribbean region, but survives in the eastern Pacific Ocean. Despite its very short siphonal canal, *Cancellaria bullbrooki* Mansfield (1925, p. 31, pl. 5, fig. 3), a middle Miocene species from Trinidad, evidently is a species of *Narona* that has strongly constricted whorls. The type doubtless is immature. Unlike *Pyruclia* and *Euclia*, *Narona* reached Florida. As recognized by both Gardner and Mansfield, it is represented there by middle and late Miocene species: *Cancellaria atraktoides* Gardner (1926–47, p. 376, pl. 45, figs. 13, 14, 1938; middle Miocene), *C. blountiana* Mansfield (1935, p. 27, pl. 2, fig. 4; middle Miocene), *C. agria uaquala* Mansfield (1935, p. 27, pl. 2, figs. 7, 8; middle Miocene), *C. agria agria* Mansfield (1930, p. 48, pl. 3, fig. 1; late Miocene), and *C. coensis* Mansfield (1930, p. 49, pl. 3, figs. 3, 4, late Miocene).

Cancellaria (Narona) barystoma Woodring, n. sp.

Plate 53, figures 5, 6

Small, slender, distinctly turreted. First two sculptured whorls weakly angulated at shoulder, later whorls rounded. Protoconch small, naticoid, 2¼-whorled, end marked by appearance of sculpture. First sculptured whorl bearing nine narrow axial ribs and two very narrow spiral threads. Axial ribs of late whorls swollen, 13 on penult and 12 on body whorl. Spiral threads of late whorls narrow, 10 on penult. Secondary spiral threads on main part of body whorl. Two ribs on penult and three on body whorl varicose. Aperture narrow, tapering to a short siphonal canal. Liræ on interior of outer lip strong. Columella bearing two strong folds. Inner edge of columellar lip slightly inflated below lower fold and bearing a denticle between the folds. Siphonal fasciole slightly inflated, close to outer edge of columellar lip.

Height 16.3 mm, diameter 7.8 mm (type).

Type: USNM 645732.

Type locality: 138d (USGS 22016, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

In essential features *Cancellaria barystoma* is similar to the type species of *Narona*. The fossil species, however, is distinguished by its smaller size, more rounded late whorls, more numerous axial ribs and spiral threads, and—above all—by the much stronger columellar folds and liræ on the interior of the outer lip. No other species of *Narona* is known to have such strong apertural features, but those features may not be fully formed on some of the fossil species.

Though *C. barystoma* is represented by 13 specimens (12 from the lower part of the Gatun formation and one from a horizon near the base of the middle part), the type is the only mature shell. The next largest has a height of 10 mm. As is to be expected, its apertural folds and liræ are not as strong as those of the type. Two of the immature shells are not as slender as the others. The edge of the outer lip of the type is missing except at and near its insertion.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, locality 139c.

Cancellaria (Narona) decaptyx Brown and Pilsbry

Cancellaria decaptyx Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 346, pl. 24, figs. 5, 6, 1911 (Miocene, Canal Zone).

This species, collected at the Gatun Locks excavation, is not recognized in the collections at hand. The type is the only available specimen.

Like *Cancellaria barystoma*, *C. decaptyx* is small and slender (height 11 mm, diameter 5 mm). It is distinguished from *C. barystoma* by its more slender outline and sculpture. The first sculptured whorl bears three spiral threads, and on the penult and body whorls the threads are more numerous and more closely spaced than those of *C. barystoma* (11 on penult). The columellar folds and liræ on the interior of the outer lip are of about the same strength as those on a specimen of *C. barystoma* of comparable size.

Type: Acad. Nat. Sci. Phila. 1701.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Occurrence: Middle part of Gatun formation (middle Miocene), Gatun Locks excavation.

Subgenus Charcolleria Olsson

Olsson, Bull. Am. Paleontology, v. 27, no. 106, p. 61, 1942.
Type (orthotype): *Cancellaria (Charcolleria) perdiciana* Olsson, Miocene, Colombia.

The large, fusiform, reticulately sculptured shells of *Charcolleria* are so different from those of *Cancellaria* s.s. that at first glance generic rank seems to be amply justified. Nevertheless *Charcolleria* evidently is allied to *Massyla* (H. and A. Adams, 1854, p. 278; type (monotype): *Cancellaria corrugata* Hinds, living, Ecuador to Perú) and *Massyla* is generally treated as a subgenus of *Cancellaria*. The type of *Massyla* is a rare species and no specimens are available. According to Hinds' (1844–45, p. 42, pl. 12, figs. 1, 2, 1844) illustrations, it is fairly slender and, like *Charcolleria*, has two columellar folds and narrowly reticulate sculpture. It is, however, less than half as large (height about 18 mm), as *Charcolleria*, less slender, and has weaker spiral sculpture. Usage of *Massyla* for European Miocene species (Sacco, 1894, p. 67, pl. 3, figs. 80a, 80b; Cossmann, 1899, p. 39–41, pl. 2, figs. 13, 14) is unjustified.

Charcolleria has been found so far in the lower Miocene of Colombia, the middle Miocene of Colombia and the Caribbean part of Panamá, the middle and upper Miocene of Venezuela, the upper Miocene or Pliocene of Ecuador, and the Pliocene of southwestern Costa Rica near the boundary of Panamá. It has no known predecessors or descendants in the Caribbean region or elsewhere.

It is surprising that in many features the two known species of *Charcolleria* are similar to a Pliocene species of southeastern United States: *Cancellaria venusta* Tuomey and Holmes (Olsson and Harbison, 1953, p. 179, pl. 28, figs. 8, 8a, 8b), which was assigned to *Massyla* by Olsson and Harbison. *Cancellaria propevenusta* Mansfield (1930, p. 47, pl. 17, fig. 2; upper Miocene, Florida) may be a predecessor of *Cancellaria venusta* and perhaps *Cancellaria propevenusta* arose from *Cancellaria runchœna* Gardner (1926–47, p. 375, pl. 45, figs. 8, 9, 1938; middle Miocene, Florida). The resemblance of *Charcolleria* to *Cancellaria venusta* is attributed to convergence.

Cancellaria (Charcolleria) terryi Olsson

Plate 54, figures 5, 6, 9, 10

Cancellaria (Charcolleria) terryi Olsson, Bull. Am. Paleontology, v. 27, no. 106, p. 62, pl. 8, fig. 1, 1942 (Pliocene, Costa Rica). Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 124, pl. 22, fig. 2, 1964 (Miocene, Ecuador). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 556, pl. 75, figs. 17–19, 1965 (Miocene, Venezuela).

Cancellaria (Charcolleria) sp., Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 124, pl. 22, figs. 1, 1a, 1964 (Miocene, Canal Zone).

Large, slender, fusiform, whorls strongly inflated. Protoconch and earliest sculptured whorl missing or worn. Sculpture of remaining whorls strongly and evenly reticulate, forming squares, or more generally rectangles that are slightly elongate spirally. Penult whorl bearing 27 to 37 axial ribs and nine or ten spiral cords. Axial ribs slightly narrower and more closely spaced on irregularly spaced varixlike slight swellings on late whorls of large shells. Microscopic axial threads visible on unworn late whorls. Aperture elongate, tapering to a short siphonal canal. Columella bearing two moderately strong folds. Siphonal fasciole slightly inflated, swinging some distance from edge of columellar lip.

Height (incomplete) 53.5 mm, diameter 24 mm (larger figured specimen). Height 42.3 mm, diameter 19 mm (smaller figured specimen).

Type: Paleontological Research Inst. 4045.

Type locality: Quebrada Peñites, Puntarenas Province, Costa Rica, Charco Azul formation.

Collections from the lower and middle parts of the Gatun formation include 16 specimens of this large fusiform cancellarid. Eight of them were collected at locality 138c and one or two at each of the other seven localities. The sculpture of all these specimens is strongly reticulate and essentially uniform. It is coarser than the sculpture of the type of *Charcolleria: Cancellaria perdiciana* (Olsson, 1942, p. 61, pl. 8, fig. 5), an early Miocene moderately deep-water species from Colombia. The coarse sculpture is the basis for the identification of the Gatun species as *Cancellaria terryi*. The identification means that *Cancellaria terryi* survived later in eastern Pacific waters than in western Atlantic waters.

Cancellaria terryi is twice as large as *Cancellaria venusta* (height 22 to 26 mm)—the Pliocene species already mentioned—and has more inflated spire whorls and stronger axial sculpture. *Cancellaria propevenusta* —also already mentioned—is low spired and inflated in outline; otherwise it is similar to *Cancellaria venusta*, aside from the difference in size. The type of *Cancellaria propevenusta* has a height of 35.8 mm, but specimens in Druid Wilson's upper Miocene collections from peninsular Florida reach a height of 46 mm.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d. Middle part, eastern area, localities 139f, 140, 155, 155a, 155b, 157. Cantaure formation (middle Miocene), Venezuela. Punta Gavilán formation (late Miocene), Venezuela. Esmeraldas formation (late Mio-

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cene), Ecuador. Charco Azul formation (Pliocene), Costa Rica.

Genus Aphera H. and A. Adams

H. and A. Adams, The genera of Recent Mollusca, v. 1, p. 277, 1854.

Type (monotype): *Cancellaria tessellata* Sowerby, living, Gulf of California to Perú.

Aphera tessellata, a remarkable cancellarid, is the sole surviving species of *Aphera*. During Miocene time the genus had a more extensive distribution. It occurs in the lower Miocene of southeastern Costa Rica; the middle Miocene of the Dominican Republic, the Caribbean part of Panamá, southeastern Costa Rica, México, Florida, and Perú; and the upper Miocene of Perú. In other words, *Aphera* (as well as *Pyruclia*, *Euclia*, and *Narona*) is one of the many genera or subgenera that formerly lived in the Caribbean region, but now survive in the eastern Pacific Panamic region.

Miocene European species that have been referred to *Aphera* (Sacco, 1894, p. 66–67, pl. 3, figs. 76–79; Cossmann, 1899, p. 18, pl. 1, fig. 11) lack the distinctive apertural features of that genus.

Aphera islacolonis (Maury)

Plate 56, figures 1, 2

Cancellaria tessellata Sowerby, Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 236, 1873 (Miocene, Dominican Republic).

Cancellaria (Aphera) islacolonis Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 65, pl. 10, figs. 12, 12a, 12b, 1917 Miocene, Dominican Republic).

Cancellaria islacolonis Maury, Olsson, Idem, v. 9, no. 39, p. 86, pl. 6, fig. 12, 1922 (Miocene, Costa Rica); assigned to subgenus *Aphera*.

Cancellaria ellipsis Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 333, pl. 22, figs. 8, 9, 1922 (Miocene, Dominican Republic).

Small, elliptical, low-spired. Protoconch naticoid, 2½-whorled, end marked by gradual appearance of sculpture. Sculpture reticulate. Spiral cords strongly overriding axial ribs, wider than the ribs on spire whorls, of about same width on body whorl. Penult whorl sculptured with 30 to 35 axial ribs and five or six spiral cords. On spire whorls width and spacing of axial ribs irregular at irregular intervals corresponding to varices on other cancellarids; on body whorl axial ribs closely spaced and subdued near outer lip. Aperture elongate, narrow. Outer lip somewhat thickened and slightly ascending; liræ on its interior strongly thickened just within aperture. Columella bearing two strong folds. Apertural shield thick; traces of underlying sculpture reflected on parietal part; low, irregular, elongate denticles on part opposite end of columellar folds. Upper part of parietal wall bearing an elongate denticle.

Height: 16.8 mm, diameter 10 mm (figured specimen).

Type: Cornell Univ.

Type locality: Bluff 3, Cercado de Mao (long bluff on left bank of Río Mao opposite Hata Viejo, about 5 km above ford at Cercado de Mao), Dominican Republic, Cercado formation.

Aphera islacolonis is a rare species in the lower part of the Gatun formation and still rarer in the middle part. The figured specimen is the largest of the five that have been found. The protoconch of a shell in a Stanford University collection (locality 138a) is slightly tilted, like that of some specimens of *A. tessellata*. The single shell from the middle part of the Gatun is incomplete and partly exfoliated. The reflection of axial ribs on the parietal part of its apertural shield is relatively strong.

As compared with topotypes and other specimens from the Dominican Republic, the axial ribs of these few Gatun fossils are wider and fewer (some 30 as compared with some 40 on the penult whorl), their outer lip is thicker, and their liræ on the interior of the outer lip are thicker just within the aperture. Perhaps these coarser features indicate that the Panamá fossils lived in shallower water than those in the Dominican Republic and they may eventually be given subspecific rank. Olsson's figured specimen and the type of Pilsbry's *Cancellaria ellipsis* are not entirely mature. In México (USGS 9995, near Santa Rosa, Vera Cruz) *A. islacolonis* reaches a slightly larger size than elsewhere (height 18.5 mm).

A. islacolonis is more similar to *A. tessellata* than to the other described species of *Aphera*. That living species is larger (height 26.5 mm), more slender, and has a higher spire. It is doubtful whether *A. wigginsi* Emerson and Hertlein (1964, p. 362, figs. 5d, e; Pleistocene, Isla Montserrate, Gulf of California) is to be distinguished from *A. tessellata*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c, 138f. Middle part, western area, locality 161c. Uscari shale (early Miocene part), Costa Rica. Middle Miocene deposits, Costa Rica, México. Cercado formation (middle Miocene), Dominican Republic.

Genus Trigonostoma Blainville

Blainville, Manuel de malacologie et de conchyliologie, p. 652, 1827.

Type (monotype and tautotype): *Delphinula trigonostoma* Lamarck (= *Trigona pellucida* Perry), living, tropical western Pacific Ocean.

Petit (1967, p. 217) has pointed out that Lamarck's well known name for the type species is a junior synonym of *Trigona pellucida.*

Trigonostoma cf. T. scalatella (Guppy)

Small, slender, scalariform, sutural area sloping toward shoulder. Protoconch and spire whorls up to later part of penult missing. Body whorl sculptured with eight strongly arched axial ribs and 18 spiral threads, swollen on crest of ribs. Spiral threads fading out in sutural area. Near base a faint secondary thread appearing in two of spaces between spiral threads. Aperture and umbilicus narrow. Liræ on interior of outer lip strong just within aperture. Columella bearing two folds and a faint basal swelling.

Estimated height 12 mm, diameter 6.8 mm.

Two fragmentary shells demonstrate the presence of a small, slender species of *Trigonostoma* in the Gatun formation. The description is based on the better of the two (locality 139c). The other fragment presumably represents the same species.

In general outline this unnamed, apparently new, species is similar to the somewhat larger Miocene Jamaican *Trigonostoma scalatella* (Guppy) (Woodring, 1928, p. 224, pl. 13, fig. 1). The sutural area of that species is horizontal, its spiral sculpture consists of closely spaced primary and secondary threads, and its aperture is wider. *T. funiculatum* (Hinds) (1844–45, p. 43, pl. 12, figs. 5, 6, 1844; living, Baja California, Gulf of California) is more inflated, and has secondary spiral threads and a wider aperture.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138e. Middle part, eastern area, locality 139c.

Trigonostoma cf. T. insulare (Pilsbry and Johnson)

Cancellaria (*Trigonostoma*) aff. *Cancellaria bullata* Sowerby, Toula, K. k. Geol. Reichsanstalt Jahrb, v. 61, p. 504, pl. 30, fig. 10, 1911 (Miocene, Canal Zone).

Toula's specimen of this Gatun species is missing in his collection and no other is available. According to his description and illustration, the sculpture of the penult whorl is finely reticulate. The body whorl is sculptured with 14 narrow, widely spaced axial ribs and fairly strong spiral threads. The columella bears three folds.

Pilsbry and Johnson thought this species may be their *Trigonostoma insulare* (Pilsbry and Johnson, 1917, p. 163; Pilsbry, 1922, p. 334, pl. 22, fig. 11) and Olsson thought it probably is his *T. toroense* (Olsson, 1922, p. 84, pl. 6, fig. 4). The early finely reticulate sculpture of the Gatun species suggests that of *T. toroense*, but the ribbing on the body whorl is more like that of *T. insulare.*

T. insulare is found in the Dominican Republic, presumably in the Cercado or Gurabo formation, and *T. toroense* in the late Miocene Limón formation of the Bocas del Toro area of northwestern Panamá.

Occurrence: Middle part of Gatun formation (middle Miocene), Gatun Locks excavation.

Trigonostoma n. sp.

Plate 63, figures 14, 15

Of medium size, moderately inflated. Sutural area depressed, forming a deep U-shaped gutter. Earliest preserved sculpture consisting of weak axial ribs and stronger spiral threads. Penult and body whorls sculptured with low, narrow-crested, widely spaced axial ribs (14 on body whorl) and subdued, closely spaced primary and secondary spiral threads. Outer lip broken back; interior of preserved part smooth. Umbilicus moderately wide. Columella bearing two slender folds.

Height (almost complete) 20.2 mm, diameter 14.7 mm.

The Chagres sandstone yielded a poorly preserved specimen of this species. Both the outer and columellar lips are broken back and much of the outer shell material is corroded. The deep U-shaped sutural gutter; the distinct, though low and narrow-crested, axial ribs; and the distinct, though subdued, spiral threads indicate it is a new species. The axial ribs of *Trigonostoma woodringi* Jung (1965, p. 557, pl. 76, figs. 1, 2; middle Miocene, Venezuela) are wider.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Family CONIDAE

Genus Conus Linné

Linné, Systema naturæ, 10th ed., p. 712, 1758.

Type (logotype, Children, Quart. Jour. Sci. Lit. Art, v. 16, p. 69, 1823): *Conus marmoreus* Linné, living, western Pacific Ocean.

Though many attempts have been made to recognize subgenera, or genera, in the traditional genus *Conus*, they have not been notably successful. The species living in both the western Atlantic and eastern Pacific Oceans have been reviewed recently (Clench, 1942; Hanna, 1963, respectively).

The genus has been found in the Gatuncillo, Bohio, Caimito, Culebra, La Boca, and Gatun formations, and in the Chagres sandstone, but the only adequate representation is in the Gatun. With the exception of two specimens of medium size, the formations older than the Gatun yielded only small specimens and the species themselves evidently are small. The exceptions are an

unidentified specimen from the Culebra formation (locality 110) and another from upper member of the Alhajuela formation (locality 89). In addition to the briefly described Caimito, Culebra, and La Boca species, the collections from those formations include a considerable number of unidentified specimens, most of which are, in fact, unidentifiable.

The Gatun formation contains 16 species and subspecies of *Conus:* eight in the lower part, 14 in the middle part, seven in the upper part in the eastern area, and six in the upper part in the western area. Eight, the largest number in any collection, were recovered at localities 138c and 155. The large number in the middle part is not unusual in the middle Miocene of the Caribbean region. Twelve occur in southeastern Costa Rica, 16 in the Bowden formation of Jamaica, and 16 in the Gurabo formation of the Dominican Republic. Four of the Gatun species are closely related to living species and one is identified as a living species. As shown in the following table, the four closely allied species are living in the eastern Pacific Panamic region, whereas the species still living is a Caribbean species.

Species of Conus *from Gatun formation and closely allied or identical species living in Panamic and Caribbean regions*

Species in Gatun formation	Closely allied or identical living species	
	Panamic region	Caribbean region
C. recognitus Guppy	*C. patricius* Hinds	----------
C. spurius Gmelin	----------	*C. spurius* Gmelin.
C. molis Brown and Pilsbry.	*C. fergusoni* Sowerby.	----------
C. consobrinus Sowerby	*C. emersoni* Hanna	----------
C. imitator Brown and Pilsbry.	*C. arcuatus* Broderip and Sowerby.	----------

Despite the large number of species in the Gatun formation, *Conus planiliratus* so far has not been found in the Canal Zone. That species is widespread in middle Miocene formations in the Caribbean region, is abundant in the late Miocene Limón formation of southeastern Costa Rica, occurs in the Pliocene Moín formation of that area, and may still be living in western Atlantic waters. It has been pointed out that the living Caribbean species *C. stimpsoni* is similar to *C. planiliratus* (Woodring, 1928, p. 211). The recently described *C. austini* (Rehder and Abbott, 1951, p. 22, fig. 7) is even more similar. In fact, it is doubtful whether *C. austini* can be distinguished consistently from *C. planiliurats* by any feature other than the slightly larger size of the Recent form.

The status of *C. tortuosopunctatus*, an alleged Gatun species, is discussed on page 358.

Conus recognitus Guppy

Plate 55, figure 4

Conus solidus Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 45, 1850 (Miocene, Dominican Republic). Guppy, Idem, v. 22, p. 287, pl. 16, fig. 1, 1866 (Miocene, Jamaica). Not *Conus solidus* Gmelin, 1791, or *Conus solidus* Sowerby, 1834(?).

Conus recognitus Guppy, Sci. Assoc. Trinidad Proc., pt. 3, p. 171, 1867 (Miocene, Dominican Republic, Jamaica); reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 50, 1921. Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 45, pl. 7, fig. 9, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 327, pl. 19, fig. 2, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 46, pl. 2, fig. 9, 1922 (Miocene, Costa Rica). Maury, Brazil Serviço, Geol. y Mineral. Mon. 4, pl. 11, fig. 20, 1925 (Miocene, Dominican Republic). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 109, 1929 (Miocene, Colombia).

Conus (Lithoconus) recognitus Guppy, Pflug, Acta Humboldtiana, Geol. Palæontologica Ser., no. 1, p. 59, pl. 18, figs. 12–15, 1961 (Miocene, Dominican Republic).

Conus pyriformis Reeve, Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 229, 1873 (Miocene, Dominican Republic).

Of medium size, moderately slender, pyriform. Spire low, its profile only slightly concave, owing to absence of earliest whorls. Shoulder rounded, but marked by obscure spiral thread. Earliest whorls missing, earliest preserved whorls corroded. Anal fasciole slightly convex, bearing faint microscopic spiral lineation. Lower two-thirds of body whorl sculptured with low spiral threads, gradually replaced by faint lineation on upper third.

Height (almost complete) 39 mm, diameter (body whorl broken back) 20.8 mm (figured specimen).

Type material: Lectotype, British Museum (Natural History) G83971.

Type locality: Valley of Río Yaque del Norte, Dominican Republic, Miocene.

A damaged small specimen, found in the upper part of the Gatun formation in the western area, is the only pyriform cone in the collections at hand. It would be more pyriform, if the outer lip were not so far broken back.

This species is identified as *Conus recognitus*, a name proposed, without any discussion of the features of the species, for Sowerby's junior homonym *C. solidus*. My discussion (Woodring, 1928, p. 203, 205) of those names was based on a cast, kindly forwarded in 1926 by the late L. R. Cox, of the British Museum (Natural History). It bears the number 12802, the number for *C. solidus* in Sherborn's register of the Heneken collection of Miocene fossils from the Dominican Republic described by Sowerby. When I had an opportunity to examine the Heneken collection in 1958, two small

cones were under that number. The larger of the two (height 39.2 mm, diameter 23.2 mm) was used in making the cast, a duplicate of which was in the tray with the specimens. As was evident from the excellent cast, this small cone is not a pyriform species, but is a representative of the *C. spurius* group. In 1961, however, Pflug published under the same Sherborn register number illustrations of two pyriform cones in the Heneken collection, the larger of which (height 65 mm, diameter 34 mm) was designated the lectotype of *C. recognitus;* that is, the lectotype of *C. solidus*, which automatically is the lectotype of *C. recognitus*. Pflug did not mention the two small specimens formerly under the number 12802. Though no pyriform cones were seen in the Heneken collection in 1958, Pflug's lectotype designation is accepted, principally because it agrees with Guppy's 1866 identification of a Miocene Jamaican pyriform cone as *C. solidus*. Guppy was the first paleontologist to deal with Sowerby's species and he had access to the Heneken collection when he was in London. As indicated by Sherborn's remarks in his register (translated on page 8 of Pflug's publication), much can happen to a collection that has passed through so many hands. Since 1867 the name *C. recognitus* has been used for a pyriform species, with the exception of my 1928 action.

In the collections from the Dominican Republic in the U.S. National Museum *C. recognitus* is represented by small specimens, comparable in size to the Gatun fossil, from the Baitoa and Cercado formations. The large lectotype was found presumably in the Gurabo formation. The occurrence in that formation was recorded by Maury.

A large broad-shouldered, low-spired, pyriform cone, collected by Gabb in the Dominican Republic, was named *C. williamgabbi* (Maury, 1917, p. 36, pl. 5, fig. 2). It is known to occur in the Baitoa formation. The Bowden formation of Jamaica yielded a similar pyriform species, *C. apium* (Woodring, 1928, p. 202, pl. 9, fig. 3), characterized by a low thread at the edge of the shoulder.

C. recognitus has an age range of late early Miocene to middle Miocene. As was recognized long ago, it has no living allies in Caribbean waters, but is similar to the eastern Pacific species *C. patricius* Hinds (Hanna, 1963, p. 49, pl. 8, pl. 10, figs. 4, 5), appropriately designated *C. pyriformis* by Reeve. Pilsbry pointed out that the tuberculate shoulder of *C. recognitus* disappears at an earlier stage than that of *C. patricius*. In fact, good preservation of the first few post-protoconch whorls is needed to show the early tuberculate shoulder of *C. recognitus*. The early tuberculate shoulder of *C. patricius* is well shown on Hinds' illustration of the type of that species, an immature shell (Hinds, 1844–45, p. 7, pl. 1, figs. 1, 2, 1844). The largest recorded *C. recognitus* is half as large as the exceptionally large *C. patricius* recently illustrated by Hanna (1963, pl. 8; height 140 mm). *C. patricius* is the type of the recently proposed subgenus *Pyruconus* (Olsson, 1967, p. 21).

Occurrence: Upper part of Gatun formation, western area (middle Miocene), locality 182. Baitoa formation (late early Miocene), Dominican Republic. Cercado and Gurabo formation (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Middle Miocene deposits, southeastern Costa Rica. Tubará formation (middle Miocene), Columbia.

Conus musaensis Olsson

Plate 57, figure 2

Conus musœnsis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 47, pl. 1, figs. 22, 24, 1922 (Miocene, Costa Rica).

Small, moderately wide at shoulder, shoulder rounded or subrounded at maturity. Spire of moderate height, its profile slightly concave. Protoconch conspicuous, slender, cylindrical, 1½–whorled. Early postprotoconch whorls sharply carinate at shoulder. Carina gradually suppressed with further growth. Anal fasciole flat. Lower half to two-thirds, or all (especially on immature shells), of body whorl sculptured with flat spiral bands, separated by generally narrower channels. Spiral bands of immature shells nonpustulose or weakly pustulose.

Height 20.6 mm, diameter 10 mm (figured specimen).

Type material: Lectotype (herewith designated), specimen represented by Olsson's fig. 24), Paleontological Research Inst. 20887.

Type locality: Río Banana, Limón Prov., Costa Rica, middle Miocene.

This small species occurs in the middle part of the Gatun formation west of Gatun Lake, where 19 specimens were collected. It is the first occurrence to be recorded outside the type area in southeastern Costa Rica. Immature shells are notably different from mature shells, owing to the carinate shoulder at an early stage.

The small size and general appearance suggest *C. jaspideus* Gmelin, of the present Caribbean fauna, especially the round-shouldered form, for which Reeve's name *C. pygmœus* is used, either as a subspecies of *C. jaspideus* (Clench, 1942, p. 12, pl. 7, figs. 1, 2), or as an infrasubspecific form of that species (Abbott, 1958, p. 89, pl. 3, fig. j). That the resemblance is superficial is indicated by the noncylindrical, more inflated protoconch and somewhat concave anal fasciole of *C. jaspideus*.

Occurrence: Middle part of Gatun formation, western area (middle Miocene), localities 161c, 161d, 170. Middle Miocene deposits, southeastern Costa Rica.

Conus spurius Gmelin

Plate 55, figure 7

Conus spurius Gmelin, Systema naturæ, 13th ed., p. 3396, 1791 (living, locality unknown). Clench, Johnsonia, v. 1, no. 6, p. 19, pl. 10, figs. 4, 5, 1942 (living, Bahamas, West Indies).

Conus proteus Hwass, variety B, *in* Bruguière, Encyclopédie méthodique, Histoire naturelle des vers, v. 1, p. 682, pl. 334, fig. 2, 1792 (living, West Indies). Pilsbry and Brown, Acad. Nat. Sci. Phila. Proc., v. 69, p. 32 (list), 1917 (Miocene, Colombia). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 42, pl. 6, fig. 11, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 331, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 43, pl. 2, figs. 3, 4, 1922 (Miocene, Costa Rica, Panamá).

Conus (*Lithoconus*) *proteus* Hwass, Woodring, Carnegie Inst. Washington Pub. 385, p. 204, pl. 9, fig. 4, 1928 (Miocene, Jamaica).

Conus leoninus Hwass, Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 359, 1881 (Pliocene, Costa Rica).

Of medium size and moderate width at shoulder, shoulder abruptly rounded. Spire low, practically flat-topped, except part formed by earliest whorls. Protoconch missing, earliest preserved whorls worn. Anal fasciole flat, bearing weak spiral threads on early unworn whorls. Color pattern consisting of well separated spiral rows of brownish rectangles, or crude rectangles, of uniform width in a row, but of varying width from row to row.

Height 45.8 mm, diameter 28.5 mm (figured specimen).

Type locality: Presumably West Indies, living.

Conus spurius, formerly designated *C. proteus*, is represented by one specimen collected at the Gatun Third Locks site. The anal fasciole, inside the slightly bulging shoulder, is not concave. Though it generally is concave on both living and fossil specimens, that feature is variable. The color pattern, though bleached, is preserved, as it generally is on fossil specimens of this species, which ranges back to at least middle Miocene. The color pattern of the Gatun fossil is like that of *C. spurius atlanticus* Clench (1942, p. 20, pl. 10, figs. 1–3), which was given a range extending from the west coast of Florida to Venezuela, along the continental border. The same pattern is shown by Miocene Jamaican shells, but is less distinct on the Jamaican specimen illustrated in 1928. Whatever may be decided about living shells, it is improbable that the color pattern can be used to distinguish geographic races in *C. spurius* of Miocene age.

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), locality 155. Middle Miocene deposits, southeastern Costa Rica, Colombia. Bowden formation (middle Miocene), Jamaica. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Deposits of late Miocene and Pliocene age, Bocas del Toro area, Panamá, Limón Peninsula, Costa Rica. Living, Florida, Bahamas, and West Indies.

Conus species

A small poorly preserved cone (restored height about 24 mm, diameter 13.5 mm) from the Caimito formation of the Gatun Lake area has a moderately low, evenly tapering spire and a wide shoulder. The shoulder is abruptly rounded and the anal fasciole is flat. A few low spiral threads are visible on the lower part of the body whorl. The outline is like that of *Conus* cf. *C. marginatus* Sowerby of Hubbard (1920, p. 162, pl. 24, fig. 16), which occurs in limestone of early Miocene age in Puerto Rico (Aymamón limestone of present terminology). *Conus marginatus* Sowerby (1850, p. 44; not *Conus marginatus* J. de C. Sowerby, 1840), as identified by Guppy (1876, p. 528, pl. 29, fig. 5), has relatively strong spiral sculpture on the body whorl.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 55b.

Conus bravoi Spieker

Plate 56, figures 10, 11

Conus molis var. *bravoi* Spieker, Johns Hopkins Univ. Studies in Geology, no. 3, p. 41, pl. 1, fig. 6, 1922 (Miocene, Perú).

Conus (*Dendroconus*) *bravoi* Spieker, Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 151, pl. 16, figs. 1, 3, 4, 1932 (Miocene, Perú). Marks, Idem, v. 33, no. 139, p. 137, 1951 (Miocene, Ecuador).

Conus molis Brown and Pilsbry, Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3, (Informe 1082), p. 294, pl. 12, fig. 8, 1960 (Miocene, Colombia).

Conus riosantiagensis Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 85, pl. 13, figs. 1, 1a, 1b, 1964 (Miocene, Ecuador).

Moderately large, broad-shouldered. Edge of shoulder marked by angulation, generally pronounced, but of varying strength. Spire low, profile smoothly conical, except part formed by strongly emerging early whorls. Protoconch missing. Early post-protoconch whorls worn, but showing suggestion of tuberculate shoulder. Succeeding whorls overlapping to edge of shoulder, or not quite to edge. Anal fasciole flat or somewhat concave, smooth (except for growth lines), or bearing faint to weak spiral threads. Spiral sculpture on lower part of body whorl faint or absent on mature shells, weak on immature shells.

Height (incomplete) 64 mm, diameter 44 mm (larger figured specimen). Height 59.4 mm, diameter 36.6 mm (smaller figured specimen).

Type: Peabody Museum, Yale University.

Type locality: Zorritos district, Perú, Zorritos formation.

This Peruvian and Ecuadorean species is fairly abundant in the lower part of the Gatun formation and is represented in the middle part by two specimens. Fourteen, ranging in height from 23.5 to 57 mm, were collected at locality 138e and 23 others at four other lower Gatun localities.

Conus bravoi may be recognized by its stubby low-spired outline, and flat or somewhat concave anal fasciole, which lacks spiral sculpture or is faintly to weakly sculptured. Three immature shells from locality 138c have a more distinctly concave anal fasciole than others. A few of the earliest post-protoconch whorls evidently have a tuberculate shoulder, but this feature is not clearly shown. The angulation at the shoulder is weak on the large specimen illustrated on plate 56, figure 11, as it is on *C. riosantiagensis*. It is also weak on the single specimen from the middle part of the Gatun. In the middle Miocene Tubará formation of Columbia *C. bravoi* reaches a height of 112 mm. Many of the specimens from that region have a faintly angulated, or even rounded shoulder.

A relatively elongate, moderately high-spired shell (locality 136a) is doubtfully referred to *C. bravoi*. The shoulder angulation is exposed on late spire whorls, but the overlap of the succeeding whorl is not uniform. This shell may be abnormal.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137a, 138c, 138e, 138f. Middle part, eastern area, localities 155, 159d. Tubará formation (middle Miocene), Colombia. Progreso and Angostura formations (middle Miocene), Ecuador. Zorritos, Cardalitos, and Montera formations (middle Miocene), Perú.

Conus acolus Woodring, n. sp.

Plate 55, figure 3

Small, broad-shouldered, edge of shoulder angulated. Spire of moderate height, profile evenly conical or almost evenly conical. Protoconch missing. Earliest post-protoconch whorls worn, shoulder angulation exposed on later whorls. Anal fasciole concave, marked only by growth lines. Lower part of body whorl sculptured with widely spaced spiral grooves.

Height 35 mm, diameter 20.8 mm (type).

Type: USNM 645741; 2 paratypes, Stanford University.

Type locality: 136a (Stanford University 2611, Transisthmian Highway, lat 9° 21′ N. plus 1,100 feet (335 meters); long 79° 49′ W., Panamá; same as USGS 16912), lower part of Gatun formation.

Conus acolus is a small species based on nine specimens in three collections from the lower part of the Gatun formation. It may be distinguished from immature shells of *C. bravoi*, with which it is associated, by its more evenly conical spire, more concave anal fasciole, and stronger spiral sculpture on the lower part of the body whorl.

C. cercadensis Maury (1917, p. 43, pl. 7, fig. 4; Cercado formation, Dominican Republic) has a more rounded shoulder; its late whorls overlap to the edge of the shoulder of the preceding whorl; and its spiral sculpture covers a larger part of the body whorl, although in reduced form. In outline *C. acolus* suggests a small version of *C. bermudensis* Clench (1942, p. 34, pl. 13, fig. 4), a living western Atlantic species from Bermuda and the east coast of Florida.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 136a, 138c. Middle Miocene deposits, Chiriquí area (USGS 7955, identification doubtful), Panamá.

Conus cf. C. sauridens Conrad

The silicified fossils of the Río Casaya area include a small incomplete, elongate, low-spired *Conus* that probably is allied to *C. sauridens*, a species of southeastern United States ranging in age from middle Eocene to early Oligocene (Palmer, 1937, p. 458, pl. 71). The shoulder is sharply carinate and the anal fasciole is concave. The sharply carinate shoulder shows on spire whorls. There is a suggestion of small tubercles on the shoulder of the earliest preserved whorls. No spiral sculpture is visible on the anal fasciole, but the granular silica is too coarse to reproduce low threads like those of *C. sauridens*. The restored height is 30 mm, the diameter 15 mm.

A similar late Eocene and late Eocene or early Oligocene cone from Perú has been named *C. chirœnsis* (Olsson, 1930, p. 39, pl. 5, figs. 1, 2, 4, 10). *C. chirœnsis*, treated as a subspecies of *C. sauridens*, has been identified in deposits of late Eocene age in Columbia (Clark, *in* Clark and Durham, 1946, p. 46, pl. 24, figs. 11, 16, 18, 19).

Occurrence: Gatuncillo formation, Río Casaya area (middle Eocene), locality 38.

Conus cf. C. sulculus Dall

The upper part of the Bohio formation on Barro Colorado Island and the Caimito formation at a nearby locality yielded poorly preserved remains of a small

species of *Conus*. It is fairly slender and has a sharply angulated shoulder. The spire is of moderate height and its profile is concave. Late whorls overlap to, or not quite to, the shoulder angulation. The anal fasciole is slightly concave and bears (at least on the specimen of best preservation) weak spiral threads. The largest of 14 specimens has an almost complete height of 22 mm and a diameter of 13 mm.

This unnamed species is smaller and more slender than *Conus sulculus* (Gardner, 1926–47, p. 359, pl. 43, fig. 3, 1938), of the early Miocene Chipola formation of Florida.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d. Caimito formation, Gatun Lake area (late Oligocene), localities 56, 57.

Conus cf. C. planiceps Heilprin

Four lots of poorly preserved small cones from the La Boca formation suggest a species similar to *Conus planiceps* Heilprin (1887, p. 110, pl. 15, figs. 48, 48a), of the early Miocene Tampa limestone of Florida. The late whorls form a low, almost flat-topped spire, from which the earliest preserved whorls (missing on many of the specimens) abruptly rise. The shoulder is broadly angulated and the whorls overlap to, or almost to, the shoulder. The anal fasciole is barely concave and is sculptured with weak spiral threads. The largest specimen has an estimated height of 32 mm and a diameter of 19.5 mm.

C. planiceps reaches a height of 46 mm. As noted by Mansfield (1937, p. 80), the shoulder of the specimen from Tampa illustrated by Dall in 1915, p. 37, pl. 6, figs. 1, 2) is sharply angulated and shows on spire whorls, but on other specimens in the same lot it is less sharply angulated and fails to show on spire whorls. Dall's 1890 illustrations (Dall, 1890–1903, p. 25, pl. 11, figs. 5, 5a, 1890) are poorly drawn or represent a different species. His brief remarks may be taken to indicate that the specimen was collected at Martin Station, Florida, by Willcox. Druid Wilson suggests that this fossil may be in the collections of the Philadelphia Academy of Natural Sciences.

A small cone from deposits of middle Miocene age in the Tehuantepec area of México, recently identified as *C. planiceps* (Perrilliat Montoya, 1963, p. 27, pl. 6, figs. 3, 10), was described as bearing small tubercles on the shoulder of early spire whorls. Such tubercles are absent on *C. planiceps*.

Occurrence: La Boca formation (early Miocene), localities 101h, 115a, 115b, 116a.

Conus molis Brown and Pilsbry

Plate 55, figures 8–10

Conus molis Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 343, pl. 23, fig. 1, 1911 (Miocene, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32 (list), 1917 (Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 42, pl. 2, figs. 1, 2(?), 1922 (Miocene, Costa Rica, Panamá, Canal Zone). Weisbord, Idem, v. 14, no. 54, p. 56, pl. 6, fig. 1, 1929 (Miocene, Colombia). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 109, 1929 (Miocene, Colombia).

?Conus molis Brown and Pilsbry, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 36, 1917 (Miocene, Dominican Republic).

Conus concavitectum Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 341, pl. 23, figs. 5, 6, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 43, 1922. (Miocene, Canal Zone, Panamá). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 110, 1929 (Miocene, Colombia).

Conus (Lithoconus) concavitectum Brown and Pilsbry, Cossmann, Jour. Conchyliologie, v. 61, p. 43, pl. 4, figs. 3, 4, 1913 (Miocene, Canal Zone).

?Conus domingensis Sowerby?, Brown and Pilsbry, Idem, p. 341, 1911 (Miocene, Canal Zone).

Not *Conus molis* Brown and Pilsbry, Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 294, pl. 12, fig. 8, 1960 (Miocene, Colombia); = *C. bravoi* Spieker.

Exceptionally large, elongate, moderately wide at shoulder. Edge of shoulder generally abruptly angulated. Spire of moderate height, its profile concave. Protoconch consisting of 2½ slightly bulging whorls. Early half of first post-protoconch whorl bearing axial riblets, angulated shoulder appearing on later half. Angulated shoulder of first five or six post-protoconch whorls exposed; first three or four slightly tuberculate. Anal fasciole generally concave, bearing spiral threads. Growth lines of fasciole generally exaggerated on some whorls. Lower part of body whorl, or entire whorl, bearing faint spiral sculpture, of decreasing distinctness upward. Spiral threads on lower part of very young shells faintly pustulose. Color pattern faintly showing on some immature shells, consisting of spiral rows of brownish crude rectangles, much like the pattern of *Conus spurius*.

Height (practically complete) 160 mm, diameter 90 mm (larger figured specimen).

Type: Princeton University.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Conus molis, based on a mature shell, is given precedence over *C. concavitectum*, the type of which is immature.

This large species—the largest American fossil species—is found throughout the Gatun formation. A total

of 67 specimens, ranging in height from 23.5 to about 180 mm, is available. The largest occur in the upper part of the formation. That shown on plate 55, figure 8, was collected in the western area. A still larger crushed shell from the eastern area would have a height of about 180 mm, if it were complete.

With the exception of two specimens, the basic features of these fossils are essentially uniform. The two exceptions are in a collection from the lower part of the Gatun (locality 136a). The shoulder of those specimens is less sharply angulated than that of the others and their anal fasciole is flat or almost flat. Though the shoulder and fasciole suggest *C. æmulator* (the next species described), these two fossils are larger than that species and have the elongate outline of *C. molis*.

The distribution of *C. molis* is clustered around the southeastern border of the Miocene Caribbean Sea: in Costa Rica, Panamá, and Columbia. It has a close Miocene ally in Ecuador and Perú: *C. cacuminatus* Spieker (1922, p. 40, pl. 1, fig. 5), which has more strongly tuberculate early whorls, a more deeply concave anal fasciole, and is not known to be of comparable size. *C. haytensis* Sowerby (Pflug, 1961, p. 60, pl. 16, figs. 1–5; Cercado and Gurabo formations, Dominican Republic) —the most similar fossil species in the West Indies— is wider at the shoulder, and has a less concave anal fasciole and more strongly tuberculate early whorls. It is likely that Maury's *C. molis* is an immature *C. haytensis*. On the contrary, Brown and Pilsbry's *C. haytensis* and *C. domingensis?*, both from the Gatun formation, are likely to be immature *C. molis*. The stubby outline and flat anal fasciole of the small middle Miocene Venezuelan cone identified as *C.* aff. *C. molis* (Jung, 1965, p. 575, pl. 78, figs. 1, 2) indicate that it is more similar to *C. æmulator* than to *C. molis*.

No similar species is living in the Caribbean Sea, but *C. fergusoni* Sowerby (Hanna, 1963, p. 42, pl. 4, fig. 2), living in the eastern Pacific Ocean, is closely allied, as pointed out by Hanna and Strong (1949, p. 295) and Hanna (1963, p. 44). Though the two species are similar in size and outline, the anal fasciole of *C. molis* is generally more concave and more strongly sculptured, and its early whorls are less distinctly tuberculate.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137a, 138c, 138d. Middle part, eastern area, localities 139e, 139f, 146, 147b (identification doubtful), 147f, 147h (identification doubtful), 151, 153, 155, 155a, 155b, 155c, 157, 158 (identification doubtful), 159, 159b. Upper part, eastern area, localities 171 (identification doubtful), 172, 175, 176a, 177, 177a, 177b, 177c; western area, locality 185. Middle Miocene, deposits, Costa Rica. Tubará formation (middle Miocene), Colombia. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Conus aemulator aemulator Brown and Pilsbry

Plate 55, figures 5, 6; plate 56, figures 4, 8

Conus æmulator Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 342, pl. 23, fig. 9, 1911 (Miocene, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32 (list), 1917 (Miocene, Colombia).

Not *Conus proteus æmulator* Brown and Pilsbry, Rutsch, Schweizer. Palæont. Gesell. Abh., v. 55, no. 1, p. 104, pl. 9, figs. 7–11, 1934 (Miocene, Venezuela); = *C. æmulator manzanillæensis* Mansfield.

Conus haytensis Sowerby, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 341, 1911 (Miocene, Canal Zone).

Conus veatchi Olsson, Bull. Am Paleontology, v. 9, no. 39, p. 44, pl. 2, figs. 5, 8, 1922 (Miocene, Panamá, Canal Zone). Woodring and Mansfield, *in* Geology of Republic of Haiti, p. 175, pl. 15, figs. 1, 2, 1924 (Miocene, Haiti). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 108, 1929 (Miocene, Colombia). Trechmann, Geol. Mag., v. 72, no. 858, p. 545, pl. 21, fig. 10, 1935 (Miocene, Carriacou). Olsson, Neogene mollusks of northwestern Ecuador, Paleontological Research Inst., p. 82, 1964 (Miocene, Ecuador).

?*Conus* sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 710, pl. 25, fig. 18, 1909 (Miocene, Canal Zone). Engerrand and Urbina, Soc. Geol. Mexicana Bol., v. 6, pl. 58, fig. 16, 1910 (reproduction of Toula's illustration).

Of medium size, stubby, wide at shoulder. Edge of shoulder angulated. Spire low, practically flat-topped, except part formed by earliest whorls. Protoconch and earliest post-protoconch whorls not well preserved. Angulated shoulder of first three or four post-protoconch whorls exposed; the shoulder slightly tuberculate. Anal fasciole practically flat or slightly concave, bearing spiral threads. Lower part of body whorl bearing weak spiral sculpture; the threads faintly pustulose on very young shells.

Height 45 mm, diameter 28 mm (larger figured specimen).

Type: Acad. Nat. Sci. Phila. 1691.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The moderate size, stubby outline, flat-topped late spire whorls, and spirally sculptured anal fasciole are diagnostic features of *Conus æmulator*. The type (pl. 55, figs. 5, 6), photographed by A. A. Olsson, is immature (height 22.7 mm) and therefore does not show the flat-topped late spire whorls. The largest specimen examined (height 59 mm) was found on Río Chico, in Darién (USGS 8433). The less elongate outline, flat-topped late spire whorls, and flatter anal fasciole distinguish mature shells of *C. æmulator* from immature shells of *C. molis*. The two species are associated at many localities and in many features are similar.

C. æmulator is fairly widespread in the Gatun formation, but so far has not been found in the upper part of the formation in the eastern area. The 42 available specimens are essentially uniform, with the exception of two from the upper part of the Gatun in the western area—the only specimens in the upper Gatun collections. The edge of the shoulder of those two shells is less sharply angulated than that of the others. Toula's *Conus* sp. is missing in his collection. His illustration suggests an immature *C. æmulator*.

This species has a wider distribution than *C. molis* and, unlike *C. molis*, occurs on both sides of Central America. It has also a greater time range: late early to late Miocene. *C. manzanillæensis* Mansfield (1925, p. 12, pl. 2, figs. 5, 10; San José calcareous silt member of Manzanilla formation, Trinidad), is assigned to subspecific rank under *C. æmulator*. It is smaller than the nominate subspecies and has faintly pustulose spiral sculpture on the lower part of the body whorl, like immature specimens of the nominate subspecies. The anal fasciole of the type is very weakly sculptured, but the sculpture is stronger on other specimens. The largest in a collection of three (height 36 mm) from the San José calcareous silt member on Guaracarita River (USGS 21098) is high-spired, like Rutsch's Venezuelan specimens.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 138, 138a, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139c, 139e, 139f, 147h, 155, 155a, 155b, 155c, 159, 159d, 160 (identification doubtful). Upper part, western area, locality 182. Baitoa formation (early Miocene), Dominican Republic. Thomonde formation (early Miocene), Haiti. Deposits of early Miocene age, Carriacou, Grenadine Islands. Deposits of early(?) Miocene age, Ecuador. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Tubará formation (middle Miocene), Colombia. Middle Miocene deposits, Darién area (USGS 8429, 8433, 8477, 8479, 8492), Panamá. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Conus cf. C. catenatus Sowerby

Small, moderately slender, angulated at shoulder. Spire high, its profile concave. Angulated and tuberculate shoulder appearing on first post-protoconch whorl. Tubercles gradually disappearing on third whorl. Last few whorls overlapping almost to shoulder of preceding whorl. Anal fasciole flat or slightly concave, bearing weak spiral threads or none. Spiral sculpture of body whorl weak, faintly to distinctly pustulose or nonpustulose.

Height 25.7 mm, diameter 12 mm (largest specimen).

Four small cones in two collections from the Gatun Third Locks site are identified as *Conus* cf. *C. catenatus*. Without much doubt they are immature. In some features they suggest *C. catenatus* (Pilsbry, 1922, p. 328, pl. 22, figs. 3, 4; Woodring, 1928, p. 213, pl. 11, figs. 4, 5), a middle Miocene species from the Dominican Republic and Jamaica. At the growth stage represented by the last few whorls of the Gatun fossils the shoulder of *C. catenatus* is not as strongly angulated.

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), localities 155, 155a.

Conus consobrinus consobrinus Sowerby

Plate 56, figures 3, 7, 9

Conus consobrinus Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 45, 1850 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 39, pl. 6, figs. 5, 6, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 330, pl. 20, figs. 7, 7a, 7b, 1922 (Miocene, Dominican Republic).

Conus (Leptoconus) consobrinus Sowerby, Woodring, Carnegie Inst. Washington Pub. 385, p. 214, pl. 11, figs. 6, 7, 1928 (Miocene, Jamaica). Perrilliat Montoya, México Univ. Nac., Inst. Geología Paleontología Mexicana, no. 8, p. 26, pl. 4, figs. 3, 4, 1960 (Miocene, México). Pflug, Acta Humboldtiana, Geol. Palæontologica Ser., no. 1, p. 62, pl. 17, figs. 1–10, 1961 (Miocene, Dominican Republic).

?Conus consobrinus Sowerby?, Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 111, 1929 (Miocene, Colombia).

Not *Conus consobrinus* Sowerby, Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 359, 1881 (Pliocene, Costa Rica); = *C. consobrinus ultimus* Pilsbry and Johnson.

Not *Conus consobrinus* Sowerby, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 341, 1911 (Miocene, Canal Zone); = *C. tortuosostriatus* Toula.

Not *Conus (Chelyconus) consobrinus* Sowerby, Cossmann. Jour. Conchyliologie, v. 61, p. 46, pl. 3, figs. 17, 18, 1913 (Miocene, Martinique).

Conus (Conospira) lavillei Cossmann, Jour. Conchyliologie, v. 61, p. 38, pl. 4, figs. 1, 2, 1913 (Miocene, Canal Zone).

Conus granazonatoides Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 39, pl. 6, fig. 7, 1917 (Miocene, Dominican Republic).

Of medium size, elongate, moderately wide at shoulder. Shoulder sharply angulated. Anal fasciole slightly sloping, producing an almost square shoulder. Spire high and its profile almost smoothly conical, or moderately high and its profile slightly concave. Protoconch and earliest post-protoconch whorls missing. Shoulder of all except last, or last two, spire whorls strongly tuberculate; tubercles gradually disappearing. Anal fasciole concave, bearing faint or distinct spiral threads. Lower part of body whorl weakly sculptured; the threads faintly pustulose on immature shells.

Height 61.7 mm, diameter 30.3 mm (larger figured specimen).

Type material: Lectotype, British Museum (Natural History) G83962.

Type locality: Valley of Río del Norte, Dominican Republic, Miocene.

Conus consobrinus consobrinus has a meager representation in the Gatun formation: two specimens from the lower part, two from the middle part, and one from the upper part in the western area. Cossmann's *C. lavillei*, collected along the canal at Mindi, where the upper part crops out, is identified as an exceptionally slender, immature specimen of this form. The two shells from the lower part, one of which is shown on plate 56, figures 3, 7, and one from a horizon near the base of the middle part are relatively low-spired—an exceptional feature. The large shell from the middle part in the western area (pl. 56, fig. 9) is the only one that is fully mature. Its spire is somewhat worn. Gatun specimens are almost square-shouldered, as are most others from mainland localities. Those from Jamaica are round-shouldered and so are most of those from the Dominican Republic.

Bose's illustration of the Mexican *C. scaliæ* (Böse, 1906, p. 51, pl. 5, figs. 41, 42) suggests an immature *C. consobrinus*. His type (height 15.2 mm), however, lacks spiral sculpture on the anal fasciole. That *C. consobrinus consobrinus* is found in deposits of middle Miocene age in the Tehuantepec area is shown by Perillat Montoya's illustration and by a specimen in the collections of the U. S. National Museum (USGS 10346).

The high, or moderately high, strongly tuberculate spire is a diagnostic feature of *C. consobrinus*. The type material (lectotype) has been designated and illustrated recently by Pflug. The nominate subspecies occurs in deposits of middle Miocene age. The lineage is continued by an almost square-shouldered form that has a tuberculate shoulder throughout, even on the body whorl of specimens that have a height of 50 mm. This form is *C. consobrinus ultimus* Pilsbry and Johnson (Pilsbry, 1922, p. 330, pl. 20, fig. 8). It first appears in the late Miocene Limón formation of southeastern Costa Rica and continues in the Pliocene Moín formation of that area. *C. torœnsis* Olsson (1922, p. 48, pl. 2, fig. 7) may be treated as a weakly sculptured late Miocene subspecies. *C. emersoni* Hanna (1963, p. 25, pl. 1, fig. 2), dredged off Cape San Lucas, Baja California, is probably a descendant of *C. consobrinus*. It is round-shouldered and lacks tubercles on the shoulder of the body whorl, and therefore is similar to *C. consobrinus consobrinus*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 139d; western area, locality 161b. Upper part, eastern area, Cossmann's record; western area, locality 185. Middle Miocene deposits, Darién area (small race, USGS 8430, 8477), Panamá. Agueguexquite formation (middle Miocene), Tehuantepec area, México. Bowden formation (middle Miocene) Jamaica. Gurabo formation (middle Miocene), Dominican Republic.

Conus symmetricus Sowerby

Plate 57, figures 13, 14

Conus symmetricus Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 44, pl. 9, fig. 1, 1850 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 36, pl. 7, figs. 7, 7a, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 328, pl. 20, figs. 2, 2a, 2b, 1922 (Miocene, Dominican Republic). Not *Conus symmetricus* Sandberger, 1862.

Conus (*Leptoconus*) *symmetricus* Sowerby, Pflug, Acta Humboldtiana, Geol. Paleontologica Ser., no. 1, p. 63, pl. 18, figs. 1–11, 1961 (Miocene, Dominican Republic).

Conus symmetricus semiobsoletus Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 37, pl. 7, fig. 8, 1917 (Miocene, Dominican Republic).

Conus symmetricus domingensis Sowerby, Sowerby, Maury, Idem, p. 37, pl. 4, fig. 10 (Miocene, Dominican Republic).

?Conus (*Lithoconus*) sp., Woodring, Carnegie Inst. Washington Pub. 385, p. 204, 1928 (Miocene, Jamaica).

Small, wide at shoulder, shoulder sharply angulated. Spire low, its profile slightly concave. Protoconch worn, consisting of about two whorls. Earliest postprotoconch whorls somewhat worn. Shoulder of about first three exposed, obscurely tuberculate. Later whorls overlapping to shoulder of preceding whorl. Anal fasciole flat, or almost flat, sculptured with spiral threads. Body whorl sculptured with primary and secondary spiral threads. Primary threads bearing pustules, arranged in axial series, or not so arranged.

Height 20.4 mm, diameter 11.8 mm (figured specimen).

Type material: Lectotype, British Museum (Natural History) G83696.

Type locality: Valley of Río Yaque del Norte, Dominican Republic, Miocene.

Two specimens, both immature and both collected at the Gatun Third Locks site, are referred to this small, broad-shouldered, delicately sculptured, pustulose species. The larger of the two is illustrated. On the early part of the body whorl of this specimen slight swelling along the alinement of the pustules produces slight axial wrinkles.

Though the unidentified *Conus* from Bowden, Jamaica, may be a corroded *Conus symmetricus*, this is the first unequivocal record for that species beyond the Dominican Republic, where it is abundant in the Gurabo formation. Sowerby's illustration is unmistakable.

Pflug recently designated and illustrated the lectotype. For the most part height at maturity is not more than 35 mm. On the largest shells (height about 40 mm) the sculpture fades out on the upper part of the body whorl: Maury's *C. symmetricus semiobsoletus*. The spire is low and may be so low that the shell is almost flat-topped: Maury's *C. symmetricus domingensis*. Pflug (1961, p. 61) preferred to hold in abeyance designation of a lectotype of *C. domingensis* Sowerby (1850, p. 45).

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), localities 155a, 155c. Gurabo formation (middle Miocene), Dominican Republic.

Conus taphrus Woodring, n. sp.

Plate 57, figures 1, 7

Small, moderately wide at shoulder, edge of shoulder angulated. Protoconch and earliest post-protoconch whorls missing. Earliest preserved whorls carinate and obscurely tuberculate; tubercles obscure owing to wear. Succeeding whorls overlapping to edge of shoulder of preceding whorl, bearing a narrow channel adjoining suture. Anal fasciole flat, bearing growth threads and microscopic spiral lineation. Lower part of body whorl weakly sculptured. Entire whorl showing microscopic spiral lineation.

Height (almost complete) 28.2 mm, diameter 15 mm (type).

Type: USNM 645748.

Type locality: 161d (USGS 8366, Cuts west of Gatun Dam, station 3a, Canal Zone), middle part of Gatun formation.

The type—the only specimen—was collected at a locality in the middle part of the Gatun formation west of Gatun Dam. Though it may not be mature, the sutural channel is a distinctive feature.

Occurrence: Middle part of Gatun formation, western area (middle Miocene), locality 161d.

Conus aff. C. chipolanus Dall

Formations of late Oligocene and early Miocene age yielded 19 cones of minute, small, or medium size: nine from the upper part of the Bohio formation of Barro Colorado island, one from the Caimito formation of the Gatun Lake area, one from the Culebra formation, and eight from the La Boca formation. The Bohio fossils are minute shells, three of which show a slender protoconch of three whorls. If the first few post-protoconch whorls are sculptured, the sculpture is obscure. A carinate shoulder appears at an early stage and shows on the remaining whorls of the high spire. One of the La Boca specimens shows a similar crushed protoconch. The lower part of the body whorl of all these fossils bears distinct spiral sculpture. The largest, the Culebra specimen (locality 104b) has an almost complete height of 31.3 mm and a diameter of 15.2 mm. Its shell material, like that of the others, is replaced by calcite.

Though these fossils are unsatisfactory, they are allied to *C. chipolanus*, which is discussed under the next heading, and show that in the Canal Zone the lineage of *C. imitator* (the next species described) extends back to late Oligocene time. Similar small cones occur in deposits of late Oligocene age in Florida and Alabama: Mansfield's *C.* aff. *C. imitator* (Mansfield, 1938, p. 101, fig. 4; 1940, p. 203). In southeastern United States, however, the lineage is unknown later than early Miocene time.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d. Caimito formation, Gatun Lake area (late Oligocene), locality 56. Culebra formation (early Miocene), locality 104b. La Boca formation (early Miocene), localities 101h, 115a, 116a.

Conus imitator imitator Brown and Pilsbry

Plate 55, figures 1, 2

Conus imitator Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 342, pl. 23, fig. 4, 1911 (Miocene, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32, 1917 (list, Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 45, pl. 2, fig. 6, 1922 (Miocene, Canal Zone, Panamá, Costa Rica). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 327, 1922 (Miocene, Dominican Republic). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 108, 1929 (Miocene, Colombia). Perrilliat Montoya, México Univ. Nac., Inst. Geología, Paleontología Mexicana, no. 14, p. 27, pl. 6, figs. 6, 7, 1963 Miocene, México). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 295, pl. 12, fig. 6, 1960 (Miocene, Colombia).

Not *Conus imitator* Brown and Pilsbry, Li, Geol. Soc. China Bull., v. 9, p. 275, pl. 8, figs. 72 (mislabelled 70), 72a, 1930 (Miocene, Panama Bay; = *C. mahogani* Reeve, fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 434, 1931, living, Panama Bay).

Conus (*Leptoconus*) *imitator lius* Woodring, Carnegie Inst. Washington Pub. 385, p. 209, pl. 10, figs. 5, 6, 1928 (Miocene, Jamaica).

?Conus cf. *imitator lius* Woodring, Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 84, 1964 (Miocene or Pliocene, Ecuador).

Conus dalli Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 509, pl. 31, fig. 23a–d, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 48, pl. 7, fig. 15, 1917 (Miocene, Dominican Republic). Alancáster-Ibarra, Asoc. Mexicana Geólogos Petroleros Bol., v. 2, p. 570, fig. 17, 1950 (Miocene, México). Not *Conus dalli* Stearns, 1873.

Conus (*Lithoconus*) *dalli* Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 41, pl. 3, figs. 30, 31, pl. 4, figs. 7, 8, 1913 (Miocene, Canal Zone).

Of medium size, moderately wide at shoulder, shoulder strongly carinate. Spire high, its profile almost

smoothly conical. Protoconch slender, consisting of three whorls, slightly enlarging in diameter. Earliest part of first post-protoconch whorl bearing one or several axial riblets, followed by appearance of carinate shoulder, generally tuberculate on first three or four whorls. Tubercles axially compressed and extending in diminished form to suture of succeeding whorl. Tubercles rarely absent or practically absent. Except on earliest whorls, succeeding whorl generally missing carinate shoulder by a considerable margin; rarely just missing it. Anal fasciole distinctly concave to almost flat, bearing faint microscopic spiral sculpture and conspicuous growth threads, exaggerated at fairly regular intervals, especially on early whorls. Lower part of body whorl bearing fairly strong or strong spiral sculpture. On immature shells spiral sculpture generally limited to lower part of whorl, rarely extending in subdued form to shoulder.

Height 49 mm, diameter 23.7 mm (largest specimen in collections at Washington). Height 45.4 mm, diameter 22 mm (larger figured specimen).

Type: Acad. Nat. Sci. Phila. 1688.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Conus imitator imitator occurs throughout the Gatun formation and its range may continue into the Chagres sandstone. The one Chagres specimen is too incomplete for unequivocal identification. Seventy of these cones are available. The largest (height 55 mm), in Thompson's collection at Balboa, was found in the middle part of the Gatun at locality 155, the largest number (20) in the upper part in the eastern area at locality 177b. As was evident from his illustrations, Toula's *C. dalli*, a junior homonym, is *C. imitator imitator*. The specimen (height 26.7 mm, diameter 12.2 mm) shown in his figure 23b is herewith designated the lectotype.

Forty-five of these fossils show the early post-protoconch whorls, which are tuberculate on all except four. On the four exceptions the tubercles are absent, although a few faint axial riblets are discernible on the earliest part of the first of these whorls. The nontuberculate shells were collected at lower Gatun localities. On the contrary, four other lower Gatun shells, one of which is shown on plate 55, figure 2, are tuberculate. The Miocene Jamaican *C. imitator lius* was named on the grounds that it is nontuberculate—grounds that are unacceptable on the basis of the Gatun samples. As a matter of fact, Olsson (1922, p. 154) reported that Jamaican specimens in his collection are tuberculate. The Ecuadoran fossils identified as *C.* cf. *C. lius* are poorly preserved.

The overlap of whorls on the preceding whorl is of variable extent. The carina on the shoulder of the preceding whorl is generally missed by a considerable margin, but it may be just missed. The overlap difference is slight in vertical dimension, but the effect on spire profile is pronounced. The sculpture on the lower part of the body whorl consists of narrow grooves separating wider bands, or of narrow threads separated by wider spaces. The threads are flat or slightly shelflike.

C. imitator imitator may be recognized by its slender, cylindrical protoconch, moderate size, sharply carinate shoulder, strong growth threads on the anal fasciole, emphasized at fairly regular intervals, and distinct spiral sculpture on the lower part of the body whorl. It is inferred to be descended from *C. chipolanus* Dall (Gardner, 1926–47, p. 360, pl. 43, fig. 6, 1938), or from the late Oligocene and early Miocene form identified as *C.* aff. *C. chipolanus*. It is found along the west and south borders of the present Caribbean Sea in deposits of middle and late Miocene age, and in the middle Miocene of the Darién area, Jamaica, and the Dominican Republic. *C. sophus* Olsson (1932, p. 154, pl. 16, figs. 6, 8, 9; middle Miocene, Perú and Ecuador) may be treated as a small (height 15 to 32 mm) subspecies of *C. imitator*. The early postprotoconch whorls are nontuberculate (Olsson, 1932, p. 154) or only the first is tuberculate (Olsson, 1964, p. 85). A still smaller subspecies (height 8 mm), which is nontuberculate and has a 2–whorled protoconch, is found in the early Miocene Baitoa formation of the Dominican Republic and the equivalent Thomonde formation of Haiti. *C. springvalensis* Mansfield (1925, p. 11, pl. 1, figs. 3, 6; upper Miocene, Trinidad) is considered to be a slightly tuberculate or nontuberculate subspecies of *C. imitator* that lacks exaggerated growth threads on the anal fasciole and is consistently sculptured with narrow grooves on the lower part of the body whorl. The type is immature and poorly preserved. The weakly denticulate carina mentioned by Mansfield is the result of corrosion.

C. aff. *C. imitator* (Jung, 1965, p. 579, pl. 78, fig. 12; middle Miocene, Venezuela), which has a strongly flaring outer lip and heavy shoulder carina, is not closely related to *C. imitator*.

The *C. chipolanus-imitator* lineage can be traced with reasonable assurance to *C. arcuatus* Broderip and Sowerby (Hanna, 1963, p. 40, pl. 3, figs. 4–6), now living at moderate depths (15 to 50 fathoms) in the eastern Pacific Ocean, from the Gulf of California to Panamá. *C. arcuatus* tends to be more slender and to have a higher spire and more steeply sloping anal fasciole. A complete protoconch of the living species is not available, but the last whorl of the protoconch suggests that it is slender.

C. imitator imitator is more similar to *C. arcuatus* than to the western Atlantic species *C. floridanus* Gabb (Clench, 1942, p. 27, pl. 13, figs. 1, 2). Late whorls of the western Atlantic species overlap to the carina of the preceding whorl or reach it, and the anal fasciole of late whorls is flat or practically flat; the protoconch is blunt and 1½–to 2–whorled. A small middle Miocene Costa Rican form has been named *C. floridanus costaricensis* (Olsson, 1922, p. 45, pl. 3, figs. 3, 9). In the type region it is associated with *C. imitator imitator*. Very young specimens of the two species may be distinguished by their protoconchs. Perhaps *C. floridanus* represents a branch of the *chipolanus-imitator* lineage adapted to shallower water than *C. arcuatus:* a few fathoms to 25 fathoms, exceptionally up to 40 fathoms. Since Miocene time *C. floridanus*, like *Antillophos candei* (p. 265), has withdrawn northward from the Caribbean Sea.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 137a, 138c, 138d, 138f. Middle part, eastern area, localities 155, 155a, 155b, 159, 159d; western area, locality 161a. Upper part, eastern area, localities 171, 172, 173, 175, 177, 177a, 177b, 177d, 178; western area, locality 182. Chagres sandstone (late Miocene), locality 208 (*Conus imitator?*). Middle Miocene deposits, southeastern Costa Rica, Tehuantepec area, México, Colombia, Darién area (USGS 8477), Panamá. Bowden formation (middle Miocene), Jamaica. Cercado and Gurabo formations (middle Miocene), Dominican Republic). Limón formation (late Miocene), Bocas del Toro area, Panamá, Limón Peninsula, Costa Rica.

Conus multiliratus multiliratus Böse

Plate 57, figures 3, 4

Conus agassizi multiliratus Böse, Inst. Geol. México Col. 22, p. 49, pl. 5, figs. 34–38 (*multistriatus* in explanation of plate), 1906 (Miocene, México).

Conus (Leptoconus) multiliratus Böse, Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 139, 1951 (Miocene, Ecuador).

conus multistriatus Böse, Olsson, Idem. v. 9, no. 39, p. 54, pl. 1, figs. 21, 23, 1922 (Miocene, Panamá).

Conus gaza Johnson and Pilsbry, *in* Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 342, pl. 23, figs. 2, 3, 1911 (Miocene, Dominican Republic, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32 (list), 1917 (Miocene, Colombia). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 46, pl. 7, fig. 12, 1917 (Miocene, Dominican Republic).

Not *Conus multiliratus gaza* Johnson and Pilsbry, Spieker, Johns Hopkins Univ., Studies in Geology, no. 3, p. 37, 1922 (Miocene, Perú).

Conus (Leptoconus) multiliratus gaza Johnson and Pilsbry, Woodring, Carnegie Inst. Washington Pub. 385, p. 212, pl. 11, fig. 3, 1928 (Miocene, Jamaica). Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 626, pl. 29, fig. 30, 1939 (Miocene, Colombia).

Conus (Leptoconus) planiliratus Sowerby, Cossmann, Jour. Conchyliologie, v. 61, p. 48, pl. 3, figs. 24–26 (not fig. 27; = *C. planiliratus* Sowerby), 1913 (Miocene, Canal Zone, Jamaica).

Conus marginatus Sowerby, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 46, pl. 7, fig. 11, 1917 (Miocene, Dominican Republic).

Small, biconical, wide at shoulder, shoulder strongly carinate. Spire high, its profile almost smoothly conical. Protoconch slender, cylindrical, 2½– to 3–whorled. Earliest part of first post-protoconch whorl bearing three to five axial riblets, followed by appearance of carinate shoulder, tuberculate on about first three whorls. Except on earliest whorls, succeeding whorl overlapping almost to carina. Anal fasciole slightly concave, bearing growth threads exaggerated at fairly regular intervals. Entire body whorl sculptured with strong, narrow, straplike spiral cords. On unworn shells exaggerated axial growth threads conspicuous in channels between cords, weaker or absent on cords themselves. Cords of immature shells rarely bearing low tubercles.

Height (almost complete) 27.2 mm, diameter 14.4 mm (figured specimen).

Type: Apparently lost, but may eventually be found at the Instituto de Geología, Universidad Nacional de México.

Type locality: Tuxtepec, Oaxaca, México, Miocene.

Though this strongly sculptured cone occurs in the three divisions of the Gatun formation—but not in the upper part in the western area—more than one or two specimens were collected at only two localities: nine at locality 138c and 10 at locality 139c. It is characterized by its broad-shouldered, biconical outline, and exaggerated growth threads on the anal fasciole and in the channels between the straplike spiral cords. The protoconch and spire whorls are like those of *Conus imitator imitator*, except that spiral threads are not discernible on the anal fasciole. One immature shell (height 17.8 mm, locality 138c) shows low tubercles on the spiral cords.

Contrary to the view that was adopted in 1928, *C. gaza* is treated as a synonym of *C. multiliratus multiliratus*. Though no specimens of the nominate subspecies are available, Böse's illustrations show the essential features of *C. gaza*. *C. multiliratus multiliratus* is recognized in middle Miocene formations in the Tehuantepec area, Panamá, northeastern and southwestern Columbia, Jamaica, the Dominican Republic, and possibly in Ecuador, and in deposits of late Miocene age in northwestern Panamá. A comparable form of the species, perhaps the same as that in Ecuador, occurs in the middle Miocene of the Darién area. It lacks strong growth threads between the spiral cords, but the ab-

sence of that feature may be a matter of preservation and perhaps should not be overemphasized.

C. multiliratus walli Mansfield (1925, p. 13, pl. 2, figs. 1, 9; middle Miocene part of Brasso formation) may be recognized as a Trinidad race that is not as broad-shouldered as the nominate subspecies. The type, which is somewhat worn, and the other shells in the type lot show scattered low tubercles on the spiral cords and slight undulations on the shoulder carina of the body whorl. Spieker's two specimens from the Zorritos formation of Perú, identified as *C. multiliratus gaza*, are no longer available. When they were examined many years ago they were found to have weaker spiral cords and less distinct growth threads than *C. multiliratus multiliratus*. *C. multiliratus spiekeri* Olsson (1932, p. 153, pl. 16, figs. 5, 7), also from the Zorritos formation, is sculptured with heavy tuberculate spiral cords and may be given specific rank. *C. turbinopsis* Gardner (1926–47, p. 361, pl. 43, fig. 12, 1938; Shoal River formation, Florida) has a turbinate outline and less conspicuous growth threads between the spiral cords. It has been identified in the Tehuantepec area (Perrilliat Montoya, 1960, p. 27, pl. 4, figs. 5, 6).

C. clarki Rehder and Abbott (1951, p. 22, fig. 6), dredged off Louisiana at a depth of 29 fathoms, is sculptured with exaggerated growth threads on the anal fasciole and between the spiral cords. Its outline, however, is turbinate and the shoulder of all the post-protoconch whorls is tuberculate. *C. frisbeyæ* Clench and Pulley (Clench, 1953, p. 369, pl. 184, fig. 1; Campeche Banks, Yucatan) evidently is *C. clarki*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d. Middle part, eastern area, localities 139c, 139e, 151, 159d. Upper part, eastern area, localities 173, 175, 176, 176a. Middle Miocene deposits, Tehuantepec area, México, northeastern and southwestern Columbia. Bowden formation (middle Miocene), Jamaica. Cercado and Gurabo formations (middle Miocene). Dominican Republic. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Conus burckhardti burckhardti Böse

Plate 57, figures 19, 20

Conus burckhardti Böse, Inst. Geol. México Bol. 22, p. 50, pl. 5, figs. 39, 40, 1906 (Miocene, México). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 224, pl. 3, figs. 4, 5, 1922 (Miocene, Panamá, Costa Rica). Maury, Idem, v. 10, no. 42, p. 187, pl. 34, fig. 5, 1925 (Miocene, Trinidad). Rutsch, Schweizer. Palæont. Gesell. Abh., Band 55, no. 1, p. 102, pl. 4, figs. 3, 4, 1934 (Miocene, Venezuela).

?Conus burckhardti Böse?, Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 110, 1929 (Miocene, Colombia).

?Conus burckhardti Böse, Alenchaster-Ibarra, in Masson and Alencaster-Ibarra, Asoc. Mexicana, Geölogos Petroleros Bol., v. 3, p. 210, fig. 25, 1951 (Miocene, México). Alencaster-Ibarra, in Ríos Macbeth, Idem, vol. 4, p. 347 (list), pl. 21, figs. 14, 15, 1952 (Miocene, México).

?Conus (Leptoconus) burckhardti Böse, Perrilliant Montoya, México Univ. Nac., Inst. Geología Paleontología Mexicana, no. 8, p. 26, pl. 3, figs. 20, 21, 1960 (Miocene, México).

Conus tortuosopunctatus Toula, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 54, pl. 3, figs. 6, 11, 1922 (Miocene, Canal Zone).

Of medium size, moderately slender, high-spired. Shoulder moderately carinate. Outline of spire smoothly conical, except part formed by earliest whorls. Protoconch slender, 2¾- to 3-whorled. Early half of first post-protoconch whorl sculptured with arcuate axial riblets. Carinate and tuberculate shoulder appearing on late half of first whorl. Tubercles gradually disappearing on second to fourth whorl. Carinate shoulder exposed on spire whorls; generally just exposed on late whorls of mature shells. Anal fasciole slightly concave, bearing exaggerated growth threads at fairly regular intervals and faint spiral lineation, or more distinct, though faint, spiral striæ. Body whorl sculptured with moderately wide, straplike spiral cords, wider on upper part of whorl than on lower part, separated by channels, narrower on upper part than on lower. Variable number of spiral cords, ranging from a few at base to those on lower half or more of body whorl, weakly tuberculate. Tubercles located on posterior part of wide cords, extending practically across narrow cords. Channels between cords bearing closely spaced exaggerated axial growth threads, producing a punctate effect in narrow channels.

Height (practically complete) 42.3 mm, diameter 17.7 mm (larger figured specimen). Height (practically complete) 33.7 mm, diameter 14.8 mm (small figured specimen).

Type: Instituto de Geología, Universidad Nacional de México.

Type locality: Tuxtepec, Oaxaca, México, Miocene.

Thirty cones from 10 localities in the Gatun formation are identified as *Conus burckhardti burckhardti*: 22 from the middle part, four from the upper part in the eastern area, and four from the upper part in the western area. Though they have the same plan of outline and sculpture, they present a considerable range of variation, chiefly affecting the sharpness of the shoulder carina, the absence or presence of spiral striæ on the anal fasciole, and the development of tubercles on the spiral cords. One shell from the upper part of the Gatun in the eastern area and another

from the upper part in the western area have distinct, though faint, spiral sculpture on the anal fasciole. The strongest tubercles—strong on all the spiral cords—is shown by an immature shell (height 23.7 mm) found in the upper part in the eastern area. The protoconch and spire whorls are like those of *C. imitator imitator* and *C. multiliratus multiliratus*.

The type of *C. burkhardti* is moderately slender and immature (height 27.3 mm, diameter 10.5). Immature Gatun shells and three small shells (largest, height 18.8 mm, diameter 7.9 mm) in Perrilliat Montoya's lot, collected 200 kilometers east of the type locality, agree well with it. All the larger specimens in Perrilliat Montoya's collection, however, are less slender and their spiral bands, beginning with that below the shoulder are tuberculate, as shown in her illustrations. If the type represents a cone that develops into this stubby tuberculate form, *C. burckhardti burckhardti* is not a suitable name for the Gatun fossils. Mature shells from the type locality are needed.

Beyond the type region *C. burckhardti burckhardti*, as identified in the present report, has been recognized in middle Miocene formations in southeastern Costa Rica, Panamá, possibly Colombia, and Trinidad, and in deposits of late Miocene age in the Bocas del Toro area, Panamá, and Venezuela. Cossmann's illustration of *C. marginatus boussaci* (Cossmann, 1913, p. 46, pl. 3, fig. 16) indicates the occurrence of a similar cone in the Miocene of Martinique.

C. harveyensis Mansfield (1930, p. 33, pl. 1, fig. 12; upper Miocene, Florida) lacks tubercles on the carina of early post-protoconch whorls and on the body-whorl spiral cords. The type—evidently the only specimen—is small (height 20.9 mm). The type of *C. corrugatus* Gardner (1926–47, p. 360, pl. 43, fig. 9, 1938; lower and middle Miocene, Florida; not *C. corrugatus* Sowerby, 1870) is even smaller (height 15.5 mm), but the largest of some 100 topotypes is comparable in size to the type of *C. harveyensis*. It is doubtful whether these two species are distinguishable. Though Gardner's name is a junior homonym, a substitute name should not be proposed for it without adequate study of the available material.

Though *C. burckhardti burckhardti* is more similar to the eastern Pacific species *C. tornatus* Broderip (Hanna, 1963, p. 39, pl. 7, figs. 10–13) than to any known to be living in the Caribbean region, the similarity—and presumably the relationship—is not close. The overlap of the late whorls of *C. burckhardti burckhardti* is greater and its anal fasciole is flatter.

C. tortuosopunctatus Toula (1911a, p. 507, pl. 31, fig. 20) is rejected as a Gatun fossil. The type is a chalky shell and the matrix in and near the aperture consists of quartz grains. Both the type of preservation and the matrix, as well as the species itself, are unlike anything known in the Canal Zone.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 144, 147b (identification doubtful), 155, 155a, 155b, 156 (identification doubtful), 157. Upper part, eastern area, localities 171, 175; western area, localities 182, 182a, 185. Middle Miocene deposits, Tehuantepec area, México, southeastern Costa Rica, Trinidad. Limón formation (late Miocene), Bocas del Toro area, Panamá. Punta Gavilán formation (late Miocene), Venezuela.

Conus burckhardti harrisi Olsson

Plate 57, figure 17

Conus harrisi Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 53, pl. 3, fig. 1, 1922 (Miocene, Costa Rica). Rutsch, Schweizer, Palæont. Gesell. Abh. v. 55, no. 1, p. 104, pl. 9, figs. 4–6, 1934 (Miocene, Venezuela). Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 88, pl. 11, fig. 6, 1964 (Miocene, Ecuador).

Resembling *Conus burckhardti burckhardti*, but outline more slender. Carinate and tuberculate shoulder appearing near end of first post-protoconch whorl and spiral cords on upper part of mature body whorl wider. Tubercles gradually disappearing on second or third whorl. Spiral sculpture on anal fasciole limited to faint lineation.

Height 37.7 mm, diameter 13.5 mm (figured specimen).

Type: Paleontological Research Inst. 20899.

Type locality: Rio Banana, Limón Prov., Costa Rica, middle Miocene.

This slender subspecies of *Conus burckhardti* is represented by 22 specimens from the lower and middle parts of the Gatun formation. An exceptionally slender shell from the upper part in the eastern area is doubtfully identified, as the shoulder and the spire whorls are missing. The slender outline and greater width of the spiral cords on mature body whorls are the most diagnostic features distinguishing *C. burckhardti harrisi* from the nominate subspecies. The other differences mentioned in the brief description are of no significance. In both Costa Rica and Venezuela *C. burckhardti harrisi* reaches a larger size (height about 60 mm) than in the Canal Zone. Both subspecies are in the collection from locality 155, but that collection is not narrowly controlled stratigraphically.

C. alaquœnsis Mansfield (1935, p. 18, pl. 1, fig. 7; upper Miocene, Florida) is wider at the shoulder and sharply carinate.

Occurrence: Lower, middle, and possibly upper parts of Gatun formation (middle Miocene). Lower part,

localities 136, 136a, 138a, 138c, 138d. Middle part, eastern area, localities 139c, 139e, 155. Upper part, eastern area, locality 177d (identification doubtful). Deposits of early(?) Miocene age, Ecuador. Middle Miocene deposits, southeastern Costa Rica. Punta Gavilán formation (late Miocene), Venezuela.

Conus cf. C. peruvianus Olsson

A fragmentary body whorl from the Caimito formation of Barro Colorado Island reveals the presence of a cone that has a strongly tuberculate shoulder and narrow spiral grooves on the lower part of the whorl. If this fossil were complete, its height would be about 18 mm. In general features, so far as it goes, it is similar to *Conus peruvianus* Olsson (1930, p. 40, pl. 5, figs. 13–15), a late Eocene Peruvian species.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 54h.

Conus tortuosostriatus Toula

Plate 57, figures 5, 6

Conus (Chelyconus) tortuosostriatus Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 508, pl. 31, fig. 22a, b, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 49, pl. 1, fig. 15, 1922 (Miocene, Panamá).

Conus (Hemiconus) tortuosostriatus Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 40, pl. 3, figs. 28, 29, 1913 (Miocene, Canal Zone).

Not *Conus tortuosostriatus* Toula, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 41, pl. 6, fig. 9, 1917 (Miocene, Dominican Republic) ;= *C. gabbi* Pilsbry and Johnson.

Conus tortuosopunctatus Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 47 (discussion), pl. 3, figs. 22, 23, 1913 (Miocene, Canal Zone).

Conus granozonatus Guppy, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 341, 1911 (Miocene, Canal Zone).

Conus consobrinus Sowerby, Brown and Pilsbry, Idem (Miocene, Canal Zone).

Of medium size, slender to inflated, shoulder angulated and tuberculate. Spire moderately high, its profile conical, except part formed by earliest whorls. Protoconch not completely preserved, consisting of about two slender whorls. Early half of first post-protoconch whorl sculptured with relatively coarse axial riblets. Angulated and coarsely tuberculate shoulder appearing on late half of first whorl. Except on first few whorls, tubercles flattened parallel to shoulder and whorls overlapping to edge of shoulder. Tubercles continuing, in reduced form, on shoulder of body whorl. Anal fasciole slightly concave, bearing exaggerated growth threads and more or less distinct spiral sculpture. Body whorl sculptured with narrow, relatively widely spaced, flattened spiral cords. Weak tubercles present or absent on cords. Channels between cords bearing exaggerated axial growth threads. Some channels, especially near top of whorl, on some shells bearing a secondary spiral thread.

Height (incomplete) 28.2 mm, diameter 15.7 mm (inflated figured specimen). Height (not quite complete) 26.3 mm, diameter 11.7 mm (slender figured specimen).

Type: Tech. Hochschule, Vienna.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Ten specimens of this species are in the collections now being studied. They were found in the upper part of the Gatun formation in the eastern area and in the Chagres sandstone. One presumably from Mount Hope, like other species presumed to have been collected at that locality by "Bland?" including the type of *Phos metuloides* (p. 267), is mislabelled "Ponton, Dominican Republic." These few specimens show the presence or absence of secondary spiral threads and of weak tubercles below the shoulder. The type has a height of 30.4 mm, and a diameter of 14 mm.

Seven names have been proposed for Miocene Central American, West Indian, and northern South American cones that are more or less similar to *Conus mcgintyi* Pilsbry (1955), a fairly deep-water species dredged off the coast of Florida and Cuba at depths of 70 to 240 fathoms. The name *C. mazei* Deshayes has generally been used for that species (Clench, 1942, p. 17, pl. 9, figs. 1, 2). The slender, high-spired species *C. larvatus* Pilsbry and Johnson (Pilsbry, 1922, p. 332, pl. 21, fig. 10; Miocene, Dominican Republic; not *C. larvatus* Gmelin, 1791) is more similar to *C. mcgintyi* than any other of these fossil forms. Perhaps some of the Miocene species other than *C. "larvatus"* have been too narrowly defined. Nevertheless, the late whorls of *C. tortuosostriatus* overlap to the edge of the shoulder of the preceding whorl and the spacing of the spiral cords is relatively wide. These features distinguish it from *C. gracilissimus* Guppy (Woodring, 1928, p. 216, pl. 12, figs. 3, 4; Miocene, Jamaica), *C. gabbi* Pilsbry and Johnson (Pilsbry, 1922, p. 332, pl. 21, figs. 8, 9; Miocene, Dominican Republic), and *C. stibarus* Woodring (1928, p. 217, pl. 12, fig. 5, Miocene, Jamaica). In addition, *C. stibarus* has fewer and coarser shoulder tubercles.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, Gatun Locks site (Toula's and Brown and Pilsbry's records). Upper part, eastern area, localities 175, 176, 177, 177b. Chagres sandstone (late Miocene), locality 208. Limón formation (late Miocene), Bocas del Toro area, Panamá.

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Family TURRIDAE

Powell's (1966) recent monograph is indispensable in dealing with this highly diversified family. His subfamily classification is adopted in the present account.

The reaction against the early usage of a few generic names to cover the entire family has gone so far that turrid generic names are almost as narrowly restricted as ammonite generic names. As a minor contribution toward bringing the family more into line with other gastropod families, six names proposed at the generic level (Woodring, 1928, p. 145–201) are now reduced to subgeneric rank: *Polystira*, *Fusiturricula*, *Cryoturris*, *Saccharoturris*, *Miraclathurella*, and *Lioglyphostoma*. Perhaps other genera named in 1928 may be downgraded, but they are not involved in the present report.

Turrids have been found in all the fossiliferous formations, except the Gatuncillo formation and the Cucaracha formation, the latter of which for the most part is nonmarine. As shown in the following table, however, 50 of the 70 species and subspecies, including all the mangilenes and daphnellines, occur in the Gatun formation.

Species and subspecies of turrid gastropods

Subfamily	Eocene or Oligocene	Oligocene		Miocene			
	Marine member of Bohio(?) formation	Bohio formation	Caimito formation	Culebra formation	La Boca formation	Gatun formation	Chagres sandstone
Turrinae	----	----	2	1	1	4	1
Turriculinae	1	----	3	----	1	4	1
Borsoninae	----	----	2	----	----	1	1
Clavinae	----	1	----	----	2	20	4
Mangeliinae	----	----	----	----	----	18	----
Daphnellinae	----	----	----	----	----	3	----
Total	1	1	7	1	4	50	7

Three of the species listed—one from the Culebra formation and two from the La Boca formation—are merely mentioned. In addition to those listed, all the formations, except the Gatun and Chagres, contain unidentifiable turrid material.

Subfamily TURRINAE

Genus Gemmula Weinkauff

Weinkauff, Deutschen Malakozoologischen Gesell. Jahrbücher, v. 2, p. 287, 1875.

Type (logotype, Cossmann, Essais paléoconchologie comparée, pt. 2, p. 62, 1896): *Pleurotoma gemmata* Hinds [*P. gemmata* Reeve, 1843, not *P. gemmata* Conrad, 1835,= *Gemmula hindsiana* Berry], living, Baja California and Gulf of California.

The type species has been illustrated by Harris (1937, p. 10, pl. 1, figs. 33, 33a) and Keen (1958a, p. 250, pl. 30, figs. 1–4).

Gemmula, a genus dating back to Paleocene time, is considered by Powell (1964, p. 243) to be the main turrine stem. Its distribution has been greatly restricted since early Tertiary time. Though it is chiefly a western Pacific genus at the present time, the type species survives in the eastern Pacific Ocean and *G. periscelida* (Dall) (1889, p. 74, pl. 32, fig. 2) in the western Atlantic.

Three fragments of a few small whorls from the Culebra formation are listed as *Gemmula* sp., and molds of a moderately large species from the La Boca formation are identified as *G.* cf. *G. vaningeni*.

Gemmula cf. G. amica Casey

Small, slender. Protoconch missing. Peripheral band coarsely gemmate. Subsutural primary spiral thread fairly strong, except on body whorl near aperture. Three widely spaced primary spiral threads on main part of body whorl below peripheral band. Fine secondary spiral threads in space between peripheral band and subsutural primary thread. Pillar broken, but aperture apparently short.

Height (incomplete) 16.2 mm (estimated complete height 23 mm), diameter 8.8 mm (largest specimen).

A small, slender species of *Gemmula* is represented in the shallow-water facies of the Caimito formation of the Gatun Lake area by four specimens. All are incomplete and their shell material is replaced by calcite. This species is larger and more strongly sculptured than *G. amica* (Casey, 1903, p. 270; Harris, 1937, p. 13, pl. 1, figs. 26–28), of the early Oligocene Red Bluff clay of Mississippi.

Harris and Palmer (1946–47, p. 420, 1947) assigned *G. amica* to *Coronia* (Gregorio, 1890, p. 23; type (logotype, Cossmann, 1896, p. 78): *Pleurotoma acutirostra* Conrad, Eocene, Alabama), which they treated as a subgenus of *Gemmula*. *Pleurotoma acutirostra* was identified by Harris (1937, p. 12, pl. 1, fig. 22) as a form of *Pleurotoma childreni* Lea. Though *G. amica*, like other Oligocene and Eocene species of *Gemmula*, is smaller than the late Tertiary and living species and has a shorter aperture, its strong and strongly gemmate peripheral band favors assignment to *Gemmula*.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 56.

Gemmula vaningeni (Brown and Pilsbry)

Plate 57, figures 11, 18, 22; plate 65, figure 1

Pleurotoma (Gemmula) vaningeni Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 505, pl. 22, fig. 4, 1913 (Miocene, Canal Zone). Cossmann, Jour. Conchyliologie, v. 61, p. 19, pl. 2, figs. 21, 22, 1913 (Miocene, Canal Zone). Mansfield, Florida Dept. Conservation, Geol. Bull. 12, p. 10, 11 (lists), 1935 (Miocene, Florida).

Turris (Gemmula) vaningeni (Brown and Pilsbry), Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 624, pl. 29, fig. 14, 1939 (Miocene, Colombia). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 126, pl. 8, fig. 11, 1951 (Miocene, Ecuador).

Gemmula vaningeni (Brown and Pilsbry), Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 93, pl. 20, fig. 12, 1964 (Miocene, Ecuador).

Hemipleurotoma eileta Gardner, U.S. Geol. Survey Prof. Paper 142, p. 290, pl. 38, figs. 27, 28, 1938 (Miocene, Florida).

Moderately large, high-spired, slender. Protoconch relatively slender, 4-whorled. First whorl emerging so abruptly that apex appears to be broken. First whorl to first 1½ whorls smooth, remainder sculptured with axial riblets of gradually increasing strength. A faint spiral thread visible at lower edge of sculptured protoconch whorls on some specimens, especially on last whorl or two. End of protoconch marked by suppression of axial riblets and appearance of spiral sculpture. Sculpture dominated by coarsely gemmate peripheral band, both edges slightly raised. Subsutural primary spiral forming a wide-based, narrow-crested collar. Intermediate and late spire whorls bearing a primary spiral thread between peripheral band and succeeding whorl. Similar threads on body whorl. Secondary spiral threads of variable strength, generally strongest between peripheral band and subsutural collar; present or absent on flanks of collar. Fine exaggerated growth threads conspicuous, especially between peripheral band and subsutural collar. Anal sinus deep, apex U-shaped. Aperture long.

Height (not quite complete) 38.8 mm, diameter (incomplete) 12.3 mm (largest figured specimen).

Type: Acad. Nat. Sci. Phila. 3855.

Type locality: Gatun Locks excavation, middle part of Gatun formation.

Though *Gemmula* is rare in the Miocene deposits of the Caribbean region, *G. vaningeni* is represented in the Gatun formation by 65 specimens. Only one, however, was found in the lower part of the formation and none in the upper part in the western area. Locality 175, in the upper part in the eastern area, yielded 27, whereas other collections contain nine or less. The type (height 19.5 mm) is immature. Its siphonal canal and outer lip, as on most of the specimens, are broken. The largest shell would have an estimated height of 45 mm, if it were complete. Twenty-six of these fossils show the protoconch, but on many of them at least some of the protoconch whorls are somewhat worn.

Two immature shells are labeled, in Dall's writing, types of *Pleurotoma pontonensis* Dall and are alleged to have been collected by "Bland?" at Ponton, in the Dominican Republic. This record, like that for the type lot of *Phos metuloides* (p. 267), is presumed to be an erroneous record for the present Mount Hope. If the rejected record is ignored, *Gemmula* is unknown in the Dominican Republic. *Pleurotoma pontonensis*, mentioned by Mansfield (1925, p. 15) and Gardner (1926–47, p. 290, 1938), is a nude name, as recognized by Mansfield.

The features of *G. vaningeni* are basically uniform, although the strength of the secondary spiral threads is somewhat variable. Three of the 27 specimens from locality 175 are malformed. The malformation takes the form of a swelling on the body whorl at and near the edge of the outer lip between the anal sinus and the siphonal canal. In apertural view the effect is an insinuation of the lip, but the growth lines are not insinuated. With further growth the swelling forms an almost closed tube, which is later sealed off and followed by another swelling (pl. 57, figs. 11, 18). The anal sinus of the smallest of these shells is partly covered by the attached valve of an anomid(?). The attachment, however, may have taken place after death of the gastropod. At all events the anal sinus of the other two shells shows no indication of blocking. The same kind of malformation is shown by other turrids. Those that have come to my attention are as follows: species in the genera *Gemmula* (Glibert, 1954, p. 7, pl. 2, figs. 3a, b; MacNeil, 1960, p. 104; Powell, 1964, p. 253); *Pinguigemmula* (MacNeil, 1960, p. 103, 104; Powell, 1964, p. 277, 279, pl. 215, figs. 5, 6); *Ptychosyrinx* (Powell, 1964, p. 289, 290, 291, pl. 223, fig. 1, pl. 224; Okutani, 1964, p. 425, pl. 4, fig. 9); *Aforia* (Dall, 1918, p. 319); and a species assigned to *Drillia* (Melvill, 1917, p. 150). Though various explanations for the malformation have been proposed, its significance, as pointed out by Powell (1966, p. 8), will not be known until the animal is found in such a shell. A. A. Olsson called my attention to the remarks concerning *Aforia* by Dall, who later (Dall, 1921, pl. 11, fig. 6) illustrated a specimen of *Aforia* showing the "anterior sulcus."

Hemipleurotoma eileta, of the Shoal River formation of Florida, is considered to be a synonym of *G. vaningeni*. The largest Florida fossils are a little smaller than Gatun shells and some, including the type, have a slightly narrower and slightly less coarse-

ly gemmate peripheral band. Incomplete shells indicate a maximum height of about 35 mm, although the type, which is not quite complete, has a height 24.3 mm. Mansfield listed the Florida form as *G. vaningeni*. The largest of his three specimens from USGS locality 12044 closely resembles Gatun fossils of intermediate size.

Small shells (maximum estimated height 17 mm) from the early middle Miocene part of the Brasso formation of Trinidad (*Globorotalia fohsi* zone, USGS 21234, 21230) appear to represent immature shells of *G. vaningeni* or a small form of that species. Two other small shells from the same part of the Brasso formation (USGS 9219) were identified by Mansfield (1925, p. 15) as *Turris vaningeni* var. *machapoorensis* (Maury). Their relatively low peripheral band and subsutural collar suggest Maury's (1925, p. 191, pl. 32, figs. 1, 14) [unnumbered on plate] *Drillia vaningeni* var. *sanctiandreæ*. The status of Mansfield's and Maury's specimens is uncertain.

Illustrations of *G. hindsiana*, the type of the genus, suggest that it is smaller and more slender than *G. vaningeni*, and has a narrower and lower sutural collar. Nevertheless *G. vaningeni* is much more closely related to *G. hindsiana* than to *G. periscelida*, a deep-water species and the only species surviving in western Atlantic waters. The type locality of that species is off the Gulf of Morrosquillo, on the Caribbean coast of Colombia. Dall's record, "near Monosquillo," was based on a cataloger's error in transcription.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 147b, 147g, 147h, 151, 155, 155a, 155b, 159d. Upper part, eastern area, localities 173a, 175, 176, 177, 177c, 178. Middle Miocene deposits, Darién area (USGS 8429, 8452, 8477), Panamá. Subibaja formation (early Miocene) and Picaderos formation (middle Miocene), Ecuador. Middle Miocene deposits, southwestern Columbia. Early middle Miocene part of Brasso formation, Trinidad. Shoal River formation (middle Miocene), Florida.

Gemmula machapoorensis (Maury)

Drillia vaningeni var. *machapoorensis* Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 191, pl. 32, figs. 5, 9, 1925 (Miocene, Trinidad).

Turris brassœnsis Mansfield, U.S. Natl. Mus. Proc., v. 66, art. 22, p. 14, pl. 2, figs. 7, 8, 1925 (Miocene, Trinidad).

Hemipleurotoma bitropis Gardner, U.S. Geol. Survey Prof. Paper 142, p. 290, pl. 38, fig. 29, 1938 (Miocene, Fla.).

Protoconch and first two post-protoconch whorls available. Protoconch large, 5-whorled, rapidly enlarging. First whorl emerging abruptly from apex. At least last three whorls sculptured with narrow, closely spaced axial riblets. Lower half of these whorls also sculptured with still narrower spiral threads. A stronger sutural thread on last whorl. Last few axial riblets coarser and more widely spaced than others, followed by abrupt suppression of riblets and appearance of strong spiral sculpture. Both edges of peripheral band of post-protoconch whorls raised to form distinct spiral threads. Subsutural primary spiral forming a strong, wide-based, narrow-crested collar. Exaggerated, uniformly spaced growth threads strong on flanks of subsutural collar.

Height (almost complete) 6.4 mm, diameter 3 mm.

Lectotype (herewith designated): Paleontological Research Inst. 1006.

Type locality: Thirteenth mile post on Guaico-Tamana Road, Trinidad, "Machapoorie Miocene" [Brasso formation].

The only specimen, from the lower part of the Gatun formation, is immature. Though the protoconch whorls are partly corroded, the features mentioned in the description are discernible. Despite the unpromising material, the identification of this distinctive species is made with considerable confidence on the combined basis of the protoconch and the post-protoconch sculpture. The protoconch is large, rapidly enlarging, and bears both axial and spiral sculpture. The spiral thread at both edges of the peripheral band and the strong, wide-based subsutural collar are diagnostic features of the post-protoconch sculpture. With further growth, as shown by shells from Trinidad and Florida, a secondary spiral thread appears on both flanks of the subsutural collar and exaggerated growth threads on parts of the shell other than the flanks of the subsutural collar. Also as shown by growth lines on shells from Trinidad and Florida, the anal sinus is typically that of *Gemmula*.

G. machapoorensis evidently is a small species. Maury estimated 19 mm for the maximum height, which is about the same as that for Florida shells. The largest Trinidad shell in the USNM collections has a height of 12.2 mm. The protoconch is not preserved on any of the nine specimens from the Shoal River formation of Florida. It is preserved, however, on all of the 18 specimens in the USNM Trinidad collections and, though somewhat worn, on the lectotype. The number of protoconch whorls is six or seven, and sculpture appears on the first or second. The *Globorotalia fohsi* zone of the Brasso formation yielded all this Trinidad material (USGS localities 8302, 9212, 19856, 19870, 21234). According to H. G. Kugler, who supplied the zonal data for these localities, and also for 21230 cited under *G. vaningeni*, the areal geology

shows that even the float collections (8302, 9212) were derived from that zone.

Mansfield commented on the similarity of Trinidad and Florida specimens. It seems remarkable that *G. vaningeni* and *G. machapoorensis* are associated at such widely separated localities as Trinidad, Panamá, and Florida.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c. Early middle Miocene part of Brasso formation, Trinidad. Shoal River formation (middle Miocene), Florida.

Genus?

"Gemmula" species

Plate 48, figures 19, 20

Small, moderately slender, biconic. Protoconch missing. Peripheral band wide, coarsely gemmate. Suture bordered by a gemmate collar, less coarsely gemmate than peripheral band. Other spiral sculpture consisting of narrow primary and secondary threads, faintly noded by conspicuous, exaggerated growth threads. Aperture long, narrow. Siphonal canal virtually absent; aperture ending in a shallow siphonal notch. Siphonal fasciole slightly inflated. Anal sinus moderately deep, apex U-shaped, located on peripheral band.

Height (almost complete) 20.7 mm, diameter 18.2 mm (figured specimen).

This unnamed species is represented by a defective specimen and a minute tip from the moderately deep-water facies of the Caimito formation on Barro Colorado Island. It is to be assigned to an apparently unnamed turrine genus that has a *Gemmula*-like anal sinus and gemmate peripheral band, but, unlike *Gemmula*, has a long, narrow aperture, siphonal notch, and siphonal fasciole. Though the anterior end of the aperture is defective, growth lines show the shallow siphonal notch. The gemmate sutural collar is a noteworthy feature. The outline suggests *Scobinella* or a small slender *Bathytoma*.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), localities 54g, 54j.

Genus Pleuroliria Gregorio

Gregorio, Annales Géol. Paléontologie, pt. 7, p. 38, 1890.
Type (orthotype): *Pleurotoma supramirifica* Gregorio, locality not specified (presumed to be *Pleurotoma cochlearis* Conrad, Oligocene, Mississippi).

Should Gregorio's type designation be considered equivocal, Cossmann unequivocally cited *Pleurotoma supramirifica* as the type four years later (Cossmann, 1893 (1894), p. 43).

Harris (1937, p. 8, pl. 1, figs. 5, 5a, b) reproduced Gregorio's illustrations of *Pleurotoma supramirifica*. There is no reasonable doubt that it is the Oligocene species *Pleurotoma cochlearis*. The known Eocene species are much smaller.

Subgenus Polystira Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 145, 1928.
Type (orthotype): *Pleurotoma albida* Perry, living, southern Florida, Gulf of Mexico, and West Indies.

Bartsch (1934, p. 8) claimed that *Pleurotoma albida* is a western Pacific species and that *Murex virgo* Wood is the proper name for the type species of *Polystira*. Despite Perry's statement that his species is "from the South Seas, being frequently found at New Zealand and Lord Howe's Island" (Perry, 1811, explanation of pl. 32, fig. 4), his illustration is considered to be a reasonably satisfactory representation of the western Atlantic species later named *Murex virgo*. *Pleurotoma albida* is not recognized in the western Pacific Ocean (Powell, 1964, p. 315).

Though *Polystira* was named at the generic level, it is proposed to treat it as a subgenus of *Pleuroliria*. It is interpreted to be the direct descendant of *Pleuroliria* and the two groups have similar basic features. *Polystira* reaches a larger size than *Pleuroliria* s.s. and has a less rapidly enlarging protoconch. The protoconch of *Polystira* generally has fewer whorls and fewer whorls sculptured with axial riblets. The number of protoconch whorls and of sculptured protoconch whorls, however, overlap in the two groups and not all of the species of *Polystira* are large. Some species of *Polystira*, including the type species, have a blunt protoconch, but that of others is acute. In other words, too much reliance was placed on type species when *Polystira* was named—a procedure that has been justly criticized (MacNeil, 1960, p. 100).

Both *Pleuroliria* s.s. and *Polystira* embrace American species. *Pleuroliria* s.s. is of Eocene and Oligocene age. The age range of *Polystira* is early Miocene to the present time and the living species occur in western Atlantic and eastern Pacific waters. They are characterized by strong, coarse, exaggerated growth threads, at least on early post-protoconch whorls, if not also on later whorls. This may seem to be a minor feature, but it can be traced back through the fossil species of *Polystira* to the Oligocene species that doubtless is the type species of *Pleuroliria*.

Pleuroliria albidoides (Gardner) (1926–47, p. 287, pl. 38, fig. 24, 1938; Chipola formation, Florida) is the earliest species of *Polystira* that is known to have a blunt protoconch. That species was illustrated by Dall (1915, p. 38, pl. 5, fig. 13) as *Turris albida* without any indication that the specimen is a Chipola fossil, not a Tampa fossil. The specimen he illustrated

(height 49 mm) would serve as a better namebearer than the minute shell (height 10.6 mm) chosen as the type because it shows the protoconch. One of the species of *Polystira* that has an acute protoconch—*Pleuroliria tenagos*, the next species described — was designated as the type of *Josephina* (Gardner, 1945, p. 246), proposed as a section of *Pleuroliria*. That proposal followed my suggestion (Woodring, 1928, p. 145), which overemphasized the distinction between blunt and acute protoconchs. The protoconch illustrated by Gardner (1926–47, p. 288, pl. 38, fig. 23, 1938) as the protoconch of *Polystira virgo* is that of a small shell (height 11.6 mm) dredged off Grenada at a depth of 73 fathoms. It presumably is one of the relatively small living West Indian species, for which six names have been proposed.

Lophiotoma (Casey, 1904, p. 130; type (logotype, Woodring, 1928, p. 146): *Pleurotoma tigrina* Lamarck (= *P. acuta* Perry), living, western Pacific Ocean) is the western Pacific analog of *Polystira*. As pointed out by Powell (1942, p. 49, figs. E2, E3; 1964, p. 303, pl. 173), *Polystira* may be distinguished by its shallower, more V-shaped anal sinus. If, however, so much emphasis is to be placed on the anal sinus, the western Atlantic species described by Dall as *Pleurotoma albida* var. *tellea* (Dall, 1889, p. 73) is not a typical species of *Polystira*. The sinus of mature shells of that species (but not of immature shells) is decidedly asymmetric and shallow. This unusual species—unusual in mature sculpture, as well as in mature anal sinus—has been illustrated recently (Abbott, 1954, p. 268, pl. 13, fig. m), but has not yet been adequately described. It has been dredged at depths of 35 to 220 fathoms off southern Florida and in the eastern Gulf of Mexico.

Pleuroliria (Polystira) tenagos (Gardner)

Plate 57, figures 12, 23, 24; plate 65, figure 2

Pleurotoma albida Perry, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 343, 1911 (Miocene, Canal Zone).

Turris albida (Perry), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 58, pl. 4, figs. 1, 2, 1922 (Miocene, Panamá).

Pleurotoma haitensis Sowerby, Cossmann, Jour. Conchyliologie, v. 61, pl. 16, pl. 2, figs. 1–4, 1913 (Miocene, Canal Zone).

Polystira (Pleuroliria) tenagos Gardner, U.S. Geol. Survey Prof. Paper 142, p. 288, pl. 38, figs. 25, 26, 1938 (Miocene, Fla.).

?Pleuroliria tenagos (Gardner), Gardner, Geol. Soc. America Mem. 11, p. 246, 1945 (Miocene, México).

Of medium size to moderately large, moderately slender to moderately inflated. Profile of late whorls slightly to decidedly modified by peripheral carina. Protoconch acute, 3- to 4-whorled (generally 3 to 3½). Last whorl, or a little less, to last two (generally last to last 1¼) bearing axial riblets. Spiral sculpture of post-protoconch whorls dominated by peripheral carina of variable strength; both edges slightly raised. Subsutural primary spiral thread strong, single or double. On intermediate and late spire whorls one or two fairly strong primary spiral threads between peripheral carina and succeeding whorl. Secondary spiral threads on intermediate and late whorls, except on pillar. Exaggerated, uniformly spaced growth threads conspicuous on unworn early whorls, more subdued on intermediate and late whorls, except those representing stages of arrested growth at irregular intervals. Anal sinus moderately shallow, V-shaped, located on peripheral carina. Interior of outer lip lirate.

Height 58.8 mm, diameter 16.6 mm (largest figured specimen). Estimated restored height 75 mm, diameter 20.8 mm (largest specimen).

Type: USNM 351134.

Type locality: USGS 3742, Shell Bluff, Shoal River, Walton County, Fla., Shoal River formation.

Pleuroliria tenagos is widespread in the three parts of the Gatun formation. It is locally abundant in the lower and middle parts, as shown by 37 specimens in a lower Gatun collection (locality 138c) and 24 in a middle Gatun collection (locality 161a). The largest specimens occur in the upper part of the formation in both eastern and western areas. Though they are incomplete, they indicate a height of about 75 mm. On his plate 4, figures 1, 2, Cossmann illustrated an incomplete large specimen from the upper part in the eastern area.

The degree of inflation, the whorl profile, and details of sculpture, especially the strength of the subsutural primary spiral thread, are variable. The strongest modification of whorl profile, due to angulation by the peripheral carina, is shown, but not uniformly shown, by shells from the lower part of the Gatun (pl. 57, fig. 12). A slightly modified profile is illustrated by the upper Gatun specimen of plate 57, figure 24; and an intermediate profile by the middle Gatun specimen of plate 57, figure 23. The fossils of the three parts, however, do not uniformly show a graded profile series. Ten of the 14 smallest shells (maximum height 22 mm) in the largest lower Gatun collection are exceptionally slender and have a low peripheral carina. They presumably would have a stronger carina at a later growth stage.

Twenty-four of the some 230 available specimens show the acute protoconch, but none of the six specimens from the upper part of the Gatun in the western area has a preserved protoconch. A minute middle Gatun shell (height 5.2 mm)—the only shell from locality 161c—has a blunt protoconch of two whorls, the last half whorl of which bears axial riblets. This fossil

is listed as *Pleuroliria* sp. It may eventually be found to be an aberrant specimen of *P. tenagos*, but that seems to be unlikely. At all events, its status is uncertain until mature features are known.

In Florida *P. tenagos* is not so variable. The Florida form is most like moderately slender Gatun fossils of intermediate whorl profile. The type is small (height 37.5 mm), but fragments suggest a height comparable to that of the largest lower and middle Gatun specimens.

P. tenagos is not similar to species of the same age in the Dominican Republic and Jamaica: *P. haitensis* (Sowerby) (Pflug, 1961, p. 69, pl. 20, figs. 2, 3, 5–13) and *P. barretti* (Guppy) (Woodring, 1928, p. 146, pl. 4, figs. 6, 7; Pflug, 1961, p. 70, pl. 20, figs. 1, 4), respectively. The protoconch of both of those species is blunt. The low peripheral carina of *P. haitensis* has no effect, or a slight effect, on whorl profile. *P. barretti*, a close relative of the living West Indian *P. albida*, is larger than *P. haitensis* and *P. tenagos*. Its peripheral carina strongly affects whorl profile. The contrast between *P. haitensis* and *P. barretti* is well shown by Pflug's illustrations on the same plate. *P. andersoni* Olsson (1964, p. 90, pl. 14, figs. 3–3b), a large early Miocene Columbian species, has exceptionally strong secondary spiral sculpture. Its protoconch is unknown.

P. tenagos occurs in the middle Miocene deposits of the Darién area (USGS 8428, 8429, 8430, 8477, 8479) and in the Limón formation, of late Miocene age, in the Bocas del Toro area. Its distribution may be found to be more extensive. The middle Miocene Venezuelan fossils identified as *P. barretti* (Jung, 1965, p. 561, pl. 76, figs. 5, 16), for example, should be compared with *P. tenagos*. Their protoconch, however, is not known.

The moderate or moderately large size, acute protoconch, and relatively narrow primary spiral sculpture show that *P. tenagos* is not closely related to *P. albida*. The relationship to the living eastern Pacific species *P. oxytropis* (Sowerby) and *P. picta* (Reeve) (Olsson, 1964, p. 90, pl. 14, figs. 1, 1a, 1b; p. 90, pl. 14, figs. 2, 2a, respectively), especially *P. picta*, is closer. That species is slender, and shows a moderately modified whorl profile, and weak subsutural primary spiral thread.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 138, 138a, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139c, 139d, 139e, 139f, 142, 146, 147b, 147g, 147h, 151, 153a (identification doubtful), 154, 155, 155a, 155b, 155c, 156, 157, 159d; western area, localities 161a, 161b, 161c (*Pleuroliria* sp.). Upper part, eastern area, localities 172, 173, 175, 176, 176a, 177c; western area, localities 182, 182a, 183, 185. Guajalote formation (late early Miocene), northeastern México (identification doubtful). Shoal River formation (middle Miocene), Florida. Middle Miocene deposits, Darién area, Panamá. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Pleuroliria (Polystira) ecuadoriana (Olsson)

Plate 62, figure 26

Polystira oxytropis ecuadoriana Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 91, pl. 14, figs. 5, 5a, 1964 (Miocene, Ecuador).

Moderately large, rapidly enlarging in diameter. Profile of all except early post-protoconch whorls strongly modified by peripheral carina. Protoconch missing. Space between peripheral carina and preceding whorl wide and concave. Subsutural primary spiral thread of intermediate whorls low, reduced practically to vanishing point on last preserved whorl. On spire whorls primary spiral thread between peripheral carina and succeeding whorl moderately strong. Secondary spiral threads of variable strength. Exaggerated growth threads strong on early and intermediate whorls. Anal sinus, as shown by growth lines, forming an open V on peripheral carina. Outer lip broken back.

Height (incomplete) 39.5 mm, diameter (incomplete) 22.5 mm (figured specimen).

Type: USNM 643960.

Type locality: Punta Gorda, Esmeraldas Province, Ecuador, Esmeraldas formation.

The Chagres sandstone yielded the illustrated incomplete, worn shell, which indicates a height of about 70 mm, and also a fragment of a few worn early post-protoconch whorls. This recently described species is noteworthy for its rapidly enlarging outline, strong peripheral carina, and weak subsutural primary spiral on the last whorl or last few whorls. Six specimens in a collection from the Valiente Peninsula, in the Bocas del Toro area of northwestern Panamá (USGS 8322), all more or less incomplete, show the same features. The fossiliferous strata in the Valiente Peninsula are considered to be of late Miocene age.

Though *Pleuroliria ecuadoriana* was named as a subspecies of the living Panamic species *P. oxytropis* (Sowerby), the large size and rapidly enlarging outline justify specific rank. It is doubtful whether the slender specimen illustrated by Olsson (1964, pl. 14, fig. 5b) is *P. ecuadoriana*.

Occurrence: Chagres sandstone (late Miocene), locality 208. Limón formation (late Miocene), Bocas del Toro area, Panamá. Esmeraldas formation (late Miocene), Ecuador.

Subfamily TURRICULINAE

Genus Zemacies Finlay?

Finlay, New Zealand Inst. Trans., v. 56, p. 252, 1926.
Type (orthotype): *Zemacies elatior* Finlay, Miocene, New Zealand.

The following two early Tertiary turriculine species are noteworthy for their slender outline, long narrow aperture, and flat, closely spaced, narrow spiral bands. They represent *Zemacies* or a related genus. Though both evidently are new species, the material is too imperfect to name. In New Zealand *Zemacies* has an age range of Paleocene to Pliocene (Powell, 1966, p. 36).

Zemacies? species a

Plate 48, figure 13

Of medium size, slender, subangulated at shoulder. Protoconch corroded, apparently consisting of about three rapidly enlarging whorls. Shoulder bearing low, axially elongate swellings, progressively more subdued on late whorls. Spiral sculpture consisting of flat, closely spaced, narrow bands. Subsutural band narrow, an adjoining band wider. Anal sinus apparently on narrow, concave space between shoulder and suture. Aperture long, narrow.

Height (incomplete) 19.3 mm (estimated restored height 27 mm), diameter (incomplete) 8.5 mm (estimated restored diameter 9 mm).

The marine member of the Bohio(?) formation at Vamos Vamos yielded two imperfect specimens of this species.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 40d.

Zemacies? species b

Plate 48, figure 21

Of medium size, slender, late whorls subangulated at shoulder. Protoconch and early post-protoconch whorls missing. Late whorls bearing widely spaced, obliquely elongate nodes on shoulder. Spiral sculpture consisting of flat, narrow, closely spaced bands. Subsutural band relatively wide. Anal sinus located on narrow, concave space between shoulder and suture. Aperture long, narrow.

Height (incomplete) 32 mm (estimated restored height 38 mm), diameter (incomplete) 11.6 mm (estimated restored diameter 13 mm).

This strongly noded species is represented by an incomplete specimen from the moderately deep-water facies of the Caimito formation on Barro Colorado Island.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 54n.

Genus Pleurofusia Gregorio

Gregorio, Annales Géol. Paléontologie, pt. 7, p. 33, 1890.
Type (orthotype): *Pleurotoma (Pleurofusia) longirostropsis* Gregorio, locality and age not specified.

Though Gregorio did not specify a locality or age for *Pleurotoma longirostropsis*, he presumably thought it is a Claiborne species; that is, according to present terminology, a species from the middle Eocene Gosport sand at Claiborne, Alabama. Dr. K. V. W. Palmer, Director of the Paleontological Research Institution, informs me that the Institution has received from the University of Palermo (the repository of Gregorio's collections) three specimens labelled *Pleurotoma longirostropsis*, but none resembles the illustration published by Gregorio as plate 2, figure 26. Harris, who reproduced Gregorio's figure 26 (Harris, 1937, p. 51, pl. 10, fig. 6) was unable to identify this species. No species closely resembling Gregorio's illustration is known to occur at Claiborne or elsewhere in the Eocene or Oligocene deposits of the southeastern states. Gregorio, of course, may have had a rare species or his drawing may be faulty. A minute specimen in the USNM collection from Claiborne, both ends of which are broken (height 4.9 mm), has the anal sinus in a strongly constricted sutural area marked with conspicuous growth threads, as shown in Gregorio's figure, but lacks the two strong peripheral spiral threads on spire whorls and the subangulated early whorls of that illustration. Casey (1904, p. 152) thought that "a specimen in the cabinet of Mr. Aldrich, from the lower Claiborne" greatly resembles Gregorio's illustration. A turrid in the Aldrich collection labelled "*Pleurofusia longirostropsis* Greg., per Casey, Lee Co., Texas, L. C., Eocene," doubtless is the specimen Casey had in mind. It is not the species represented by Gregorio's illustration. Gregorio compared his species with *Pleurotoma servata* Conrad, an Oligocene species from the Byram marl, cited in the third following paragraph; indeed, despite the lack of similarity, he thought it may be a variety of the Oligocene species.

It is unfortunate that nothing more than Gregorio's drawing is available for the type species of *Pleurofusia*. Nevertheless, it is proposed to treat the name as the name for a genus embracing small to moderately large turriculine turrids that have a *Fusinus*-like outline and sculpture, and an asymmetrical sinus adjoining the suture. Such species are found in American faunas since Eocene time, and now live in western Atlantic and eastern Pacific waters at low latitudes.

At present it is uncertain what species other than *Pleurotoma longirostropsis* are to be referred to the subgenus *Pleurofusia* s.s. The protoconch of the type species is unknown, and some post-protoconch features appear to be unique. Eocene species of *Pleurofusia* have been described by Harris (1937, p. 50–53) and Harris and Palmer (1946–47, p. 429–431, 1947). Whether the species that have a short pillar should be referred to that genus is debatable; *Pleurotoma collaris* Casey (1903, p. 270; Harris and Palmer, 1946–47, p. 431, pl. 59, figs. 13–15, 1947), for example, seems to be a clavine species. The protoconch of not all of the long-pillared Eocene species have been described. Those that are known are blunt, smooth, and about 2-whorled.

Pleurofusia servata (Conrad) (1847 (1848), p. 284; Harris, 1937, p. 50, pl. 10, fig. 4, not fig. 5; Harris and Palmer, 1946–47, pl. 59, fig. 21, 1947), from the Oligocene Byram marl, has an acute, 3½- to 4-whorled protoconch. The later part of the last whorl bears four to six axial riblets. *Pleurofusia olivia* (Casey) (1903, p. 269), from the Oligocene Red Bluff clay, has a similar protoconch. This type of protoconch was assumed to be typical for *Pleurofusia* when *Fusiturricula* (Woodring, 1928, p. 165; type (orthotype): *Turris* (*Surcula*) *fusinella* Dall, living, Gulf of Panama) was proposed as a generic name for species that have a range of Miocene to the present time, but that assumption was unjustified. The status of *Fusiturricula*, which has a blunt or moderately acute, 1½- to 2¾-whorled, smooth protoconch (last half whorl rounded or slightly bulging), is uncertain, on account of the uncertainty concerning *Pleurofusia* s.s. If it is to be retained, it rates subgeneric rank under *Pleurofusia*. The type still is the only dredged specimen of the type species of *Fusiturricula*. It is a small, thin-shelled, deep-water shell dredged at a depth of 153 fathoms. Though it may be immature (height 17.2 mm), it is not much smaller than *Pleurofusia enæ* (Bartsch) (1934, p. 13, pl. 3, figs. 1, 2, 10; height 25 mm), a similar, thin-shelled, deep-water species.

P. enæ is represented by eight specimens, taken in hauls at five stations on the south border of the Puerto Rico Trench, off Puerto Rico, and the Virgin Islands, at depths of 240 to 360 fathoms. Three of these thin shells, including the type, as shown in Bartsch's figure 2, have a perfectly preserved anal sinus, showing the wide forward sweep of the lower limb. Until this species and *P. fenimorei* (Bartsch) (cited under *P.* cf. *P. fenimorei*) were described, *Pleurofusia* was unknown in the western Atlantic Ocean.

Subgenus?

Pleurofusia species

Plate 48, figure 27

Of medium size, apex and pillar broken. Sculpture consisting of wide, low axial swellings (four on penult whorl), overridden by two moderately strong peripheral spiral threads. Thread (later two threads) on spire whorls between peripheral threads and succeeding whorl, and corresponding threads on base of body whorl almost as strong as those on periphery. Subsutural thread and that at base of subsutural area narrower. Anal sinus on depressed subsutural area.

Height (incomplete) 18.7 mm (estimated restored height 30 mm), diameter 9 mm (figured specimen).

The description of this unnamed species is based on an incomplete fossil, replaced by calcite, collected from the shallow-water facies of the Caimito formation in the Gatun Lake area at locality 56. In general features it resembles the Gatun species *Pleurofusia fusinus*, but lacks secondary spiral threads. Its protoconch and outer lip are, of course, unknown.

A poorly preserved fragment of two whorls from the La Boca formation is listed as *Pleurofusia?* sp.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 56.

Pleurofusia acra Woodring, n. sp.

Plate 57, figure 8; plate 65, figure 3

Of medium size, *Fusinus*-like in outline and gross sculpture, pillar long and slender. Protoconch acute, 3½-whorled, last two whorls carinate below middle of whorl. Post-protoconch whorls bearing closely spaced, wide axial swellings below anal fasciole (8 on body whorl), disappearing on body whorl below shoulder. Axial swellings overridden by spiral threads (5 on penult whorl). Similar threads on body whorl below lower end of axial swellings undulated by low, elongate nodes, except near end of pillar, where the threads are smooth. Anal fasciole of late whorls bearing weak secondary spiral threads and weak, retractive subsutural swellings. Outer lip broken. Apex of anal sinus, as shown by growth lines, close to lower edge of anal fasciole.

Height (practically complete) 22.4 mm, diameter 7.5 mm (type).

Type: USNM 645764.

Type locality: 155c (USGS 16915, Gatun Third Locks excavation, east side of excavation, 1 mile (1.6 km) north of Gatun Lake, Canal Zone), middle part of Gatun formation.

Though the type of this species, which may be immature, is the only specimen, it combines three un-

usual features: acute, polygyrate, carinate protoconch; retractive subsutural swellings; and noded spiral threads on the lower part of the body whorl. *Pleurofusia fusinella* Dall (1908, p. 261, pl. 14, fig. 7, living, Gulf of Panama), the type of *Fusiturricula*, has an acute, polygyrate protoconch. Its last half whorl bulges at the periphery, but is not sharply carinate. The retractive subsutural swellings and the faintly noded spiral threads on the lower part of the body whorl of *P. acra* appear to be unique among American fossil and living species of *Pleurofusia*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 155c.

Pleurofusia cf. P. fenimorei (Bartsch)

Two incomplete shells from the Chagres sandstone represent an undescribed species of *Pleurofusia*. The protoconch, early post-protoconch whorls, and end of the pillar are missing on both. The periphery of the whorls is strongly inflated and the anal fasciole correspondingly strongly constricted. The strong axial swellings (9 on body whorl) are separated by spaces slightly wider than the swellings themselves. The spiral sculpture consists of primary (4 on penult whorl) and secondary threads. The estimated restored height is between 25 and 30 mm, the diameter 10 mm.

The whorl outline and its few, strong, widely spaced swellings suggest *Pleurofusia fenimorei* (Bartsch, 1934, p. 7, pl. 2, figs. 4, 5), a large species (height 71 mm) dredged on the south border of the Puerto Rico Trench at a depth of between 80 and 180 fathoms. At the same diameter the fossils have two more swellings and their primary spiral threads are fewer and stronger. The same dredge haul yielded another shell of *P. fenimorei* that is smaller than the type, but in better condition than the somewhat worn type.

P. fenimorei is the type of *Fusisyrinx* (Bartsch, 1934, p. 7). The only essential difference between *Fusisyrinx*, as now known, and the type of *Fusiturricula* (cited in the discussion under *Pleurofusia*) lies in the number, width, and spacing of the axial ribs or swellings. The protoconch of *Fusisyrinx*, however, is unknown.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Subgenus Cruziturricula Marks

Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 129, 1951.
Type (orthotype): *Turricula (Pleurofusia) cruziana* Olsson, Miocene, Perú, Ecuador.

Cruziturricula is distinguished from other groups of species assigned to *Pleurofusia* by its blunt or acute protoconch, the last whorl or less of which is carinate below the middle of the whorl and bears fine arcuate axial riblets above the carina. The axial sculpture consists of swellings rather than ribs and is present or absent on late whorls. As shown in the following table, the fossil species have a lirate outer lip, whereas the lip of the living species is nonlirate. Also as shown in the table, *Cruziturricula* has an age range of Oligocene to present time and survives in the eastern Pacific Ocean.

Species of Pleurofusia, *subgenus* Cruziturricula

Age and locality	Species	Protoconch	Interior of outer lip
Living, Panamic province	*Pleurofusia panthea* (Dall)	Unknown, except later part of last whorl; carinate, axial riblets above carina.	Nonlirate.
	P. arcuata (Reeve)	Blunt, 2-whorled; last whorl carinate, axial riblets above carina.	Nonlirate.
Middle and late Miocene, Trinidad	*P. fusinus sanctidavidis* (Maury)	Blunt, 1¾- to 2-whorled; last ½ to 1¼ whorls carinate; axial riblets above carina.	Lirate.
Middle Miocene, Panamá	*P. fusinus fusinus* (Brown and Pilsbry)	Blunt, 1¾- to 2-whorled; last ¼ to 1 whorl carinate; axial riblets above carina.	Lirate.
Middle Miocene, Ecuador	*P. latira* (Olsson) (=*P. fusinus fusinus*)	Blunt, 2-whorled; last half whorl carinate, axial riblets above carina.	Lirate.
Early Miocene, Ecuador; middle Miocene, Perú	*P. cruziana* (Olsson)	Tip broken, evidently blunt, about 2-whorled; last ¼ whorl carinate, axial riblets above carina.	Lirate.
Early Miocene, Florida	*P. glypta* (Gardner)	Blunt, 1½-whorled; last ½ whorl carinate, axial riblets above carina.	Lirate.
Oligocene, Mississippi	*P. vicksburgensis* (Casey)	Acute, 3- to 4-whorled; last ½ to ¾ whorl carinate, axial riblets above carina.	Lirate.

Marks assigned the two living Panamic species to *Cruziturricula*, but under erroneous names. His "*Turricula*" *arcuata* Dall evidently is an inadvertent error for "Reeve": the species described by Reeve (1843, pl. 3, fig. 15, and accompanying text) as *Pleurotoma arcuata*. For "*Turricula*" *lavinia* Dall, Marks intended to mean *Turricula* (*Surcula*) *panthea* Dall (1919, p. 4, pl. 1, fig. 6 [not fig. 5 as printed]), not *Turricula* (*Surcula*) *lavinia* Dall (Idem, p. 4, pl. 1, fig. 5 [not fig. 6 as printed]). Marks was misled by errors in Dall's publication, involving transposition of figure numbers on page 4 and in the explanation of plate 1. *Turricula lavinia* is a clavine species, not turriculine. Marks was not the first paleontologist to be misled by these errors. Olsson (1922, p. 55, pl. 4, fig. 6) named a Miocene Costa Rican species as *Turricula lavinoides* on account of the supposed relation to the alleged *Turricula lavinia*. The Miocene species, however, is a species of the living Panamic genus *Knefastia*. I am indebted to Dr. K. V. W. Palmer for forwarding Marks' illustrated specimen of *Cruziturricula cruziana*, and to Dr. L. G. Hertlein for forwarding the shell illustrated by Marks as *Cruziturricula arcuata* (Dall).

Pleurofusia (Cruziturricula) fusinus fusinus (Brown and Pilsbry)

Plate 57, figures 16, 21; plate 65, figure 4

Drillia fusinus Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 344, pl. 23, fig. 7, 1911 (Miocene, Canal Zone).

Fusiturricula latira Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 94, pl. 20, fig. 4, 4a, 1964, (Miocene, Ecuador).

Moderately large, *Fusinus*-like in outline and sculpture; pillar long and slender. Protoconch blunt, almost flat-topped, 1¾- to 2-whorled, last ¼ to 1 whorl carinate below middle of whorl, bearing fine, arcuate axial riblets above carina. End of protoconch marked by strengthening of carina to form lower peripheral spiral thread, and appearance of upper peripheral and subsutural spiral threads, and closely spaced, wide axial swellings. Upper peripheral spiral thread gradually strengthened to become as strong as lower. On spire whorls these two peripheral primary spiral threads slightly to decidedly stronger than subsutural primary, decidedly stronger than primary thread at lower edge of depressed sutural area, and slightly stronger than primary thread below periphery. Secondary spiral threads, generally of two ranks, on early post-protoconch and later whorls. Axial sculpture consisting of low, wide swellings, generally weaker on body whorl (or last two whorls), or narrower and lower on part of body whorl. Anal sinus, as shown by growth lines, asymmetric; upper limb short, lower limb long. Interior of outer lip lirate.

Height (incomplete) 45.7 mm, diameter (incomplete) 13.5 mm (larger figured specimen). Estimated restored height 60 mm, estimated restored diameter 16 mm (largest specimen).

Type: Acad. Nat. Sci. Phila. 1693.

Type locality: Gatun Locks site, Canal Zone, middle part of Gatun formation.

Variation, on a minor scale, affects the strength of primary spiral threads with reference to the two on the periphery and the strength of axial swellings on the last whorl or two. The outer lip and the long slender pillar are invariably broken. On the type and a few other shells, one of which is shown on plate 57, figure 16, the pillar is practically complete. The lirae on the interior of the outer lip appear at intervals on the inside of the body whorl, corresponding to former positions of a fully developed outer lip. The readily recognizable protoconch—so blunt that it is almost flat-topped—is preserved on 36 of the 141 specimens. If it is even slightly worn, the fine axial riblets disappear.

This turrid is widespread in the Gatun formation, but was not found in the upper part in the western area. The largest collections are those from the lower part at locality 138c and the upper part in the eastern area at locality 175: 34 and 16 specimens, respectively. It has been found in two other Panamá areas: in Darién (USGS 8433) and Chiriquí (USGS 7955).

Turris albida sanctidavidis (Maury, 1925, p. 188, pl. 32, figs. 6, 7), which is widespread in the late middle Miocene San José calcareous silt member of the Manzanilla formation of Trinidad, is classified as a scarcely distinguishable subspecies of *P. fusinus*. Fifty specimens are represented in 14 USNM collections. It is considerably smaller than the nominate subspecies, as the maximum height ranges from 40 to an estimated 45 mm. The axial swellings generally disappear on the third to fifth post-protoconch whorl. Two exceptional shells, however, on which they disappear on the seventh and ninth whorl, are indistinguishable from immature shells of the nominate subspecies. *P. fusinus sanctidavidis* occurs also in the late Miocene Melajo clay member of the Springvale formation of Trinidad (USGS 21178, 18634). On the four specimens that show the early sculpture the swellings disappear on the third or fourth whorl.

The specimen illustrated by Maury in her figure 7 (Paleontological Research Inst. 1008) is herewith selected as the lectotype.

Except for its blunt protoconch of fewer whorls, larger size of shell, and larger apical angle, *Pleuro-*

fusia fusinus fusinus resembles the Oligocene species *Pleurotoma vicksburgensis* Casey (1903, p. 268, Harris, 1937, p. 51, pl. 10, fig. 3; Harris and Palmer, 1946–47, pl. 59, fig. 22, 1947; height 27 mm), from the Byram marl. The acute, polygyrate protoconch of *Pleurofusia vicksburgensis* was described by Casey, and is shown in Harris and Palmer's illustration, and also in Harris' (1937, pl. 10, fig. 5) illustration of a fossil cited as *P. servata.* Casey, however, attributed the carinate and axially sculptured part to the earliest post-protoconch stage. Despite the difference in protoconch, *P. vicksburgensis* and *P. fusinus fusinus* are considered to be closely related. *P. latira* is indistinguishable from *P. fusinus fusinus.* The axial swellings of *P. cruziana* (Olsson, 1932, p. 150, pl. 15, figs. 6, 10; Marks, 1951, p. 131, pl. 8, fig. 6) are more subdued than those of *P. fusinus fusinus.*

The early Miocene *P. glypta* (Gardner) (1926–47, p. 293, pl. 38, fig. 34, 1938; Chipola formation, height 25.3 mm) is not closely related to any of the other species of *Cruziturricula.* Its last protoconch whorl merges into the first post-protoconch whorl. The first three post-protoconch whorls are unicarinate, angulated by the continuation of the protoconch carina, and bear four weak spiral threads above the carina. Low axial swellings appear on the lower part of the third whorl. The type of *P. glypta* is the only specimen now in Gardner's collections, although an additional locality was cited. The protoconch of the type is worn. The preservation is better on two minute shells (USNM 644754) in C. R. Locklin's collection from the type locality: McClelland's farm, Calhoun County, Fla.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137a, 138, 138a, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139b, 139c, 142, 146, 147b, 147f, 147g, 151, 155, 155b, 155c, 157, 159, 159d; western area, locality 161c. Upper part, eastern area, localities 173a, 175, 176, 177b. Middle Miocene deposits, Darién and Chiriqui areas, Panamá. Angostura formation (middle Miocene), Ecuador.

Genus Leucosyrinx Dall

Dall, Harvard Coll. Mus. Comp. Zoology Bull., v. 18, p. 75, 1889.

Type (orthotype): *Pleurotomella verrillii* (Dall) (*Pleurotoma* (*Pleurotomella*) *verrillii*), North Carolina and eastern Gulf of Mexico.

Leucosyrinx xenica Woodring, n. sp.

Plate 57, figure 15

Small for the genus, very slender, anal fasciole barely constricted, forming a steep ramp. Protoconch blunt 1¾-whorled, last whorl carinate, the carina gradually retreating toward base, end marked by gradual appearance of sculpture. First post-protoconch whorl sculptured with 10 swollen axial ribs, strong only on periphery, fadng out on anal fasciole, subdued toward base of whorl. Nine ribs on antepenult whorl. Ribs lower, wider, and gradually fading out on penult, absent on body whorl, except a slight swelling at beginning of whorl. Spiral sculpture obscure on first post-protoconch whorl, gradually strengthened on succeeding whorls, consisting of closely spaced, narrow threads of unequal width, subdued on anal fasciole. Outer lip broken back. As shown by growth lines, anal sinus wide, adjoining suture, upper limb short, lower limb long. Aperture long, narrow. Siphonal canal not notched, according to growth lines. Siphonal fasciole not inflated.

Height 15.4 mm, diameter 4.9 mm (type).

Type USNM 645768.

Type locality: 185 (USGS 8383, Caribbean coast, west of Río Miguel, station 26 plus 100 feet (30 m), Panamá), upper part of Gatun formation.

The type, the only specimen of this unusual turrid, was found in the upper part of the Gatun formation in the western area. The combination of barely constricted anal fasciole, disappearing axial sculpture, and fairly strong spiral sculpture is unique in the genus. Only two other species are known in the Tertiary Caribbean province: *Leucosyrinx chloris* Olsson (1922, p. 59, pl. 5, fig. 19; Limón formation, Bocas del Toro area, Panamá) and *L. nicoya* Olsson (1942, p. 57, pl. 12, fig. 2; Charco Azul formation, southwestern Panamá), and none in southeastern United States.

Leucosyrinx is basically a deep-water genus. It has been dredged in western Atlantic waters at depths of 90 to 1,180 fathoms, for the most part between 300 and 800. It is improbable, however, that the fossils from the type locality of *L. xenica* represent a depth greater than 100 fathoms, if that much.

Occurrence: Upper part of Gatun formation (middle Miocene), western area, locality 185.

Genus Cochlespira Conrad

Conrad, Am. Jour. Conchology, v. 1, p. 19, 1865.

Type (monotype): *Pleurotoma cristata* Conrad, Oligocene, Mississippi.

During recent years *Cochlespira engonata* Conrad generally has been accepted as the type species. That species and *Pleurotoma cristata* were assigned to *Cochlespira* by Conrad. In 1913, however, Vincent (1913, p. 25) pointed out that *Cochlespira engonata* was a nude name when *Cochlespira* was proposed, and was not validated until three (actually a little more than four) months later (Conrad, 1865, p. 142; Conrad,

1865a, p. 210, pl. 21, fig. 12). *Pleurotoma cristata* therefore is the monotype. *Cochlespira engonata* is the type of *Cochlespiropsis* (Casey, 1904, p. 143; logotype, designated by Cossmann, 1906, p. 221).

Cochlespira? species

A fragment of 2½ incomplete whorls, found in the moderately deep-water facies of the Caimito formation on Barro Colorado Island, probably represents *Cochlespira*. The peripheral frill is slightly upturned. It is faintly noded, but if it had been serrate, the spines are gone. A faint spiral thread lies in the concavity between the frill and the suture, closer to the frill than to the suture. The penult whorl has a height of about 1.5 mm.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 54g.

Subgenus Ancistrosyrinx Dall

Dall, Harvard Coll. Mus. Comp. Zoology Bull., vol. 9, p. 53, 1881.

Type (monotype): *Ancistrosyrinx elegans* Dall, living, West Indies.

The protoconch of *Ancistrosyrinx* is about 1½-whorled and bluntly tipped, whereas the protoconch of *Cochlespira* is about 2½-whorled and has an acute tip. The peripheral frill of *Ancistrosyrinx* is more strongly upturned than that of *Cochlespira*, producing a deeper concavity between the frill and the suture. These are minor differences. Nevertheless Harris' (1937, p. 45) suggestion that a group of species, ranging in age from middle Eocene to the present time, may be assigned to *Ancistrosyrinx* as a subgenus of *Cochlespira* is adopted.

Cochlespira (Ancistrosyrinx) cedonulli (Reeve)

Plate 57, figures 9, 10

Pleurotoma cedo-nulli Reeve, Zool. Soc. London Proc., p. 185, 1843 (Recent, Panamá). Reeve, Conchologia iconica, v. 1, *Pleurotoma*, species 117, figs. 117, 117a, 1843 (living, Panamá).

Ancistrosyrinx cedonulli reevi Olsson, Bull. Am. Paleontology, v. 27, no. 106, p. 53, pl. 10, fig. 4, 1942 (Pliocene, Costa Rica). Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 111, pl. 15, fig. 5, 1964 (Miocene or Pliocene, Ecuador).

Pleurotoma miranda Guppy, Sci. Assoc. Trinidad Proc., v. 2, no. 4, pt. 12, p. 178, pl. 7, fig. 19, 1882 (Miocene, Jamaica); reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 99, pl. 5, fig. 19, 1921.

Ancistrosyrinx miranda (Guppy), Woodring, Carnegie Inst. Washington Pub. 385, p. 165, pl. 6, figs. 1–3, 1928 (Miocene, Jamaica). Perrilliat Montoya, México Univ. Nac., Inst. Geología Paleontología Mexicana, no. 8, p. 29, pl. 4, figs. 11, 12, 1960 (Miocene, México).

Ancistrosyrinx dalli Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 60, pl. 4, fig. 16, 1922 (Miocene, Panamá).

Of medium size, moderately inflated. Protoconch about 1½-whorled, tip broken. First post-protoconch whorl bearing discrete, swollen nodes. With further growth nodes joined and extended into flat triangular spines, forming serrate peripheral frill. Spines more or less broken on intermediate and late whorls. A spiral thread, appearing near upper base of frill on third post-protoconch whorl, gradually becoming stronger and sharply raised, and gradually shifted backward until at aperture it is almost halfway between frill and suture. An obscure spiral thread on body whorl emerging at upper end of aperture. Pillar bearing weak spiral threads. Anal sinus very deep, lying between suture and spiral cord.

Height (incomplete) 19.3 mm, diameter (spines broken) 10.2 mm (figured specimen).

Type: British Museum (Natural History).

Type locality: Panamá Bay, living.

A minute shell from the middle part of the Gatun formation and the figured specimen from the upper part in the eastern area are referred to *Cochlespira cedonulli*.

Three living American species of the subgenus *Ancistrosyrinx* are recognized: *Cochlespira elegans* Dall (1881, p. 54; 1889, p. 78, pl. 38, fig. 3) and *C. radiata* Dall (1889, p. 78, pl. 12, fig. 12) in the Caribbean region, and *C. cedonulli* in the Panamic region. *C. elegans* (height 32 mm, depth range 260 to 805 fathoms) is sculptured below the frill with strong, noded spirals. The corresponding spiral threads of *C. radiata* (height 25 mm, depth range 22 to 170 fathoms) are nonnoded and moderately strong. *C. cedonulli* (height 23 mm, depth range 10 to 153 fathoms) lacks spiral threads between the frill and the pillar, except that on some specimens, both living and fossil, an obscure thread emerges at the upper end of the aperture.

These three species appeared abruptly in the middle Miocene sea of the present Caribbean region. The Miocene representatives of both living Caribbean species, however, are smaller than living shells. Whether the small fossils are to be considered as a small predecessor race or as immature is uncertain until larger samples are available. The occurrence of only small specimens of *C. cedonulli* at some fossil localities suggests that the small specimens of all three species are immature. Four small specimens of *C. elegans* (maximum height 17 mm) have been found in Costa Rica—Olsson's (1922, p. 60, pl. 4, fig. 17) *Ancistrosyrinx elegans*, variety—and in the Cercado and Gurabo formations of the Dominican Republic. The Gurabo formation yielded also a small specimen (height 18 mm) of

C. radiata. A small shell (height 12 mm) in Spencer's collection of deep-water Miocene fossils from Tehuantepec has a strong spiral thread emerging at the upper end of the aperture and the thread is flanked on both sides by a smooth space. Should this type of sculpture prove to be consistent, treatment as a subspecies of *C. radiata* would be warranted. Böse's (in Böse and Toula, 1910, p. 251, pl. 13, fig. 26) *Pleurotoma* (*Ancistrosyrinx*) aff. *radiata*, from the same locality, evidently is not a species of *Cochlespira.*

C. cedonulli is fairly widespread in middle Miocene deposits: Jamaica, the Tehuantepec area of México, Costa Rica, and Panamá. Small Jamaican specimens (maximum height 13 mm) were named *Pleurotoma miranda.* They are slender, but not more slender than an immature living shell of *C. cedonulli* (USNM 96801). The fossils from the Tehuantepec area are comparable in size to Jamaican specimens; those from Costa Rica and Panamá are of medium size (20 mm and about 21 mm, respectively). The largest fossils (height 35 to 43 mm), larger than any available living shell, occur in the present Panamic region: in the Esmeraldas formation of Ecuador and the Charco Azul formation of southeastern Costa Rica.

Though the pattern of former distribution and survival shown by *C. cedonulli* is unusual at the specific level, it is common at subgeneric and generic levels.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 147b. Upper part, eastern area, locality 177b. Bowden formation (middle Miocene), Jamaica. Middle Miocene deposits, Tehuantepec area, México, Costa Rica. Limón formation (late Miocene), Bocas del Toro area, Panamá. Esmeraldas formation (late Miocene or Pliocene), Ecuador. Charco Azul formation (Pliocene), Costa Rica. Living, Mazatlan, México, to Panamá Bay.

Subfamily BORSONIINAE

Genus Scobinella Conrad

Conrad, Acad. Nat. Sci. Phila. Jour., 2d ser., vol. 1, p. 120, 1848. Type (monotype): *Scobinella cælata* Conrad, Oligocene, Miss.

In southern United States *Scobinella*, an extinct endemic American genus, has an age range of Eocene to Oligocene, but in the Tertiary Caribbean province it survived until the end of Miocene time. The Eocene and Oligocene species heretofore described have a height of 10 to 35 mm, whereas the Miocene species are larger: height 42 to 70 mm. The Miocene species have been reviewed recently by Olsson (1964, p. 114–117).

Scobinella morierei (Cossmann)

Plate 58, figures 26, 27

Euchilodon Moricrei Laville mss., Cossmann, Jour. Conchyliologie, v. 61, p. 34, pl. 3, figs. 6, 7, 1913 (Miocene, Canal Zone).

Scobinella Morierci (Laville) Cossmann, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 79, pl. 4, figs. 3, 4, 1922 (Miocene, Panamá).

Scobinella morierei(?) (Laville), Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 131, pl. 8, figs. 6, 7, 1929 (Miocene, Colombia).

Scobinella morierei (Cossmann), Olsson, Neogene mollusks from northwestern Ecuador, p. 115 (in discussion), pl. 19, figs. 4, 4a, 1964 (Miocene, Panamá).

Scobinella morieri gavilanensis Rutsch, Eclogæ Geol. Helvetiæ, v. 23, p. 611, pl. 17, figs. 8, 9, 1930 (Miocene, Venezuela). Rutsch, Schweitzer. Palæont. Gesell. Abh., v. 55, no. 1, pl. 8, fig. 17, text fig. 13, 1934 (Miocene, Venezuela).

Not *Scobinella morierei* (Laville) Cossmann, Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 193, pl. 34, fig. 1, 1925 (Miocene, Trinidad).

Not *Scobinella morierei* (Laville), Perrilliat Montoya, México Univ. Nac. Inst. Geología Paleontología Mexicana, no. 8, p. 28, pl. 4, figs. 7, 8, 1960 (Miocene, México).

Moderately large, slender, turreted, anal fasciole strongly constricted. Protoconch not preserved. Sculpture of earliest preserved whorls consisting of a noded sutural band; arcuate axial threads on anal fasciole; closely spaced protractive axial ribs, noded by two peripheral spiral cords and a narrower cord at base of whorl. Sculpture of later whorls consisting of retractive nodes on sutural band; two closely spaced rows of small nodes on anal fasciole (three on-body whorl), arranged in axially arcuate pattern; coarsely noded shoulder cord, bilirate on last 2½ whorls, upper part wider and more coarsely noded than lower part; and up to body whorl two or three noded spiral cords similar to narrow lower part of shoulder cord. Nodes arranged in protractive pattern. On pillar nodes progressively suppressed toward siphonal fasciole. Anal sinus and siphonal notch moderately deep, as shown by growth lines. Interior of outer lip lirate. Columella bearing two widely spaced upper folds and two closely spaced, weak lower folds. Siphonal fasciole slightly inflated, bearing a few widely spaced, weak spiral threads.

Height (almost complete) 37 mm (estimated height 42 mm), diameter (incomplete) 12.5 mm.

Type: Ecole des Mines, Paris.

Type locality: Mindi, Panama Canal, Canal Zone, upper part of Gatun formation.

The description is based on an almost complete specimen of moderate size from the lower part of the Gatun formation—the only specimen in the collections now being studied. The type (height 42 mm) was col-

lected at an outcrop of the upper part of the Gatun in the Mindi area near locality 172.

Scobinella morierei occurs also in the late Miocene Limon formation at Limón, Costa Rica, and on islands of the nearby Bocas del Toro Archipelago, Panamá. The change from arcuate axial threads to small nodes on the anal fasciole takes place two or three whorls earlier on these late Miocene shells than on the Gatun specimen. Shells from Costa Rica (Olsson, 1964, pl. 19, fig. 4a) are decidedly less turreted than the Gatun form; those from the Bocas del Toro area (Olsson, 1922, pl. 4, figs. 3, 4; 1964, pl. 19, fig. 4) are somewhat less turreted.

The sutural band of Maury's Trinidad specimen is bipartate or tripartate and swollen, so that it affects the whorl profile. As suggested by Olsson (1964, p. 115), the illustrations of *S. morieri gavilanensis* indicate no features to substantiate that subspecies. If Anderson's *Scobinella* is *S. morierei* the age range of the species is early to late Miocene.

Though the early and middle Miocene Ecuadorean *S. onzola* Olsson (1964, p. 116, pl. 19, figs. 2, 2a, 2b) reaches a slightly larger size (estimated height 58 mm) and is slightly more coarsely noded, it is very similar to *S. morierei.*

The flat-sided, biconic Mexican *Scobinella*, recorded as *S. morierei*, is relatively small for a Miocene species (height 38 mm). A slightly smaller, more slender, biconic species occurs in the Brasso formation of Trinidad (USGS 21234).

The name *Scobinella morierei* is to be attributed to Cossmann. According to his statement (1913, p. 36), there is no indication that he published Laville's description of the species. Where or how Cossmann picked up the trivial name is irrelevant.

Occurrence: Lower and upper parts of Gatun formation (middle Miocene). Lower part, locality 138a. Upper part, Cossmann's record. Las Perdices shale (early Miocene), Colombia. Limón formation (late Miocene), Costa Rica, and Bocas del Toro area, Panamá. Punta Gavilán formation (late Miocene), Venezeula.

Scobinella aff. S. morierei (Cossmann)

Three defective specimens establish the presence of *Scobinella* in the moderately deep-water facies of the Caimito formation on Barro Colorado Island. So far as the meager material goes, this Oligocene *Scobinella* is closely allied to *S. morierei*, but the shoulder nodes are more widely spaced. The largest of these incomplete specimens has a height of 30 mm and an estimated total height of about 40 mm; that is, comparable to *S. morierei* and larger than any other known Oligocene species.

Occurrence: Caimito formation (late Oligocene), Barro Colorado Island, localities 54h, 54m.

Scobinella ecuadoriana Olsson

Plate 62, figures 33, 34

Scobinella ecuadoriana Olsson, Neogene mollusks from northwestern Ecuador, p. 117, pl. 19, figs. 1, 1a, 1b, 1964 (Miocene, Ecuador).

The Chagres sandstone yielded an incomplete large *Scobinella* identified as *S. ecuadoriana.* It shows the most distinctive feature of that species: large nodes on the shoulder, immediately below the anal fasciole, even on the penult whorl, as well as on the body whorl. The interior of the outer lip is lirate and the columella bears four folds, arranged like those of *S. morierei.* The height of the body and penult whorls is 43.4 mm, indicating a total height of about 63 mm.

S. ecuadoriana is a large species, but not as large as the appropriately named middle Miocene *S. magnifica* (Gabb) (Olsson, 1964, p. 115, pl. 19, figs. 3, 3a), which occurs in the Dominican Republic and Jamaica (height 70.5 mm).

Occurrence: Chagres sandstone (late Miocene), locality 208. Esmeraldas formation (late Miocene), Ecuador.

Genus Paraborsonia Pilsbry

Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 326, 1922.
Type (orthotype): *Borsonia* (*Paraborsonia*) *varicosa* (Sowerby) (*Mitra varicosa* Sowerby), Miocene, Dominican Republic.

Paraborsonia is another extinct endemic American borsonine genus. Its age range is late Oligocene to late Miocene, but early Miocene species are as yet unknown.

Paraborsonia aff. P. brassoensis (Mansfield)

Small, biconic, anal fasciole not constricted, pillar short. Protoconch and about first two post-protoconch whorls missing. Remaining spire whorls bearing a sutural groove; a sutural cord sculptured with axially elongate nodes, separated by a groove from a wide band sculptured with axially elongate nodes and traces of obscure spiral sculpture. Noded band of body whorl bilirate: two low spiral threads overriding nodes. Remainder of body whorl up to pillar sculptured with primary and secondary noded spiral threads. Spiral threads on pillar not noded. Tip of pillar missing. Apex of anal sinus on wide noded band, as shown by growth lines. Interior of outer lip and columella inaccessible.

Height (incomplete) 8.5 mm (estimated height 12 mm), diameter (incomplete) 5.5 mm.

An incomplete, crushed specimen from the moderately deep-water facies of the Caimoto formation on Barro Colorado Island is identified as the earliest known species of *Paraborsonia*. If it is mature, it is also the smallest species. Though the shell is too fragile to attempt to expose the columella, in other features it is a *Paraborsonia* closely allied to the middle Miocene Trinidad species *P. brassœnsis* (Mansfield, 1925, p. 30, pl. 5, fig. 8). The wide band of that species is bilirate at an earlier stage. Like *Microdrillia trina* (p. 389), *P. brassœnsis* was based on float material, but is represented by some 40 outcrop specimens from USGS locality 21234 on Mayo River: the same locality that yielded an adequate sample of *Microdrillia trina*. *P. brassœnsis* occurs also in the San José calcareous silt member of the Manzanilla formation (USGS 21231).

Heretofore *Paraborsonia* was known in the middle Miocene deposits of the Dominican Republic and Trinidad, and in late Miocene in the Bocas del Toro area, Panamá. *Borsonia* (*Paraborsonia*) *centaurana* (Jung, 1965, p. 572, pl. 77, figs. 11–14; middle Miocene, Venezuela) is not a *Paraborsonia*.

Occurrence: Caimito formation (late Oligocene), Barro Colorado Island, locality 54k.

Subfamily CLAVINAE

Genus Drillia Gray

Gray, Ann. Nat. History, v. 1, p. 28, 1838.

Type (logotype, Gray, Zool. Soc. London Proc., p. 134, 1847): *Drillia umbilicata* Gray, living, West Africa.

The type species has been well illustrated by Bartsch (1943, p. 82, pl. 7, fig. 5, pl. 10, fig. 7).

Subgenus Neodrillia Bartsch

Bartsch, Soc. Cubana Historia Nat. Felipe Poey, Mem., v. 17, p. 83, 1943.

Type (orthotype): *Neodrillia cydia* Bartsch, living, North Carolina to Florida and West Indies.

The smaller size, more slender outline, lack of an umbilicus, and finer spiral sculpture of *Neodrillia* distinguish it from *Drillia* s.s. *Leptadrillia* (Woodring, 1928, p. 159; type (orthotype): *Turris* (*Surcula*) *parkeri* Gabb, Miocene, Dominican Republic) is more slender than *Neodrillia* and has narrow axial ribs and no spiral sculpture, except on the pillar.

According to Pilsbry and Harbison (1933, p. 112), *Leptadrillia* "differs from *Cymatosyrinx* by its more slender shape and longer anterior canal, but there seems to be no other structural difference." *Leptadrillia*, however, lacks a constricted anal fasciole, deep stromboid notch, deep siphonal notch, and sharp thread limiting the siphonal fasciole—all shown by *Cymatosyrinx* (Dall, 1889, p. 95; type (orthotype): *Pleurotoma lunata* H. C. Lea, Miocene, Virginia). *Cymatosyrinx* is the temperate counterpart of *Clathrodrillia* (p. 381). On morphologic grounds it may be better to assign *Cymatosyrinx lunata aclinica* Tucker and Wilson (1933, p. 13, pl. 4, figs. 6, 7; Olsson and Petit, 1964, p. 537, pl. 82, figs. 5–5b; assigned specific rank), a late Miocene Florida turrid, to a subgenus under *Clathrodrillia* that has no spiral sculpture. A middle Miocene ally of *Cymatosyrinx aclinica* is found in the Tehuantepec area, where it has been recorded as *Cymatosyrinx lunata* (Perrilliat Montoya, 1963, p. 29, pl. 5, figs. 17, 18).

Drillia (Neodrillia) riogurabonis eurysoma Gardner

Plate 58, figures 17, 18; plate 64, figure 2

"Drillia" eurysoma Gardner, U.S. Geol. Survey Prof. Paper 142, p. 316, pl. 40, fig. 10, 1937 (1938) (Miocene, Florida).

Of medium size, moderately inflated, pillar short, whorls not constricted adjoining suture to form an anal fasciole. Protoconch acute, 3– to 3½–whorled, last 1 to 1½ whorls bulging near base. End of protoconch marked by an arcuate riblet, followed by first axial rib. Axial ribs undulating suture except where they are alined and on body whorl, where they are attenuated near suture; alined on first 3 to 4½ whorls; practically straight on about first 3 whorls, slightly arcuate on remaining spire whorls, decidedly arcuate on body whorl; 7 or 8 on all whorls. Last rib wide and high, forming a hump. Spiral sculpture consisting of weak, closely spaced, narrow threads, not discernible on earliest few whorls. Outer lip broken back. Anal sinus moderately deep, as indicated by growth lines; upper limb heavily bordered. Stromboid notch very shallow, according to growth lines. Siphonal notch moderately deep. Siphonal fasciole slightly inflated, sculptured with spiral threads, stronger and more widely spaced than those elsewhere.

Height (practically complete) 11.8 mm, diameter (including hump) 4.6 mm (larger figured specimen).

Type: USNM 351188.

Type locality: USGS 3856, 5 to 6 miles west-northwest of Mossyhead, Walton County, Florida, Shoal River formation.

The larger figured specimen, on which the earliest part of the protoconch is missing, is the only practically complete mature shell among the six specimens of this Gatun turrid. Though it is identified as the Florida form, the axial ribs on the early whorls of the two available specimens from the Shoal River formation are not uniformly alined. Gardner realized that her species is closely related to *Neodrillia riogurabonis*

(Maury, 1917, p. 54, pl. 9, fig. 2), found in the Gurabo formation of the Dominican Republic. The nominate subspecies has one or two more axial ribs on late whorls and they are somewhat more attenuated near the suture. As on the Florida specimens, the ribs on early whorls are not uniformly alined. The ribs of the species from the late Miocene Savaneta glauconitic sandstone member of the Springvale formation in Trinidad, identified by Mansfield (1925, p. 24, pl. 3, fig. 8) as *Drillia* aff. *D. riogurabonis* and by Rutsch (1942, p. 166) as *Cymatosyrinx?* sp. ind., are narrower and on late whorls are more decidedly attenuated near the suture. This species is represented in USNM collections, deposited by H. G. Kugler, by better material than that available to Mansfield and Rutsch. The turrids from the Bowden formation of Jamaica described as "*Drillia*" sp. and *Bellaspira?* sp. (Woodring, 1928, p. 162, 163, respectively) represent *Neodrillia*. Though the so-called *Bellaspira?* is poorly preserved, they probably are the same species—a species that is larger and more inflated than *D. riogurabonis*.

The species so far mentioned, and also early Miocene species from the Tampa limestone of Florida and the Thomonde formation of Haiti (USGS 9945), are more similar to the living Panamic species *D. cybele* (Pilsbry and Lowe (1932, p. 46, pl. 2, fig. 6) than to the living Caribbean species *D. cydia*. The sutural area of the Caribbean species is constricted, forming an anal fasciole, and the shell is sculptured with fine, submicroscopically crimped spiral threads. The sutural area of *D. subperpolita* Böse) (*in* Bose and Toula, 1910, p. 246, pl. 13, fig. 22), a late Miocene species from the Tehuantepec area, is constricted, but not as strongly constricted as that of *D. cydia*.

Abbott (1958, p. 96) was justified in placing in synonymy under *D. cydia* the four other living Caribbean species of *Neodrillia* named by Bartsch (1943, p. 84–89) and in rejecting, on the basis of Melvill's illustration, Bartsch's identification of the Cuban species *D. euphanes* Melvill (1923, p. 164, pl. 4, fig. 4). If Bartsch's identification were correct, *D. cydia*, the type species of *Neodrillia*, would be a synonym of *D. euphanes*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 139b; western area, locality 162. Shoal River formation (middle Miocene), Florida.

Drillia? (Neodrillia?) species

The upper part of the Bohio formation of Barro Colorado Island yielded an incomplete minute clavine turrid consisting of the protoconch and four post-protoconch whorls, all replaced by calcite. The apertural face of the penult and body whorls is missing. The protoconch is acute and 3–whorled. The post-protoconch whorls are almost flat-sided and are sculptured with eight strong, straight axial ribs that are alined or almost alined. The anal fasciole is not constricted and spiral sculpture is not discernible. The height, minus the pillar, is 4 mm, and the diameter, minus the outer lip, 2mm.

Despite the absence of spiral sculpture, the outline, protoconch, and style of ribbing point to *Neodrillia*. The absence of spiral sculpture may be due to masking by the replacing calcite, or the specimen may be immature. If it is *Neodrillia*, it is the earliest species, possibly a small primitive species.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d.

Genus Carinodrillia Dall

Dall, U.S. Natl. Mus. Proc., v. 56, p. 17, 1919.
Type (orthotype): *Clathrodrillia halis* Dall, living, Gulf of California to Manzanillo, México.

Subgenus Carinodrillia s.s.

Carinodrillia, like *Pleurofusia*, has *Fusinus*-like sculpture. It appeared in early Miocene time and survives in the western Atlantic and eastern Pacific oceans.

The subgenus *Carinodrillia* s.s. embraces species of medium to moderately large size. The type and other species, including *C. zooki*, have an acute, polygyrate protoconch (three to four whorls), the last ¼ to ½ of which bears arcuate axial riblets. The protoconch of other fossil and Recent species, however, is blunt, paucigyrate (about two whorls), and near the end bears a few peripheral axial swellings. The siphonal canal of all the species described in the present report is slightly notched and the siphonal fasciole is slightly inflated.

Several western Atlantic species are characterized by their small size and blunt protoconch of two to three whorls that lack axial sculpture other than faint, crowded, slightly arcuate growth threads. These species are assigned to the subgenus *Buchema* Corea (1934, p. 1; type (orthotype): *Carinodrillia* (*Buchema*) *tainoa* Corea, living, Puerto Rico).

Carinodrillia (Carinodrillia) zooki (Brown and Pilsbry)

Plate 58, figures 9–12; plate 65, figure 9

Drillia zooki Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 345, pl. 23, fig. 18, 1911 (Miocene, Canal Zone).
Drillia (*Crassispira*) *zooki* Brown and Pilsbry, Cossmann, Jour. Conchyliologie, v. 61, p. 23, pl. 3, figs. 8, 9, 1913 (Miocene, Canal Zone).
Not *Drillia zooki* Brown and Pilsbry, Li, Geol. Soc. China Bull., v. 9, p. 275, pl. 8, fig. 71, 1930 (Miocene, Panamá Bay); = *Clathrodrillia alcestis* Dall, fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 434, 1931 (Living, Panamá Bay).

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Of medium size, slender, *Fusinus*-like, aside from short pillar. Protoconch acute, 3– to 4–whorled, last ¼ to ½ whorl bearing 3 to 7 arcuate riblets terminating on or below the swollen, almost carinate periphery. End of protoconch marked by abrupt appearance of axial and spiral sculpture. First post-protoconch whorl sculptured with 6 to 8 closely spaced, wide, swollen axial ribs and 3 spiral threads: 1 sutural and 2 peripheral. Axial ribs on late whorls moderately swollen and fading out on lower part of anal fasciole, or strongly swollen and modifying outline of lower part of anal fasciole; 8 to 10 ribs on penult whorl. Spiral sculpture of late spire whorls consisting of a sutural thread and generally 3 other widely spaced primary threads overriding axial ribs; a fourth thread exposed at base of whorl on some specimens. Sutural thread strong on all whorls or relatively weak. In addition to sutural thread, 15 to 17 primary threads on body whorl, those on pillar more closely spaced and weaker than elsewhere. Microscopic secondary spiral threads and exaggerated growth threads visible on late whorls. An axial rib near outer lip widened to form a hump; ribs absent between hump and lip. Anal sinus deep, border of upper limb somewhat thickened.

Estimated restored height 25 mm, diameter (including hump) 8 mm (largest specimen). Height 19.8 mm, diameter (including hump) 6 mm (figured strongly sculptured specimen).

Type: Acad. Nat. Sci. Phila. 1695.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The 20 specimens from the three parts of the Gatun formation in the eastern area identified as *Carinodrillia zooki* show a wide range of variation, chiefly affecting the strength of the axial ribs and sutural spiral thread. The type is an incomplete specimen that has subdued sculpture, like that shown on plate 58, figures 9, 10, whereas plate 58, figures 11, 12, shows strong sculpture. Other shells, however, are more or less intermediate. The suppression of axial ribs on the lower part of the anal fasciole of specimens that have subdued sculpture produces the effect of a wide fasciole.

This slender species is more similar to *C. haliostrephis* (Dall) (1889, p. 86, pl. 13, fig. 3), dredged northwest of Alacran Reef off Yucatán at a depth of 84 fathoms, than to any of the described fossil species. The primary spiral threads of the living species are more delicate. The protoconch of the type (the only available specimen) is blunt and paucigyrate: 1¾ whorls. It shows a suggestion of a few axial riblets, but is worn. The primary spiral threads of *C. felis* Olsson (1964, p. 102, pl. 19, fig. 6), a middle to late Miocene, or early Pliocene, species from Ecuador, are more widely spaced and fewer (12 on body whorl), except on the penult whorl.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138a. Middle part, eastern area, localities 139b, 139e, 146, 147b, 147f, 147g, 155c, 157, 159d. Upper part, eastern area, localities 173, 175.

Carinodrillia (Carinodrillia) cf. C. elocata (Pilsbry and Johnson)

Plate 58, figures 13, 14

Moderately large, moderately slender, pillar moderately long, anal fasciole constricted. Protoconch and early post-protoconch whorls missing. Earliest preserved whorls partly corroded. Axial ribs wide, swollen; 6 on penult and body whorls. A sutural primary spiral thread and 4 others on penult whorl; 19 others on body whorl, one of which is replaced by 2 weaker threads. A strong secondary spiral thread at lower edge of anal fasciole. Submicroscopic secondary spiral threads on noncorroded whorls; those on late half of body whorl strengthened. Exaggerated growth threads here and there, especially on late half of body whorl. Last axial rib widened to form a hump. Outer lip broken back. Upper limb of anal sinus heavily bordered. Aperture moderately long.

Height (almost complete) 26.8 mm, diameter (including hump) 9.8 mm (figured specimen).

One specimen of this species is in a collection from the middle part of the Gatun formation. It is more slender than *Carinodrillia elocata* (Pilsbry, 1922, p. 318, pl. 16, fig. 9; Gurabo formation, Dominican Republic) and has stronger secondary spiral sculpture.

It has been claimed that *C. winchesteræ* Pilsbry (1922, p. 318, pl. 16, figs. 7, 8), also from the Dominican Republic, is an unusually slender, long-canaled form of *C. elocata* (Woodring, 1928, p. 155), but it doubtless is a distinct species, as Pilsbry thought.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139c.

Carinodrillia (Carinodrillia) species

Plate 63, figure 5

Moderately large, moderately slender, pillar moderately long, anal fasciole strongly constricted. Protoconch and early post-protoconch whorls missing. Axial ribs moderately wide, swollen; 8 on penult and body whorls. Sutural primary spiral thread closely hugging suture. Four other primary spiral threads on penult whorl; 11 on body whorl. Submicroscopic secondary spiral threads on noncorroded parts; those on anal fasciole fainter than elsewhere. A strong secondary thread at lower edge of anal fasciole. Last axial rib

higher and wider than others, forming a narrow hump. Outer lip broken back. Upper limb of anal sinus heavily bordered. Aperture moderately long.

Height (almost complete) 27.6 mm, diameter (including hump) 10.3 mm.

An unnamed clavine turrid from the Chagres sandstone is represented by an imperfect specimen. The entire apertural face of the shell and part of the adapertural face are corroded. The relatively narrow axial ribs and strongly constricted, weakly sculptured anal fasciole are distinctive. This species evidently is new and has no known close allies.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Genus Darbya Bartsch?

Bartsch, Smithsonian Misc. Colln., v. 91, no. 2, p. 22, 1934.
Type (orthotype): *Darbya lira* Bartsch, living off north coast of Puerto Rico.

Subgenus Buridrillia Olsson?

Olsson, Bull. Am. Paleontology, v. 27, no. 106, p. 51, 1942.
Type (orthotype): *Clathrodrillia panarica* Olsson, Pliocene, Pacific coast of Central America straddling Costa Rica-Panamá boundary.

Though the protoconch of *Buridrillia* is unknown and *Darbya* is so far represented by only the type species, Powell (1966, p. 63) was justified in pointing out their close alliance and possible identity. As matters now stand, the species of *Buridrillia* are moderately large and inflated, whereas the single species of *Darbya* is small and slender. Not all species of *Buridrillia* have a columellar swelling and only one of the five specimens of *Darbya lira* shows that feature. This peculiar swelling is hardly comparable to the columellar plaits of the borsonines and does not belie the clavine features.

A worn corroded shell, dredged at a depth of 134 fathoms near Cocos Island (USNM 106888), is indistinguishable from the type species of *Buridrillia*, so far as it goes. Cocos Island is off Coiba Island, in the Pacific coastal waters of Panamá.

Darbya? (Buridrillia?) species

Plate 63, figures 6, 7

Small, moderately slender, whorls strongly inflated, pillar of moderate length. Protoconch and early postprotoconch whorls missing. Anal fasciole constricted. Axial ribs wide and widely spaced, attenuated and bent on anal fasciole, 10 on penult whorl. Spiral sculpture consisting of narrow bands, separated by grooves, in which microscopic axial threads are conspicuous. Spiral bands closely spaced on anal fasciole. A hump on body whorl near aperture. Outer lip broken back to hump. Aperture and siphonal canal of moderate length. As shown by growth lines, anal sinus moderately deep; border of upper limb thin. Siphonal fasciole sculptured with closely spaced spiral threads.

Height (incomplete) 15 mm, diameter 6 mm.

A second unnamed clavine species from the Chagres sandstone, like the preceding species, is represented by an imperfect shell. The outer shell layer and therefore the spiral sculpture are corroded on the apertural face of the shell, except on the lower part of the body whorl. The outline, moderately long siphonal canal and other apertural features, so far as they are preserved, suggest a small species of *Buridrillia* that lacks a columellar swelling. The fossil species of the subgenus so far described are found in formations of late Miocene or Pliocene age in Ecuador (Olsson, 1964, p. 98–100) and on the Pacific coast of Central America straddling the Costa Rica-Panamá boundary (Olsson, 1942, p. 51–53). The spiral sculpture of the Chagres species is stronger than that of the described species.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Genus Crassispira Swainson

Swainson, A treatise on malacology, p. 313, 1840.
Type (logotype, Herrmannsen, Indicis generum malacozoorum, v. 1, p. 318, 1847): *Pleurotoma bottæ* Valenciennes *in* Kiener (cited by Swainson as *Pleurotoma Bottæ* Auct.), living, Gulf of California.

Subgenus Crassispira s.s.

Crassispira henekeni has a narrower aperture and less inflated siphonal fasciole than the type species, as well as fewer and wider axial ribs. In number and width of ribs *C. ægis* (Woodring, 1928, p. 151, pl. 4, fig. 12; Bowden formation, Jamaica) is more similar to the type species, but, like *C. henekeni*, has a narrower aperture.

Crassispira (Crassispira) henekeni leptalea Woodring, n. subsp.

Plate 58, figure 19; plate 65, figure 5

Of medium size, slender, aperture long and narrow. Protoconch acute, conical, 3-whorled; end marked by faint arcuate axial riblet. Sculpture consisting of slightly protractive, swollen axial ribs (8 on body whorl), overridden by strong, narrow primary spiral threads (7 or 8 on penult whorl). Subsutural thread strong; anal fasciole below subsutural thread bearing faint secondary spiral threads. Outer lip broken back. Anal sinus wide, apex below subsutural thread. Siphonal fasciole scarcely inflated.

Height (practically complete) 30.6 mm, diameter 9.7 mm (type). Height (almost complete) 34 mm, diameter 10.5 mm.

Type: USNM 645777.

Type locality: 147h (USGS 6442, ½ mile (750 meters) south [southeast] of Gatun, Canal Zone), middle part of Gatun formation.

This subspecies, which is smaller and more slender than the nominate subspecies, and has more sharply chiseled spiral sculpture, is rare. Only two specimens, both from the middle part of the Gatun formation, have been found. It is the first record of the species along the west border of the Miocene Caribbean Sea. The nominate subspecies (Sowerby, 1850, p. 50, pl. 10, fig. 6) occurs in the Cercado and Gurabo formations of the Dominican Republic, but is much more abundant in the Gurabo, and also in middle Miocene deposits in Trinidad, Venezuela, and Colombia. The blunt, cylindrical protoconch is not thought to belie the affinities of the Panamá form.

Crassispira inæquistriata (Li) (Pilsbry, 1931, p. 437, pl. 41, fig. 2), living in Panamá Bay, is the most similar living species. No comparable species is known in the western Atlantic Ocean. The deep-water western Atlantic species *Pleurotoma (Drillia) horrenda* Watson (1886, p. 308, pl. 26, fig. 4) bears a superficial resemblance. Its aperture, however, is wide and its outer lip strongly flaring.

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), localities 147h, 157.

Subgenus Hindsiclava Hertlein and Strong

Hertlein and Strong, Am. Mus. Nat. History Bull., v. 107, p. 227, 1955.

Type (orthotype): *Pleurotoma militaris* Hinds *in* Reeve, living, Baja California to Colombia.

The more slender outline, more numerous and narrower axial ribs, stronger spiral sculpture, narrower aperture, and less inflated siphonal fasciole distinguish *Hindsiclava* from *Crassispira* s.s.

The Oligocene species *Pleurotoma abundans* Conrad (1848, p. 115, pl. 11, fig. 25; Byram marl, Mississippi) is the earliest *Hindsiclava* now known. Conrad's illustration, however, leaves much to be desired.

Crassispira (Hindsiclava) consors consors (Sowerby)

Plate 58, figures 1, 22; plate 65, figure 6

Pleurotoma consors Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 50, 1850 (Miocene, Dominican Republic). Guppy, Idem, v. 32, p. 527, pl. 28, fig. 7, 1876 (Miocene, Dominican Republic).

Drillia consors (Sowerby), Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 345, 1911 (Miocene, Canal Zone). Maury, Bull. Am Paleontology, v. 5, no. 29, p. 53, pl. 8, figs. 15, 16, 1917 (Miocene, Dominican Republic). Maury, N.Y. Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 1, p. 71, 1920 (Miocene, Puerto Rico). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 319, pl. 16, fig. 3, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 61, pl. 4, figs. 8, 10, 13, 1922 (Miocene, Costa Rica, Canal Zone, Panamá). Palmer, Idem, v. 10, no. 40, p. 11, pl. 2, figs. 7, 8, 1923 (Miocene, Costa Rica, Dominican Republic). Maury, Idem, v. 10, no. 42, p. 190, pl. 32, fig. 10, 1925 (Miocene, Trinidad). Maury, Brasil Serviço Geol. Mineral. Mon. 4, p. 203, pl. 12, fig. 5, 1925 (Miocene, Dominican Republic).

Drillia consors (Guppy), Cossmann, Jour. Conchyliologie, v. 61, p. 20, pl. 2, figs. 8–14, 1913 (Miocene, Martinique, Dominican Republic, Canal Zone).

Turris (Crassispira) consors (Sowerby), Rutsch, Schweizer Palæont. Gesell. Abh., v. 55, p. 99, pl. 8, figs. 13–16, 1934 (Miocene, Venezuela).

Crassispira consors (Sowerby), Pflug, Acta Humboldtiana, Geol. Palæontologica ser., no. 1, p. 67, pl. 19, figs. 4, 7, 10, 1961 (Miocene, Dominican Republic).

Crassispira aff. *consors* (Sowerby), Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 565, pl. 76, figs. 14, 15, 1965 (Miocene, Venezuela).

?Crassispira? cf. *Crassispira? consors* (Guppy), Marks, Idem, v. 33, no. 139, p. 135, 1951 (Miocene, Ecuador).

?Drillia consors portoricœnsis Hubbard, N.Y. Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 2, p. 158, pl. 24, figs. 8, 9, 1920 (Miocene, Puerto Rico; not *Drillia portoricœnsis* Hubbard, Idem, p. 159, pl. 24, figs. 11, 12).

?Drillia consors bullbrooki Mansfield, U.S. Natl. Mus. Proc., v. 66, p. 16, pl. 3, fig. 10, 1925 (Miocene, Trinidad).

?Drillia consors trinitatensis Mansfield, Idem, p. 17, pl. 3, figs. 12, 13, 1925 (Miocene, Trinidad).

Turris (Drillia) militaris (Hinds), Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 207, 1873 (Miocene, Dominican Republic). Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 350, 1881 (Pliocene, Costa Rica).

Pleurotoma sp. aff. *P. alesidota macilenta* Dall, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 506, pl. 30, fig. 11, 1911 (Miocene, Canal Zone).

Pleurotoma (Drillia) Dalli Toula, Idem, p. 506, pl. 30, fig. 12, 1911 (Miocene, Canal Zone).

Not Pleurotoma dalli Verrill and Smith, Connecticut Acad. Trans., v. 5, p. 451, pl. 57, figs. 1, 1a, 1882.

Drillia macilenta rectaxis Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 319, pl. 16, figs. 1, 2, 1922 (Miocene, Dominican Republic).

Surcula hobsoni Hanna, California Acad. Sci. Proc., 4th ser., v. 13, no. 10, p. 181, 1924 (substitute name for *Pleurotoma dalli* Toula).

Moderately large, slender, aperture long and narrow. Protoconch acute (apex almost invariably broken), 2½- to 3-whorled, last half whorl slightly or decidedly bulging, end marked by appearance of first axial rib. First 3 to 5 axial ribs narrow, arcuate, extending practically from suture to suture. Later ribs wider, slightly protractive, cut off at anal fasciole. Ribs progressively narrower and more closely spaced. Sculpture of late whorls consisting of skewed rectangles formed by strong, slightly protractive axial ribs (22 to 30 on mature penult whorl) and narrower primary spiral threads (4 or 5 on mature penult whorl),

slightly swollen on crest of ribs. Microscopic spiral threads, crenulated by microscopic growth threads, between primary threads. Anal fasciole dominated by strong subsutural thread, flanked on lower side by secondary and microscopic spiral threads and somewhat exaggerated growth threads, and on upper side by microscopic spiral threads. Subsutural thread and space between it and suture slightly undulated by swellings corresponding in position to axial ribs. Anal sinus wide, moderately deep, apex on lower part of fasciole.

Height (not quite complete) 42.9 mm, diameter 12 mm (larger figured specimen).

Type: British Museum (Natural History) G83972.

Type locality: Valley of Río Yaque del Norte, Dominican Republic, presumably Gurabo formation.

This moderately large turrid is widespread in the Gatun formation. The largest number of specimens were found at localities 138c, 155c, and 175: 15, 20, and 11, respectively. The largest, an incomplete shell from locality 138c, would have a height of about 50 mm, if it were complete, comparable to the height of a large shell from the upper part of the Gatun illustrated by Cossmann (1913, pl. 2, figs. 13, 14). The number and spacing of the axial ribs and the number and strength of the secondary spiral threads on the anal fasciole show minor variation. The subsutural thread of Toula's *Pleurotoma* aff. *P. alesidota macilenta* is split and the lower part itself is doubled. The type of his *Pleurotoma dalli* is an immature shell (height 26.6 mm).

Crassispira consors and the nominate subspecies have been found in many areas in the Miocene and Pliocene Caribbean province. Sowerby's specimens presumably were collected from the Gurabo formation. A lectotype has been designated and illustrated recently by Pflug. Slender specimens in Gabb's Dominican Republic collection were named *Drillia macilenta rectaxis* by Pilsbry. *C. consors consors* reaches a height of about 75 mm in the middle Miocene deposits of southeastern Costa Rica. The axial ribs on the last two whorls of that large specimen and another almost as large, illustrated by Olsson (1922, pl. 4, fig. 8; height 60 mm), are narrow and very closely spaced.

All of the some 100 specimens from the Gatun formation that are not worn or corroded show, between the primary spiral threads, microscopic spiral threads crimped by microscopic growth threads. With few known exceptions, shells from the type region and many other localities have microscopic growth threads, but lack microscopic spiral threads. A late Miocene specimen, collected on a cay off Bluefields Point at the west end of Valiente Peninsula (in the Bocas del Toro area of northwestern Panamá), has microscopic spiral threads, whereas they are absent on two of the same age collected on Swan Cay, off the west end of Bocas Island, 50 km northwest of Bluefields Point. The last two or three whorls of *C. consors bullbrooki* and *C. consors trinitatensis*, both from the middle Miocene part of the Brasso formation of Trinidad, bear one to three microscopic spiral threads, like those of the Panamá fossils, or a little stronger. Both subspecies probably are to be suppressed. All the specimens are small, doubtless immature, and *C. consors trinitatensis* was based on a stream-float collection. Elsewhere the middle Miocene part of the Brasso formation contains moderately large specimens that show faint microscopic threads (USGS 21234, 21240). Should it be considered appropriate to name the Gatun form, *C. consors hobsoni*, which was used by Gardner (1926–47, p. 300, 1938) is available. The name *Surcula hobsoni* was proposed in a wholesale naming of junior homonyms.

The earliest Caribbean fossils of the *C. consors* lineage are of early Miocene age. Those of that age from Haiti, the Dominican Republic, and Venezuela are like small replicas of middle Miocene specimens (height 15 to 25 mm). The Brazilian *C. consors pennæ* (Maury), (1925a, p. 205, pl. 12, figs. 1, 2, 4, 6), however, is large (height 40 mm) and has more ribs than *C. consors consors*. The slightly arcuate ribs shown in Maury's illustrations presumably are due to inaccurate drawing. *Pleurotoma* (*Drillia*) *alesidota magna* Böse (1906, p. 47, pl. 5, figs. 30, 31, 33, 45) may be treated as a middle Miocene Mexican subspecies of *D. consors* that has spiral bands instead of narrower threads.

The status of the lineage in the Miocene of Florida has not yet been carefully evaluated: *Drillia eupora* Dall (1915, p. 42, pl. 5, fig. 3), *Crassispira præconsors* Gardner (1926–47, p. 299, pl. 39, fig. 3, 1938), *C. calligonoides* Gardner (Idem, p. 300, pl. 39, figs. 4, 9), *C. blountensis* Mansfield (1935, p. 22, pl. 1, fig. 11), and *C. antealesidota* Mansfield (1930, p. 39, pl. 2, fig. 10). At least some of the Florida fossils have a shorter, wider aperture and more inflated siphonal fasciole than *C. consors*. This tendency culminates in the unillustrated Pliocene species *C. perspirata* (Dall) (1890–1903, p. 31, 1890).

C. consors left descendants on both sides of Central America: *C. alesidota* (Dall) (1889, p. 84) and *C. macilenta* (Dall) (Idem, p. 85, pl. 36, fig. 1) in western Atlantic waters, and *C. militaris* (Hinds *in* Reeve) (1843, species 55, pl. 7, fig. 55), the type of *Hindsiclava*, in eastern Pacific waters. *C. alesidota* ranges from Cape Hatteras to southern Florida at depths of 35 to 110 fathoms. It has a somewhat less constricted anal

fasciole than *C. consors;* the subsutural spiral thread is weaker; and that thread and the space between it and the suture bear stronger undulations. The protoconch is blunt and 2- to 2¼-whorled. The type of *C. macilenta*, dredged in the northeastern Gulf of Mexico (depth 111 fathoms) is the only specimen of that species in the collections of the U.S. National Museum. It is more slender than *C. consors* and *C. alesidota*, and has a less constricted anal fasciole than either of those species. The secondary threads on the anal fasciole and the swellings on the axial ribs are strong. The protoconch is like that of *C. alesidota.* A specimen of *C. alesidota*, dredged off Cape Hatteras, was identified by Dall as *C. macilenta.* It remains to be seen whether *Hindsiclava* actually has withdrawn from the Caribbean Sea since Pliocene time. *C. militaris* has strong swellings on the axial ribs and fairly strong undulations on the subsutural spiral thread. It occurs in the Esmeraldas formation, of late Miocene age, of Ecuador (Olsson, 1964, p. 97, pl. 17, figs. 3, 3a, 3b).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139c, 139e, 146, 147b, 147f, 147g, 147h, 151, 155, 155a, 155b, 155c, 156, 157, 159d; western area, locality 161a. Upper part, eastern area, localities 172, 173, 175, 176, 176a, 177b; western area, locality 182a. Thomonde formation (early Miocene), Haiti. Baitoa formation (early Miocene), Dominican Republic. Aymamón limestone (early Miocene), Puerto Rico. La Rosa formation (early Miocene), Venezuela. Early Miocene part of Uscari shale, Costa Rica. Gurabo formation (middle Miocene), Dominican Republic. Middle Miocene deposits, Martinique, Trinidad, Venezuela, Costa Rica, Colombia, Darién area, Panamá (USGS 8477). Punta Gavilán formation (late Miocene), Venezuela. Limón formation (late Miocene), Costa Rica, and Bocas del Toro area, Panamá. Deposits of late Miocene age, Tehuantepec are, México. Pliocene deposits, Cumaná area, Venezuela, Costa Rica.

Crassispira (Hindsiclava) pyrgoma Woodring, n. sp.

Plate 62, figures 21, 27

Of medium size, slender, distinctly turreted, aperture long and narrow. Protoconch and early postprotoconch whorls missing. Sculpture consisting of slightly protractive axial ribs (15 or 16 on penult whorl) and low primary spiral bands (4 or 5 on penult whorl), swollen on crest of ribs. Secondary threads of varying width between primary bands, some almost as wide as the bands, others microscopic. Anal fasciole wide, strongly constricted. Subsutural thread strong, undulated secondary spiral threads between it and base of fasciole. Anal sinus wide, shallow, apex on lower part of fasciole.

Height (incomplete) 35.5 mm, diameter 10.5 mm (type).

Type: USNM 645867. Paratype, USNM 645866.

Type locality: 208 (USGS 8437, Caribbean coast at mouth of Río Indio, Panamá), Chagres sandstone.

Though the type and paratype—the only specimens—are incomplete and partly worn and corroded, this species is named, as the turreted outline, and wide and strongly constricted anal fasciole are distinctive. In general the sculpture resembles that of *C. consors magna*, mentioned under that species.

C. pyrgoma doubtless is an offshoot from the lineage of *C. consors.* A middle Miocene Mexican turrid, from the Sayula district, Chiapas (USGS 5886), has a similar slender, turreted outline, a few less ribs (13 on penult), and somewhat weaker primary spiral sculpture.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Subgenus Crassispirella Bartsch and Rehder

Bartsch and Rehder, U.S. Natl. Mus. Proc., v. 87, p. 135, 1939.
Type (orthotype): *Crassispira (Crassispirella) rugitecta* (Dall) [*Turris (Crassispira) rugitecta* Dall], living, Baja California.

Crassispirella is adopted as the name for species of *Crassispira* that have a short aperture. They generally are small or of medium size. The type species, however, is relatively large (height 30 mm) and its subsutural spiral thread is only slightly wider and higher than other threads on the anal fasciole.

The earliest species are found in formations of early Miocene age: the Tampa formation of Florida and the Thomonde formation of Haiti. The subgenus now lives in both eastern Atlantic and western Pacific waters, but is represented by far more species in the eastern Pacific Ocean than in the Atlantic.

Crassispira (Crassispirella) species

The La Boca formation yielded a small incomplete *Crassispirella* and a minute shell that evidently is a tip of the same species. The axial ribs are closely spaced (about 15 on last whorl). The subsutural thread is strong, undulated, and occupies most of the anal fasciole. The spiral sculpture below the anal fasciole is weak. The height, almost complete, is 8.8 mm and the diameter 3.6 mm.

Occurrence: La Boca formation (early Miocene), locality 116a.

Crassispira (Crassispirella) cymation Woodring, n. sp.

Plate 58, figures 4, 5

Small, rapidly enlarging. Protoconch acute, 3- to 3½-whorled, a wide axial swelling preceding end, marked by an arcuate riblet. Sculpture consisting of slightly protractive, inverted V-shaped axial ribs, swollen at apex (10 on body whorl) and low, narrow primary spiral threads (8 or 9 on penult whorl), roughened by microscopic growth threads. Spiral threads subdued or disappearing on swollen apex of ribs; those on lower part of body whorl above siphonal fasciole widely spaced. Anal fasciole undulated; subsutural thread strong; fasciole below subsutural thread bearing subdued secondary spiral threads. Rib adjoining outer lip varicose. Anal sinus wide, upper border thickened on parietal wall. Stromboid notch on lower part of outer lip very shallow. Siphonal fasciole slightly inflated.

Height (not quite complete) 8 mm, diameter (incomplete) 3.3 mm (type). Height (incomplete) 7.5 mm, diameter 4 mm (paratype).

Type: USNM 645781. Paratype, USNM 645782.

Type locality: 161c (USGS 8382, railroad cuts west of Gatun Dam, station B, Canal Zone), middle part of Gatun formation.

The undulated anal fasciole, including the subsutural thread, is a distinguishing feature of this small species, which is represented by three specimens, all found in the middle part of the Gatun formation in the western area. In sculptural plan it is not comparable to other small species from the Caribbean region: *Crassispira maonisriparum* (Maury) (1917, p. 56, pl. 9, fig. 5; Cercado formation, Dominican Republic), *C. hispaniolæ* (Maury) (1917, p. 56, pl. 9, fig. 6; Gurabo formation, Dominican Republic), *C. ritanida* (Mansfield) (1925, p. 24, pl. 4, fig. 10; Matura formation, Trinidad), and *C. annella* Woodring (1928, p. 151, pl. 4, fig. 11; Bowden formation, Jamaica).

Occurrence: Middle part of Gatun formation (middle Miocene), western area, localities 161c, 170a.

Crassispira (Crassispirella) tyloessa Woodring, n. sp.

Plate 58, figures 2, 3

Of medium size, subsutural spiral thread noded. Protoconch acute, about 2½-whorled (apex worn), last whorl bulging below middle, apparently merging into first post-protoconch whorl. Axial ribs narrow, 20 on penult whorl. Subsutural spiral thread bearing nodes alined with axial ribs. Spiral threads below anal fasciole narrow, relatively widely spaced, slightly noding crest of ribs; 5 on penult whorl. Anal fasciole below subsutural thread bearing faint microscopic spiral threads. A varicose hump on body whorl near outer lip. Axial ribs subdued and closely spaced on hump and between it and outer lip. Outer lip broken back. Growth lines showing a deep anal sinus and shallow stromboid notch. Upper border of anal sinus thickened. Siphonal fasciole slightly inflated, sculptured with spiral threads cruder than those elsewhere.

Height 13.4 mm, diameter (including hump) 5.2 mm (type). Height 15.3 mm, diameter 5.8 mm (paratype).

Type: USNM 645783; paratype USNM 645784.

Type locality: 139c (USGS 22018, east side of road leading from Transisthmian Highway to refinery site on Payardi Island, Panamá; about 100 meters southwest of refinery gate), middle part of Gatun formation.

The combination of noded subsutural spiral thread and relatively widely spaced other spiral threads, not observed on other species of *Crassispirella*, is distinctive. The paratype is slightly larger than the type, but its outer lip is broken back beyond the hump. No other specimens are in the collections.

It is strange that no larger species of *Crassispirella*, similar to *Crassispira jamaicensis* (Guppy) (Woodring, 1928, p. 149, pl. 4, fig. 8) and its fossil and living allies, has so far been found in the Gatun formation.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139c.

Genus Clathrodrillia Dall

Dall, U.S. Natl. Mus. Proc., v. 54, p. 317, 323, 1918.

Type (orthotype, p. 323): *Pleurotoma gibbosa* Reeve (*Pleurotoma gibbosa* Kiener = *Murex gibbosa* Born), living, south border of Caribbean Sea.

A fragment of two incomplete whorls from the La Boca formation is listed as *Clathrodrillia* sp.

Clathrodrillia gatunensis (Toula)

Plate 58, figures 8, 20, 21, 23–25; plate 65, figure 7

Pleurotoma (Drillia) gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 707, pl. 25, fig. 16, 1909 (Miocene, Canal Zone). Engerrand and Urbina, Soc. Geol. Mexicana Bol., v. 6, pl. 59, fig. 27, 1910 (reproduction of Toula's illustration).

Pleurotoma (Drillia) gatunensis Toula, n. var., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 507, pl. 31, fig. 20, 1911 (Miocene, Canal Zone).

Drillia gatunensis (Toula), Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 344, 1911 (Miocene, Canal Zone). Pilsbry and Brown, Idem, v. 69, p. 32 (list), 1917 (Miocene, Colombia). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 292, 1960 (Miocene, Colombia).

Drillia venusta (Sowerby), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 61, pl. 4, fig. 9, 1922 (Miocene, Costa Rica).

Drillia puertocolombiana Weisbord, Idem, v. 14, no. 54, p. 55, pl. 5, fig. 16, 1929 (Miocene, Colombia).

Clathrodrillia puertocolombiana (Weisbord), Jung, Idem, v. 49, no. 223, p. 566, pl. 76, figs. 12, 13, 19, 1965 (Miocene, Venezuela).

Clathrodrillia onzola Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 96, pl. 15, figs. 6, 6a, 1964.

Moderately large, moderately slender, pillar strongly constricted, aperture relatively short and wide. Protoconch blunt, almost cylindrical, 1¾ to 4-whorled, generally 1¾ to 2; lower part of last half whorl faintly to distinctly angulated. Lower part of first post-protoconch whorl or two angulated; first whorl sculptured with 7 or 8 axial ribs, swollen on angulation, gradually pinched off near suture. Faint spiral sculpture appearing on second or third post-protoconch whorl; anal fasciole on about third. At that and later stages axial ribs slightly protractive, moderately narrow, separated by spaces greater than their width, disappearing on body whorl below periphery; 24 to 26 on penult whorl. Spiral sculpture below anal fasciole consisting of narrow bands (4 to 7 on penult whorl), which widen on late whorls of a few specimens and are separated by narrow grooves. Secondary spiral threads between bands on a few specimens. Anal fasciole strongly constricted. Subsutural cord of variable strength and width. Wide subsutural cord strongly wrinkled by swellings corresponding to axial ribs and also swellings intermediate in position with reference to ribs. Narrow subsutural cord faintly wrinkled. On shells that have narrow subsutural cord, concave lower part of fasciole generally steeply sloping; rarely gently sloping, producing distinctly turreted outline. Concave lower part of fasciole bearing exaggerated growth threads, some as strong as wrinkles on subsutural cord. Faint spiral sculpture visible on entire fasciole of some shells, especially on early whorls. Pillar sculptured with widely spaced spiral cords and faint secondary spiral threads. A massive hump at varying distance from outer lip; ribs subdued and closely spaced between hump and outer lip. Earlier humps, as many as 10, but generally 1 to 5, on spire whorls of some shells. Outer lip flaring forward, bearing a deep, wide stromboid notch at top of pillar. Anal sinus deep, lower limb long, upper limb bordered by thick pad of callus on parietal wall. Siphonal notch wide and deep. Siphonal fasciole slightly inflated, bearing no spiral sculpture or weak spiral sculpture, generally limited by a strong, narrow thread, especially on mature shells.

Height (almost complete) 52.4 mm, diameter (including hump) 17.5 mm (largest figured specimen). Height (almost complete) 40.5 mm, diameter (including hump) 12.5 mm (figured specimen of intermediate size).

Type: Tech. Hochschule, Vienna.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The 76 specimens of *Clathrodrillia* from the Gatun formation (lower and middle parts, and upper part in eastern area) closely related to *C. gibbosa* are identified as *C. gatunensis*. Otherwise three names, presumably subspecific names, would be needed and some specimens that show intermediate features would have to be placed doubtfully under one of the three names. The three main forms are as follows:

Forms of Clathrodrillia gatunensis *in Gatun formation*

1. Subsutural cord narrow, weakly wrinkled.
   a. Concave part of anal fasciole below subsutural cord steeply sloping (pl. 58, figs. 24, 25).
   b. Concave part of anal fasciole below subsutural cord gently sloping (pl. 58, fig. 8).
2. Subsutural cord wide, strongly wrinkled (pl. 58, figs. 20, 21, 23).

Type 1a is represented in the lower part of the Gatun and in strata near the base of the middle part, although some specimens in that part are transitional toward type 2. Only one shell, collected at a middle Gatun locality in the western area, represents type 1b. It is associated with a specimen leaning toward type 2. The remaining specimens from the middle part that are larger than a few whorls and those from the upper part, 65 percent of the total number, are unmistakably referred to type 2. That type agrees with Toula's type specimen: an incomplete shell of six whorls (height 32.6 mm, diameter 12.3 mm). His *Pleurotoma* (*Drillia*) *gatunensis* n. var. is an immature shell (height 10.1 mm, diameter 4.1 mm). It shows the 2–whorled, almost cylindrical protoconch. Type 1b closely duplicates the Ecuadorean fossils named *C. onzola*.

These Gatun fossils could be further subdivided on the basis of outline and spiral sculpture. One of five specimens from locality 139c is as slender as *Crassispira consors*. On a few, like that shown on plate 58, figures 20, 21, the spiral cords of late whorls are wide and separated by narrow grooves. That specimen is one of three that has a perfectly preserved outer lip.

As now identified, *Clathrodrillia gatunensis* occurs in deposits of middle Miocene age in Venezuela, Colombia, Costa Rica, the Canal Zone, the Darién and Chiriquí areas of Panamá, and Ecuador, and at least a related form in the Miocene of Martinique (Cossmann, 1913, p. 22, pl. 2, fig. 7). If the indefinite type locality of *C. puertocolombiana* represents the Las Perdices shale, the age range extends back to early

Miocene. The Venezuelan shells identified as *C. puertocolombiana* have a few less ribs than Gatun shells (18 to 20 on penult whorl) and lack a strong thread at the margin of the siphonal fasciole. A middle Miocene specimen of *C. puertocolombiana* from Colombia (USGS 11241) has 25 ribs on the penult whorl and a strong thread at the margin of the fasciole.

C. venusta (Sowerby) (1850, p. 50, pl. 10, fig. 7), which was well illustrated by Sowerby, was the first Miocene species of a closely knit group of *Clathrodrillia* to be described. It occurs in the Gurabo formation of the Dominican Republic and is distinguished by the absence of a subsutural cord and by the attenuated continuation of the axial ribs across the entire anal fasciole. A lectotype was designated and illustrated by Pflug (1961, p. 65, pl. 19, fig. 9). *C. gibbosa*, the type of *Clathrodrillia*, survives in the Caribbean Sea. Its subsutural cord is slightly raised and slightly wrinkled. It is a rare species and for many years its habitat was unknown. Only two specimens, both originally in the Casey turrid collection, are in USNM collections. It is found as a Pliocene fossil in the Cabo Blanco and Cumaná areas of Venezuela. *C. mareana* (Weisbord, 1962, p. 437, pl. 41, figs. 16, 17; Pliocene, Venezuela) is an immature *C. gibbosa*.

The earliest of this closely knit group of species in Florida, perhaps earlier than any in the Caribbean region, occurs in the early Miocene Chipola formation: *C. aulakœssa* (Gardner) (1926–47, p. 310, pl. 40, figs. 2–4, 1938), a small, slender species that has a moderately constricted anal fasciole. The younger *C. subvaricosa* (Gardner) (Idem, p. 312, pl. 40, figs. 5, 6; Oak Grove sand member of Shoal River formation) also has a moderately constricted anal fasciole. The fasciole of the still younger *C. empera* (Gardner) (Idem, p. 312, pl. 40, figs. 7, 8; Shoal River formation proper), however, is strongly constricted. That species, as Gardner realized, is like a small version of type 2 of *C. gatunensis*, but, at least on intermediate whorls, attenuated wrinkles more consistently extend across the anal fasciole.

No matter whether the synonymy of *C. gatunensis* is modified, the past and present distribution of *C. gibbosa* and its close allies, like that of *Muracypraea*, *Sconsia* and *Xancus*, reverses the general trend. Close allies formerly lived in western Atlantic and eastern Pacific waters, but the Caribbean *C. gibbosa* itself is the sole survivor.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d, 138f. Middle part, eastern area, localities 139b, 139c, 139e, 139f, 147f, 147g, 151, 155, 155a, 155b, 155c, 156, 157, 159a, 159b, 159d; western area, locality 161a. Upper part, eastern area, localities 175, 176. Deposits of early(?) Miocene age, Colombia, Ecuador. Deposits of middle Miocene age, Venezuela, Colombia, Costa Rica, Darién area, Panamá (USGS 8477), Chiriquí area, Panamá (USGS 7955), Ecuador.

Clathrodrillia saavedrai Woodring, n. sp.

Plate 59, figures 13, 14; plate 65, figure 8

Small, subsutural cord noded, anal fasciole constricted, pillar short. Protoconch blunt, 1½–whorled, lower part of last half whorl swollen. First post-protoconch whorl sculptured with 8 axial ribs, swollen on lower part, pinched off near suture. At later stages axial ribs narrow; 17 or 18 on penult whorl. Subsutural cord strong, bearing elongate retractive nodes, alined with axial ribs. A spiral thread marking lower edge of anal fasciole. Spiral sculpture below anal fasciole consisting of narrow bands (4 to 6 on penult whorl), separated by deep grooves. Axial ribs on late part of body whorl slightly noded by spiral bands. A hump on body whorl about 45° from outer lip. Axial ribs subdued and irregular in spacing between hump and outer lip. Anal sinus deep, upper limb heavily bordered. Stromboid notch wide and deep. Siphonal notch deep. Siphonal fasciole slightly inflated, bearing no spiral sculpture, limited by a fairly strong thread.

Height 16.5 mm, diameter 6.2 mm (type).

Type: USNM 645790.

Type locality 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 m) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

Three specimens of *Clathrodrillia saavedrai* have been found in the middle part of the Gatun formation. It suggests a miniature *C. gatunensis*, but is distinguished from immature specimens of that species by its noded subsutural cord, more delicate sculpture, and weaker thread limiting the siphonal fasciole. Though the outer lip of the type was well preserved, it was damaged in handling.

This species is named for Alvaro de Saavedra Ceron, who early in the 16th century suggested Central American routes to open the land from sea to sea (Howarth, 1966, p. 56–57).

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), localities 147b, 147h.

Clathrodrillia aff. C. saavedrai Woodring, n. sp.

Plate 58, figures 6, 7

Resembling *Clathrodrillia saavedrai* in general features of protoconch and post-protoconch whorls, but distinguished as follows. Smaller and more slender.

Axial ribs narrower (16 on penult whorl), pinched on lower part of anal fasciole, but continuing across entire fasciole, including subsutural cord. Axial ribs on subsutural cord slightly arcuate on intermediate and late whorls. Grooves between spiral bands wider than those of *C. saavedrai*. Siphonal fasciole sculptured with 2 coarse spiral threads.

Height 10.4 mm, diameter 3.5 mm (figured specimen).

The middle part of the Gatun formation in the western area yielded the only specimen of this minute *Clathrodrillia*. Though it evidently represents a new species, the outer lip is damaged and the shell is further disfigured by two bore holes, which are large for the size of the shell.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, locality 161c.

Clathrodrillia aff. C. lelandi (Olsson)

Plate 59, figures 5, 6

Of medium size, slender, whorls slightly inflated, pillar short. Protoconch and first few post-protoconch whorls missing. Anal fasciole slightly constricted on earliest preserved whorls, distinctly constricted on later whorls. Axial ribs narrow, slightly protractive, slightly bent backward and pinched at lower edge of anal fasciole, continuing across subsutural cord marking anal fasciole, straight or slightly arcuate on fasciole; 21 on penult whorl. Spiral sculpture below anal fasciole consisting of low bands (9 or 10 on penult whorl), separated by narrow grooves, faint except on body whorl. Faint spiral grooves visible on anal fasciole adjoining anal sinus. A hump on body whorl opposite aperture. Axial ribs subdued and closely spaced between hump and outer lip. Aperture short. Stromboid notch on outer lip shallow. Anal sinus deep, upper limb heavily bordered. Siphonal notch deep, siphonal fasciole limited by a strong thread.

Height (incomplete) 21.8 mm, diameter 7.5 mm (figured specimen).

This slender species is represented by one somewhat worn specimen from the lower part of the Gatun formation. Owing to wear, the spiral sculpture is faint, except on the abapertural face of the body whorl near the outer lip. The whorls are less inflated, or shouldered, below the anal fasciole than those of the middle Miocene Ecuadorean *Agladrillia lelandi* (Olsson, 1964, p. 101, pl. 15, fig. 7) and the spiral bands are slightly wider.

It seems to be more appropriate to assign *Agladrillia lelandi* to *Clathrodrillia*.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 136a.

Clathrodrillia cf. C. islalindae (Maury)

Plate 58, figures 15, 16

Small, slender, whorls slightly inflated, pillar short. Protoconch and first few post-protoconch whorls missing. Anal fasciole slightly constricted, except on late half of body whorl. Axial ribs narrow, slightly protractive, continuing to suture without being pinched at lower edge of anal fasciole, arcuate on fasciole; 16 to 18 on penult whorl. Spiral sculpture below anal fasciole consisting of low bands (6 on penult whorl), separated by narrow grooves. Faint spiral sculpture visible here and there on anal fasciole. A hump on body whorl near outer lip. Aperture short. Outer lip broken back to hump, except at and near anal fasciole. Anal sinus deep, upper limb heavily bordered. End of siphonal canal broken. Siphonal fasciole limited by a strong, though worn, thread.

Height (not quite complete) 15.8 mm, diameter (including hump) 5.5 mm (figured specimen).

Four more or less worn specimens, also from the lower part of the Gatun formation, are identified as another species of *Clathrodrillia*. The illustrated shell is the largest and the least worn. In general features this species is similar to *C.* aff. *C. lelandi*. It is, however, smaller, has less inflated whorls, and its ribs are uninterrupted and decidedly arcuate on the anal fasciole. The ribs of *C. islalindæ* (Maury, 1917, p. 57, pl. 9, fig. 7; Cercado and Gurabo formations, Dominican Republic) are similar, but are more protractive, fewer in number, and therefore more widely spaced. Moreover, the spiral sculpture of that species is stronger.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 138d, 138f.

Clathrodrillia? species

Plate 63, figures 1, 2

Of medium size, moderately slender, whorls moderately inflated, pillar short. Protoconch and early post-protoconch whorls missing. Anal fasciole molded against preceding whorl, progressively more strongly constricted. Axial ribs wide, bent and attenuated on anal fasciole, subdued on anal fasciole of body whorl and absent on last quarter of that whorl, 17 on penult whorl. Spiral sculpture faint, except on lower two-thirds of body whorl, where it consists of narrow, closely spaced, crimped threads. A hump on body whorl about 60° from aperture. Aperture short. Outer lip and lower part of siphonal canal broken back. As shown by growth lines, anal sinus deep; upper limb heavily bordered. Stromboid notch wide and very shallow, as indicated by growth lines. Siphonal fasciole not bordered by a strong thread.

Height (incomplete) 25.9 mm, diameter (including hump) 9.7 mm (figured specimen).

The Chagres sandstone yielded an incomplete, corroded clavine turrid of undetermined affinities. The anal fasciole, molded against the preceding whorl in the fashion of some species of *Latirus*, is a diagnostic feature. The outer shell layer is missing on the crest of most body-whorl ribs and on all parts of spire whorls, except on the lower part of the penult, where faint spiral sculpture is discernible.

Though the apertural features are imperfect, aside from the heavy border of the upper limb of the anal sinus, this species evidently is not a typical *Clathrodrillia*.

Occurrence: Chagres sandstone (late Miocene), locality 208.

Genus Agladrillia Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 157, 1928.
Type (orthotype): *Agladrillia callothyra* Woodring, Miocene, Jamaica.

Subgenus Agladrillia s.s.

The earliest species of *Agladrillia* s.s. now known occur in the late early Miocene Thomonde formation of Haiti. The subgenus survives in the eastern Pacific Ocean, but has not been recognized in the western Atlantic.

The four species in the Gatun formation, all of which are small, have a hump on the body whorl 90° or less from the outer lip. Between the hump and the outer lip the axial ribs are suppressed, irregularly and generally closely spaced, and generally noded by the spiral bands, or are absent. As shown by the few shells that have an intact outer lip and by growth lines on other shells, the anal sinus is deep and the stromboid notch shallow, although distinct. The siphonal notch is moderately deep, and the siphonal fasciole is slightly inflated and sculptured with relatively coarse spiral threads. These nondiagnostic features are not repeated in the descriptions of the species.

Agladrillia (Agladrillia) characta Woodring, n. sp.

Plate 59, figures 3, 4; plate 64, figure 1

Small, moderately inflated, anal fasciole slightly constricted, subsutural cord generally faint, rarely distinct. Protoconch acute, 1¾– to 3–whorled (generally 1¾ to 2½), lower part of last whorl swollen. Axial ribs pinched off near suture on first, or first two, post-protoconch whorls. On remaining whorls axial ribs extending across the faint, or distinct, subsutural cord, arcuate on the cord; 11 to 15 ribs (generally 12 to 14) on penult whorl. Spiral sculpture below subsutural cord consisting of bands separated by relatively deep and relatively wide grooves; 5 to 7 bands on penult whorl, not including 1 to 3 minor bands on or near anal fasciole.

Height 12.8 mm, diameter (including hump) 4.3 mm (type).

Type: USNM 645794.

Type locality: 147g (USGS 5899, highest fossil-bearing beds, Quebrancha Hills, ¾ mile (1.2 km) from Gatun, Canal Zone), middle part of Gatun formation.

This species is the largest of the four in the Gatun formation. The relatively large size and more uniform greater inflation distinguish it from the others.

A. characta, represented by 22 specimens, occurs in the lower and middle parts of the Gatun formation. Three additional specimens from the lower part are doubtfully referred to it. They have a blunt protoconch of 1¾ whorls and the lower part of the last whorl is subcarinate. The spiral sculpture of two agrees with that of *A. characta*, but the spiral bands of the third are narrow. More material is needed to resolve the identification of these specimens. They probably represent still another species.

Agladrillia mimys Olsson (1964, p. 100, pl. 16, figs. 6, 6a; Esmeraldas formation, Ecuador) is the most similar described fossil species. Its ribs are subdued near the suture and its spiral sculpture is weaker than that of *A. characta*. In spiral sculpture the Gatun species resembles *A. callothyra* (Woodring, 1928, p. 158, pl. 5, fig. 7), the type species, but that species is larger (height 20 mm) and has a more constricted anal fasciole, on which the axial ribs are subdued. Aside from its larger size and fewer, wider ribs, *A. callothyra* is similar to *Clathurella panamella* Dall (1908, p. 288, pl. 14, fig. 1). In Dall's illustration the ribs on the anal fasciole are too strong. Powell (1966, p. 92) suspected that Dall's species is to be assigned to *Agladrillia*. It has been dredged in the Gulf of California at depths of 47 to 153 fathoms.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138a (identification doubtful), 138c, 138d (identification doubtful). Middle part, eastern area, localities 139b, 146, 147b, 147g, 151, 159d.

Agladrillia (Agladrillia) enneacyma enneacyma (Brown and Pilsbry)

Plate 59, figures 10, 11, 15, 16; plate 64, figure 4

Very small, slender to moderately inflated, anal fasciole slightly constricted, or not constricted. Subsutural cord faint on last whorl or two, or absent on all whorls. Protoconch acute, 3– to 3½–whorled, lower part of last whorl swollen, rarely subcarinate. Axial ribs extending to suture, or almost to suture, on first post-

protoconch whorl. On remaining whorls ribs extending across entire whorl of shells that have no subsutural cord, but gradually bent on anal fasciole, or on nonconstricted part of whorl corresponding to anal fasciole, forming elongate nodes on anal fasciole; 9 to 12 ribs on penult whorl. Spiral sculpture consisting of narrow bands separated by shallow grooves; 5 or 6 bands on penult whorl, not including 1 to 3 narrow bands at lower edge of anal fasciole, or on corresponding part of whorls that lack a constricted fasciole.

Height 7.7 mm, diameter (including hump) 2.5 mm (figured slender specimen). Height 7.2 mm, diameter (including hump) 2.8 mm (figured inflated specimen).

Type: Acad. Nat. Sci. Phila. 3848.

Type locality: Gatun lower locks excavation, Canal Zone, middle part of Gatun formation.

The little glistening shells of *Agladrillia enneacyma enneacyma* were abundant in the middle part of the Gatun formation about a kilometer southeast of Gatun railroad station during the construction period, when fresh cuts were accessible on the present line of the Panama Railroad. A hundred shells, all of which have the protoconch preserved, were collected at locality 147b, where many other small species were found to be abundant, and 45 at locality 147g. Shells that have an intact outer lip, however, are rare. The upper part of the Gatun yielded only one specimen and its spiral sculpture consists of narrow threads instead of bands.

This minute *Agladrillia* is variable in outline and in the presence or absence of a subsutural cord. Aside from the single upper Gatun shell, the sculpture is basically uniform, although the spiral grooves on many well-preserved shells are faint and the crest of the axial ribs of the type is exceptionally wide. The illustrations on plate 59, representing two specimens selected from the large 147b collection, show some of the range in variation. The contrast between the unpinched early axial ribs of *A. enneacyma enneacyma* and the pinched ribs of *A. characta* is shown by figures 1 and 4 on plate 64.

A larger similar species occurs in the Thomonde formation of Haiti and a smaller species in the Cerado and Gurabo formations of the Dominican Republic. The early axial ribs of both are pinched.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139b, 139c, 146, 147b, 147f, 147g, 147h, 153a, 155c, 159d. Upper part, eastern area, locality 173a.

Agladrillia (Agladrillia) enneacyma (Brown and Pilsbry), subsp.

Four specimens from the lower part of the Gatun formation are distinguished from the nominate subspecies of *Agladrillia enneacyma* by the presence of a subsutural cord on all except the first few post-protoconch whorls and by relatively deep grooves between the spiral bands, like those of *A. characta*. These shells have the protoconch and unpinched early axial ribs of the nominate subspecies. Two (height 8.7 and 9.5 mm) are larger than any shells of the nominate subspecies. The sample of this form is inadequate.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 137, 138, 138c.

Agladrillia (Agladrillia) phengoides Woodring, n. sp.

Plate 59, figures 1, 2; plate 64, figure 3

Very small, slender, anal fasciole constructed, subsutural cord narrow, moderately strong. Protoconch blunt, 1½- to 1¾-whorled, lower part of about last half whorl subcarinate. Axial ribs pinched off near suture on first few post-protoconch whorls. Subsutural cord appearing on fourth or fifth post-protoconch whorl. On later whorls axial ribs pinched at lower edge of subsutural cord, forming small, retractives nodes on the cord; 9 or 10 ribs on penult whorl. Spiral sculpture below subsutural cord consisting of narrow bands separated by shallow grooves; 5 to 7 bands on penult whorl, not including 1 or 2 minor bands present on some shells near edge of subsutural cord. Grooves near subsutural cord distinct, indistinct, or even absent.

Height 6.8 mm, diameter (including hump) 2.2 mm (type).

Type: USNM 645799.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

The slender outline, blunt, paucispiral protoconch, and moderately strong, noded subsutural cord on intermediate and late whorls are characteristic features of this little glistening species. Unlike *Agladrillia enneacyma enneacyma*, it is not variable in basic features, but the spiral grooves near the subsutural cord may be distinct, indistinct, or absent.

A. phengoides was found in the middle part of the Gatun formation. The largest number of specimens (46) was collected at the type locality, where it is associated with *A. characta* and *A. enneacyma enneacyma*. It is, in fact, associated with *A. enneacyma enneacyma* at the six localities where it occurs.

The more slender outline, more strongly constricted anal fasciole, and more bulging whorls distinguish *A. phengoides* from *A. estrellana* (Olsson) (1922, p. 69, pl. 10, figs. 31, 32), a middle Miocene Costa Rican species.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 146, 147b, 147f, 147g, 147h, 159d.

Agladrillia (Agladrillia) acaria ectypha Woodring, n. subsp.

Plate 59, figures 12, 17; plate 64, figure 8

Very small, moderately slender, anal fasciole not constricted, subsutural cord strong. Protoconch blunt, 1- to 2-whorled, lower part of last half whorl swollen. Axial ribs pinched off near suture on first, or first two, post-protoconch whorls. Subsutural cord appearing on second or third post-protoconch whorl, strong on later whorls. Axial ribs wide, swollen, pinched at edge of subsutural cord, forming spirally elongate nodes on the cord; 9 to 11 ribs on penult whorl. Spiral sculpture below subsutural cord consisting of bands separated by relatively deep and relatively wide grooves; 4 to 6 bands on penult whorl, not including 1 or 2 narrow bands near edge of subsutural cord.

Height 6.5 mm, diameter 2.3 mm (type).

Type: USNM 645801.

Type locality: 138 (USGS 16909, north and south sides of Transisthmian Highway, 1.6 kilometers northeast of Canal Zone boundary, Panamá), lower part of Gatun formation.

Agladrillia acaria ectypha is represented by 60 specimens, 16 of which were collected at locality 138c. All the localities are in the lower part of the Gatun formation and in strata near the base of the middle part.

This *Agladrillia* is distinguished by its wide, swollen axial ribs and strong subsutural cord, which appears at an early stage on the second or third post-protoconch whorl. The spiral sculpture is like that of *A. characta* on a diminutive scale.

The axial ribs of the Gatun subspecies are wider and more swollen than those of the nominate subspecies (Mansfield, 1925, p. 18, pl. 1, fig. 2), which occurs in the early middle Miocene part of the Brasso formation of Trinidad (float from upper part of *Globorotalia fohsi* zone s.l.), and in the late middle Miocene San José calcareous silt member of the Manzanilla formation. A comparable species from the early Miocene Thomonde formation of Haiti (USGS 9945, 9946) has smaller nodes on the subsutural cord and weaker spiral sculpture.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138c, 138d, 138e. Middle part, eastern area, localities 139b, 139c, 139d, 139e. Middle Miocene deposits, Darién area (USGS 8477).

Subgenus Eumetadrillia Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 159, 1928.
Type (orthotype): *Agladrillia (Eumetadrillia) serra* Woodring, Miocene, Jamaica.

The strong, crosscutting, exaggerated growth threads of *Eumetadrillia* are a conspicuous feature on well-preserved shells. They are not visible on the illustration of the type species (Woodring, 1928, pl. 5, fig. 9), which shows a somewhat worn shell. In different species the protoconch is blunt and paucispiral, or acute and multispiral. A subsutural cord is present or absent, and the stromboid notch on the outer lip is shallow or deep.

Eumetadrillia has been found in the Miocene of the Dominican Republic, Jamaica, Panamá, and Florida. It is not known to be living in the western Atlantic or the eastern Pacific oceans. A Magellanic species, *Pleurotoma (Surcula) fuegiensis* Smith (1888, p. 300), has been assigned to *Eumetadrillia* (Powell, 1951, p. 173, fig. N, 118). The protoconch has been illustrated, but not the shell itself. It would be remarkable for this Miocene tropical subgenus to survive in Magellanic waters.

Agladrillia (Eumetadrillia) isthmica (Brown and Pilsbry)

Plate 60, figures 11, 18, 19; plate 64, figure 10

Drillia isthmica Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 344, pl. 23, figs. 10, 11, 1911 (Miocene, Canal Zone).

Of medium size, moderately slender, anal fasciole not constricted, obscured by strong subsutural cord, pillar constricted in alinement with stromboid notch on outer lip. Protoconch acute, 3- to 3½-whorled (generally 3½). Subsutural cord appearing on first or second post-protoconch whorl (generally second), undulated by axial ribs of preceding whorl, bearing irregularly spaced, retractive wrinkles. On intermediate and late whorls an obscure spiral cord of about same width as subsutural cord, for most part represented by a groove in interrib spaces, generally adjoining subsutural cord, faintly overriding axial ribs on early part of body whorl up to hump. Otherwise spiral sculpture absent, except thread limiting siphonal fasciole. On intermediate and late whorls axial ribs wide, swollen, wide-crested, separated by V-shaped interspaces; 7 to 10 (generally 8) on penult whorl. Ribs narrower and more closely spaced on early part of body whorl up to hump. Exaggerated growth threads crosscutting ribs. A hump about 90° from outer lip. Axial ribs absent between hump and outer lip, except near lip, where they are narrow and closely spaced. Ribs continuing on pillar as subdued irregular wrinkles and exagger-

ated growth threads, rarely as regular narrow riblets. Anal sinus wide and deep. Stromboid notch narrow and deep. Siphonal notch deep. Siphonal fasciole not inflated, bearing subdued growth threads, limited by a narrow spiral thread.

Height 19.9 mm, diameter (incomplete) 6.8 mm (larger figured specimen). Height 13.9 mm, diameter 5.6 mm (smaller figured specimen). Height 21.2 mm, diameter (incomplete) 6.4 mm (largest specimen).

Type: Acad. Nat. Sci. Phila. 1696.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Twenty-three specimens of *Agladrillia isthmica* from the three parts of the Gatun formation in the eastern area, are available, not more than six at any of the eight localities. All except one (pl. 60, fig. 11) are more or less damaged, chiefly through breakage of the outer lip far back. A few show no trace of the faint cord adjoining the subsutural cord. On the other shells it is represented by a short groove in the interrib spaces, except on the early part of the body whorl, where it faintly overrides the narrow ribs. The constriction of the pillar, in alinement with the stromboid notch, in *Cymatosyrinx* (p. 374) and some species of *Eumetadrillia* is correlated with a deep notch.

A. isthmica is closely related to *A. bocasensis* (Olsson) (1922, p. 73; pl. 5, fig. 5; late Miocene, Bocas del Toro area), the only other described species marked by a subsutural cord. *A. bocasensis* has a blunt, paucispiral protoconch and weaker subsutural cord, and its ribs have a narrower base.

Occurrence: Lower, middle, and upper parts of Gatun formation, eastern area (middle Miocene). Lower part, localities 138, 138c, 138d, 138f. Middle part, localities 139c, 155b, 155c. Upper part, eastern area, locality 175.

Agladrillia (Eumetadrillia) acidna Woodring, n. sp.

Plate 60, figures 16, 17

Of medium size, slender, anal fasciole constricted, subsutural cord weak. Protoconch acute, 3-whorled. Subsutural cord appearing on fourth post-protoconch whorl, weak and slightly undulated on all whorls, not obscuring anal fasciole. On intermediate and late whorls axial ribs moderately wide, swollen, narrow-crested, separated by U-shaped interspaces; 10 on penult whorl. Ribs continued as narrow, low wrinkles on lower part of anal fasciole, greatly attenuated or absent on subsutural cord. Ribs of uniform spacing on body whorl up to hump, absent between hump and outer lip, replaced by a wrinkle near lip. Somewhat exaggerated growth threads crosscutting ribs. Faint microscopic spiral lineation discernible. A hump on body whorl about 90° from outer lip. Anal sinus wide and deep. Stromboid notch moderately deep and siphonal notch deep, as shown by growth lines. Siphonal fasciole not inflated, marked by growth threads, limited by a low, narrow spiral thread.

Height 18 mm, diameter 5.9 mm (type).

Type: USNM 645806.

Type locality: 172 (USGS 6035, Mindi Hill cut, near bottom of canal, Canal Zone), upper part of Gatun formation.

Though the only specimen of this species, collected at a locality in the upper part of the Gatun formation, has a damaged outer lip and siphonal canal and is disfigured by two bore holes, it shows distinctive features. It is a little more slender than *Agladrillia isthmica*, and has a constricted anal fasciole and weaker subsutural cord; its axial ribs are narrower and have a narrower crest and base. The acute protoconch indicates that it is not closely allied to *A. bocasensis*. In addition, the subsutural cord of *A. acidna* is even weaker than that of *A. bocasensis*, and the rib crests are narrower. The crosscutting growth threads of *A. acidna* are not as strong as those of the other two species mentioned. The faint microscopic spiral lineation is discernible only because the glistening surface of the shell is wholly intact.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 172.

Genus Syntomodrillia Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 160, 1928.
Type (orthotype): *Drillia lissotropis* (Dall) [*Pleurotoma* (*Mangilia*) *lissotropis* Dall], living, Gulf of Mexico and Florida to West Indies.

Though the minute genus *Syntomodrillia* has not been found in the faunas under consideration, a misrepresentation concerning it should be rectified.

Bartsch (1934, p. 25) gratuitously confused the designation of the type species. He claimed that *Pleurotoma* (*Mangilia*) *lissotropis* Dall (1881, p. 58) is not the same species as *Drillia lissotropis* (Dall) (1889, p. 91, pl. 11, figs. 3, 4). (As a matter of fact, when the name *Syntomodrillia* was proposed, I neglected to cite Dall's original combination.) He further remarked that "Woodring, in selecting a specimen for his genotype" chose a specimen that has microscopic spiral threads between the ribs of late whorls. The type of a genus is, of course, a species, not a specimen. Bartsch's statement was based on the description of the genus, which was not a description of the type species, much less a description of a specimen of the type species. It

would have been better, however, to include in the description of the genus a statement that faint microscopic spiral sculpture may be present or absent on late whorls.

The immature specimen (height 4.5 mm; Dall, 1889, pl. 11, fig. 3) that is the type of *Pleurotoma* (*Mangilia*) *lissotropis* has not been found in the collections of the U.S. National Museum or of the Museum of Comparative Zoology. In his 1881 description Dall mentioned no spiral sculpture above the pillar, but, according to his 1889 description "the spaces between [the ribs] are indifferently perfectly smooth, or finely spirally striate, especially toward the anterior end of the shell"; that is, on late whorls. That statement was found to be appropriate when *Syntomodrillia* was named, and still is appropriate. Bartsch (1934, p. 27, pl. 8, figs. 5, 7, 9) selected from a lot of seven, identified by Dall as *Drillia lissotropis* (USNM 87477, off Barbados, 103 fathoms), a specimen that has faint microscopic spiral threads on late whorls, too strongly retouched on his illustrations, as the type of his new species *Syntomodrillia woodringi*, and cited that species as the type of *Syntomodrillia*. (The height is 8.6 mm, not 18.2 mm). *S. woodringi* is a synonym of *S. lissotropis*.

Powell, as summarized in his latest publication (1966, p. 84), assigned to *Syntomodrillia* species in the Tertiary deposits of New Zealand and Australia and treated it as a subgenus of *Splendrillia*. His size range for *Syntomodrillia* (height 4.5 to 18 mm) was based on the erroneous dimension of *S. woodringi*. No American species has a height greater than 10 mm. The earliest American species is of early Miocene age (Thomonde formation of Haiti).

Genus Microdrillia Casey

Casey, Acad. Nat. Sci. Phila. Proc., v. 55, p. 276, 1903.

Type (logotype, Cossmann, Essais de paléoconchologie comparée, pt. 7, p. 223, 1906): *Pleurotoma cossmanni* Meyer, 1887, Eocene, Miss.

Meyer's name, of course, is not a primary homonym of *Purpura cossmanni* de Raincourt (1884, p. 345, pl. 12, fig. 11); nor is it a secondary homonym. Cossmann (1889, p. 252; p. 256 of separate publication), thinking that de Raincourt's and Meyer's species are congeneric, proposed the substitute name *Oligotoma meyeri* for Meyer's species. That name, in the combination *P.* [*leurotoma*] *meyeri*, used by Cossmann in 1906, is generally cited for the type of *Microdrillia*. *Purpura cossmanni*, however, is not a *Microdrillia*.

This ancient, widespread genus—widespread in Tertiary seas and in modern warm seas—occurs in the Gatun formation.

Microdrillia trina Mansfield

Plate 59, figures 7–9; plate 64, figure 5

Microdrillia trina Mansfield, U.S. Natl. Mus. Proc., v. 66, art. 22, p. 28, pl. 4, fig. 5, 1925 (Miocene, Trinidad).

Moderately small, whorls generally carinate at periphery, exceptionally flat-sided. Protoconch acute, 4- to 5¼-whorled (generally 5), last to last 2¼ whorls (generally 1¼ to 1½) bearing arcuate axial riblets, ending just below middle of whorl, or extending practically to base of whorl. A gradually strengthened sutural spiral thread on sculptured part of protoconch. First post-protoconch whorl sculptured with a sutural spiral thread (a continuation of protoconch thread), a peripheral spiral thread, and generally a lower spiral thread. On some shells appearance of lower thread delayed until second whorl. Remaining spire whorls generally bearing three spiral threads, exceptionally four. Position and relative strength of threads variable. Peripheral or lower thread, or both, generally stronger than sutural thread, modifying whorl profile, except on flat-sided shells, which have subequal threads. Regularly spaced submicroscopic axial threads on post-protoconch whorls, arcuate on anal fasciole, protractive below fasciole. Anal sinus between sutural and next spiral thread, apex semicircular. Interior of outer lip bearing 4 widely spaced liræ. Two elongate denticles present or absent on columellar lip. Siphonal notch shallow. Siphonal fasciole slightly inflated, limited by a narrow spiral thread, sculptured with a few coarser threads.

Height 6.7 mm, diameter 2 mm (largest specimen, flat-sided). Height 5.6 mm, diameter 2 mm (larger figured carinate specimen).

Type: USNM 352624.

Type locality: USGS 9212, about one mile south of Brasso, Trinidad, flood wash from stream, Brasso formation.

Microdrillia trina was found in the three parts of the Gatun formation in the eastern area. It is rare in the lower and upper parts, and locally abundant in the middle part. One hundred and sixty-five of the 225 specimens were collected at locality 147b, where so many small species are abundant. The outer lip of all is more or less defective and only one (locality 177b) has an intact siphonal canal.

This is a variable species—variable in size and profile, and in relative strength of the spiral threads. The prevailing profile and sculpture is shown on plate 59, figure 9; subequal peripheral and lower spiral threads on plate 59, figure 8. Ten shells from the three parts of the Gatun are flat-sided and have subequal spiral threads. They reach a relatively large size: height up

to 6.7 mm. Although no complete shell of normal profile is that large, a few incomplete ones indicate a comparable size. Plate 59, figure 7, represents one of the flat-sided shells. One specimen (locality 147g) has two spiral threads below the peripheral thread on the penult and antepenult whorls, and another (locality 174) shows the same feature on the last half of the penult. This condition is determined, of course, by the low height of whorl overlap.

When *M. trina* was named it was based on a float specimen from the early middle Miocene part of the Brasso formation (upper part of *Globorotalia fohsi* zone s.l.). An outcrop collection from the *Globorotalia fohsi barisanensis* zone on Mayo River (USGS 21234, deposited by H. G. Kugler) contains 25 specimens of the *Microdrillia*. They show practically the same range of variation as the more numerous Gatun specimens. This species ranges upward into the San José calcareous silt member of the Manzanilla formation (USGS 21233).

M. trina occurs also in the subsurface La Rosa formation of the Maracaibo basin, Venezuela. In fact, Hoffmeister (1938, p. 106) named a zone the *Microdrillia* zone. According to his faunal lists (Hoffmeister, 1938, p. 106, 107–109), both that zone and the underlying *Cadulus* zone are of middle Miocene age. Fossiliferous outcrop strata at El Mene de Saladillo near Los Quiroz, Hodson's (*in* Hodson and Hodson, 1931, p. 5) localities 6 [and 1140], which have been assigned to the La Rosa formation, are late early Miocene.

M. trina is closely related to the living *M. comatotropis* (Dall) (1881, p. 58; 1889, p. 116, pl. 11, fig. 12), which ranges from Georgia to Yucatan Strait and the West Indies at depths of 100 to 640 fathoms. It has a more evenly tapering protoconch than the Miocene species, a weaker sutural spiral thread, and lacks liræ on the interior of the outer lip. The type evidently is lost. Dall thought that *Pleurotoma* (*Mangelia*) *tiara* Watson (1886, p. 347, pl. 21, fig. 7) is a synonym. If so, the geographic range is to be extended to Bermuda and the depth range to 1,075 fathoms.

So far *Microdrillia* has been found only in middle Miocene deposits in the Caribbean region. The youngest species in southern United States, *M. hebetika* Gardner (1926–1947, p. 356, pl. 42, figs. 15, 16, 1938), occurs in the late early Miocene Chipola formation of Florida. Aside from its smaller protoconch and unsculptured siphonal fasciole, it is similar to the middle Miocene Jamaican *M. tersa* (Woodring, 1928, p. 197, pl. 8, fig. 14).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene), eastern area. Lower part, localities 138, 138c. Middle part, localities 139b, 139c, 146, 147b, 147f, 147g, 147h, 153a, 155, 155c, 159d. Upper part, eastern area, localities 174, 177b, 177c. Early middle Miocene part of Brasso formation, Trinidad. San José calcareous silt member of Manzanilla formation (late middle Miocene), Trinidad. Subsurface La Rosa formation (middle Miocene), Maracaibo basin, Venezuela.

Subfamily MANGELIINAE

Genus Lepicythara Olsson

Olsson, Neogene mollusks from northwestern Ecuador, p. 110, 1964.

Type (orthotype): *Cythara terminula* Dall, Pliocene, Fla.

A genus of relatively large, biconic endemic American mangelines, of traditional "*Cythara*" aspect, has long needed a name, which was supplied recently by Olsson. The species of this genus have an age range of early Miocene to Pliocene. The axial riblets on the last whorl of the protoconch of the type species are so faint that good preservation is needed to show them.

Lepicythara heptagona (Gabb)

Plate 60, figure 4; plate 64, figure 11

Mangelia heptagona Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 211, 1873 (Miocene, Dominican Republic).

Cythara heptagona (Gabb), Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 345, 1911 (Miocene, Canal Zone). Pilsbry, Idem, v. 73, p. 322, pl. 17, fig. 9, 1922 (Miocene, Dominican Republic).

Cythara heptagona? (Gabb), Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 55, pl. 5, figs. 13, 14, 1929 (Miocene, Colombia).

Cythara cercadica Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 61, pl. 9, fig. 15, 1917 (Miocene, Dominican Republic).

?Cythara cf. *cercadica* Maury, Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 624, 1939 (Miocene, Colombia).

Cythara terminula costaricensis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 77, pl. 5, figs. 21, 22, 1922 (Miocene, Costa Rica).

Cythara sp., Mansfield, U.S. Natl. Mus. Proc., v. 66, art. 22, p. 26, 1925 (Miocene, Trinidad).

Relatively large, biconic, spire moderately high. Protoconch a wide-based cone of 3½ whorls, tip acute, last whorl strongly bulging near base and bearing arcuate axial riblets, all except the last 4 or 5 of which are faint and closely spaced. End of protoconch marked by appearance of heavier subcarinate axial ribs. First post-protoconch whorl progressively more distinctly subcarinate near base, sculptured with 6 to 8 axial ribs. Later whorls sculptured with widely spaced, narrow-crested axial ribs, alined from whorl to whorl, or not alined; 7 or 8 on penult whorl, 7 to 9 on body whorl. Spiral sculpture limited to submicroscopic, irregularly spaced, shallow grooves and microscopic lineation. Faint microscopic axial threads visible in widest

grooves. Rib adjoining outer lip varicose. Anal sinus adjoining suture, shallow. Aperture long, narrow. Siphonal notch shallow. Siphonal fasciole barely inflated.

Height 11.5 mm, diameter 5.7 mm (figured specimen). Height 12.7 mm, diameter (incomplete) 5.2 mm (largest specimen).

Type: Acad. Nat. Sci. Phila. 2915.

Type locality: Dominican Republic, Miocene.

This relatively large mangeline is rare, although it was collected in the three parts of the Gatun formation. Only three of the six specimens are complete, mature shells and one of those is worn. The protoconch is preserved on three. As a matter of fact, though *Lepicythara heptagona* is widely distributed, it has not yet been found to be abundant anywhere.

Weisbord's Colombian specimen is poorly preserved, but two well-preserved specimens are in a north Colombian collection (USGS 7873, about half a kilometer east of Usiacuri). Though Mansfield's middle Miocene Trinidad shell is imperfect and immature, it shows the protoconch and basic post-protoconch features. Oinomikado's record of a comparable form in southwestern Colombia is undocumented, but the species itself occurs in Darién (USGS, 8477).

Details of the pattern of the finely engraved spiral grooves (or striæ) differ from place to place. The pattern is essentially the same in the Canal Zone, Colombia, and Trinidad. The grooves of shells from both the Cercado and Gurabo formations of the Dominican Republic and from Costa Rica are in general more uniformly spaced than at other localities.

The *Lepicythara* in the late Miocene Savaneta glauconite sandstone member of the Springvale formation of Trinidad—Rutsch's "*Cythara*" (*Brachycythara?*) cf. *terminula* Dall (Rutsch, 1942, p. 169, pl. 3, figs. 10, 11)—has a lower spire and heavier axial ribs than *L. heptagona*. On the contrary, the ribs of *L. camaronensis* (Olsson, 1964, p. 110, pl. 20, fig. 3; late Miocene or early Pliocene, Ecuador), are weak.

L. terminula (Dall) (1890–1903, p. 38, pl. 2, fig. 5, 1890), from the Pliocene Caloosahatchie formation of Florida, is the type species and the youngest *Lepicythara*. It occurs also in deposits of late Miocene age in peninsular Florida, where it is represented in Druid Wilson's collection from Acline. Pilsbry thought that this species is the same as *L. heptagona*. Though a close relationship is unmistakable, the protoconch stage of four or five widely spaced axial riblets is skipped on the Florida species; the subcarinate outline is continued on the second post-protoconch whorl; and the axial ribs of spire whorls are attenuated near the suture. The Florida species also reaches a slightly larger size: 17 mm, as compared with a maximum of 15 mm for *L. heptagona*.

A distinctive species is found in late Miocene deposits in western Florida: *Brachycythara turrita* Mansfield (1930, p. 43, pl. 3, fig. 8). The last ¾ protoconch whorl is subcarinate and bears fairly strong, closely spaced axial riblets; the lower part of the first three post-protoconch whorls also are subcarinate and swollen; and the axial ribs on those and later whorls are attenuated near the suture.

The earliest species showing alliance to *L. heptagona* are of early Miocene age: "*Cythara*" *basilissa* Gardner (1926–47, p. 344, pl. 42, figs. 23, 24, 1938; Chipola formation, Fla.) and an undescribed species from the Thomonde formation of Haiti (USGS 9945, 9946).

Occurrence: Lower, middle and upper parts of Gatun formation (middle Miocene). Lower part, locality 138a. Middle part, eastern area, localities 155, 157; western area, locality 161c. Upper part, western area, locality 185. Middle Miocene deposits, Costa Rica, Colombia, Darién, Panamá. Early middle Miocene part of Brasso formation, Trinidad. Cercado and Gurabo formations (middle Miocene), Dominican Republic.

Genus Ithycythara Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 168, 1928.

Type (orthotype): *Mangilia* [*Mangelia*] *psila* Bush, living, North Carolina to Florida, eastern Gulf of Mexico, and West Indies.

The earliest species of *Ithycythara* are found in deposits of early Miocene age in Puerto Rico, Haiti, and Florida; in Haiti and Florida in association with the earliest species of *Lepicythara*. The genus survives in western Atlantic and eastern Pacific waters.

Ithycythara defuniak Gardner

Plate 60, figure 13; plate 64, figure 12

Ithycythara defuniak Gardner, U.S. Geol. Survey Prof. Paper 142, p. 333, pl. 41, figs. 31, 32, 1937 (1938) (Miocene, Florida).

Very small, slender, biconic. Protoconch a wide-based cone of 3 to 3½ whorls, tip acute, last half whorl bulging near base, bearing weak to moderately strong arcuate axial riblets; 1 or 2 faint spiral threads present or absent at base of whorl near end of protoconch. End marked by appearance of heavier axial ribs. Post-protoconch whorls sculptured with 6 narrow axial ribs, somewhat swollen near base on spire whorls, alined from whorl to whorl, except on first. A faint suggestion of microscopic, spiral lineation on body whorl. Rib adjoining outer lip varicose. Anal sinus shallow. A small denticle on interior of outer lip at lower end

of sinus. Other weaker denticles present or absent. Siphonal canal not notched, siphonal fasciole barely inflated.

Height 4 mm, diameter 1.5 mm (figured specimen).

Type: USNM 352137.

Type locality: USGS 7264, Alaqua Creek, Walton County, Florida, Shoal River formation.

Four small shells from widely separated localities in the Gatun formation are identified as *Ithycythara defuniak*. One consists of the protoconch and three post-protoconch whorls, but the others have an additional whorl and their varicose rib adjoining the outer lip indicates they are mature. If so, they represent a small race of the Florida form, which has five whorls, making a difference of two millimeters in the height. The type is the only Florida specimen now available. *I. defuniak* may be a synonym of *Mangilia tarri* Maury (1910, p. 13, pl. 3, fig. 7), from the Oak Grove sand member of the Shoal River formation, but the type and other specimens handled by Maury—the only available material—is poorly preserved or immature.

Unlike most species of *Ithycythara*, including the type species, the whorls of *I. defuniak* are not even slightly angulated.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 147b; western area, locality 161c. Shoal River formation (middle Miocene), Florida.

Ithycythara cf. I. elongata (Gabb)

Plate 60, figure 14

Moderately small, slender, biconic. Last half protoconch whorl preserved; strongly bulging near base and bearing closely spaced, narrow, arcuate axial riblets. First two post-protoconch whorls somewhat angulated. Post-protoconch whorls sculptured with 6 narrow axial ribs, alined from whorl to whorl. Spiral sculpture consisting of faint, microscopic, closely spaced threads of varying width. Rib adjoining outer lip varicose. Anal sinus shallow. A denticle on interior of outer lip at base of sinus. Siphonal canal not notched, siphonal fasciole barely inflated.

Height (not quite complete) 6.2 mm, diameter 2.2 mm (figured specimen).

The description is based on a specimen from the lower part of the Gatun formation at locality 138c, where it is associated with *Ithycythara defuniak*. It is larger and more slender than that species, and has distinct spiral sculpture. It is smaller and more slender than *I. elongata* (Gabb) (Pilsbry, 1922, p. 323, pl. 18, fig. 6), which occurs in the Cercado formation of the Dominican Republic and also in the late Pliocene Moín formation of Costa Rica. Moreover, the preserved part of the protoconch of the Gatun species bulges more strongly, and its axial riblets are narrower and more closely spaced. None of the few specimens of *I. elongata* in the USNM collections shows spiral sculpture, but that may be a matter of preservation. Spire whorls and the upper part of the body whorl of the type is faintly sculptured.

A species comparable in sculpture to the Gatun species, but smaller and more slender, is found in middle Miocene deposits in Costa Rica (USGS 5288g).

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c.

Genus Cytharella Monterosato?

Monterosato, Soc. Malac. Italiana Bull., v. 1, p. 73, 1875 (*Cyharella* by error).

Type (logotype, Woodring, Carnegie Inst. Washington Pub. 385, p. 168, 1925): *Murex costatus* Donovan, living, northeastern Atlantic Ocean and Mediterranean Sea.

A few years after the name was proposed Monterosato (1884, p. 128) corrected the spelling, when he cited his genus as a synonym of *Mangelia*.

Cytharella? cf. C. compsacosta (Gardner)

Plate 60, figure 12

Very small, slender, periphery of whorls rounded. Protoconch missing, except about last half whorl, corroded. First post-protoconch whorl sculptured with about 10 axial ribs, swollen on lower part of whorl, attenuated near suture; spiral sculpture obscure. Remaining whorls sculptured with widely spaced, swollen axial ribs, somewhat attenuated near suture; 6 on penult and body whorls. Spiral sculpture consisting of faint, closely spaced, microscopically roughened threads. Outer lip broken back. Anal sinus shallow, according to growth lines. Aperture moderately long, narrow. Siphonal canal not notched, siphonal fasciole barely inflated, its spiral sculpture weaker than that elsewhere on body whorl.

Height (not quite complete) 4.2 mm, diameter 1.7 mm (figured specimen).

Cytharella? cf. *C. compsacosta*, like *Ithycythara* cf. *I. elongata*, is represented by an almost complete shell collected at locality 138c. Whether it is mature is indeterminable. In general features it resembles *Ithycythara compsacosta* (Gardner, 1926–47, p. 334, pl. 41, figs. 33, 34, 1938; Chipola formation, Florida), but has more swollen axial ribs and distinct spiral sculpture.

Cytharella seems to be an appropriate name for small mangelines of traditional "*Cythara*" aspect that

have a narrow, long, or moderately long, aperture; strong, nonalined axial ribs, generally widely spaced, except on the earliest post-protoconch whorls; and faint spiral sculpture. These species include *Ithycythara compsacosta*, as well as four other Chipola species described in the same publication ("*Mangelia*" *cryptopleura* Gardner, "*Cythara*" *chariessa* Gardner, "*C.*" *barbadoides* Gardner, and "*C.*" *isabellæ* Maury), *Mangelia elevata* Gabb (Pilsbry, 1922, p. 323, pl. 18, fig. 3; Miocene, Dominican Republic), *Cytharella limata* Olsson, 1922, p. 77, pl. 5, fig. 20; Miocene, Costa Rica), *Brachycythara galæ* Fargo (in Olsson and Harbison, 1953, p. 388, pl. 20, figs. 5, 5a; Pliocene, Florida), and *Cythara cymella* Dall (1889, p. 101, pl. 12, fig. 4; living, Florida, Gulf of Mexico, eastern Caribbean Sea). The type species of *Cytharella* has spiral threads between the arcuate axial riblets on the last quarter whorl of the protoconch. The Pliocene Florida species is the only one of the American species mentioned that shows this feature. The others have a protoconch like that of *Ithycythara;* nevertheless the basic protoconch pattern is similar in all. Some specimens of *Ithycythara*, as noted in the description of *I. defuniak*, have faint protoconch spiral threads. The protoconch of the Gatun species doubtfully assigned to *Cytharella* is unknown.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c.

Genus Kurtziella Dall

Dall, Biol. Soc. Washington Proc., v. 31, p. 137, 1918.
Type (orthotype): *Pleurotoma cerinum* Kurtz and Stimpson, living, Massachusetts to Florida.

A considerable number of generic names have been proposed for mangelines characterized by delicately frosted spiral sculpture. *Kurtzia* Bartsch (1944, p. 63; type (orthotype): *Mangilia arteaga* Dall and Bartsch, living, Vancouver Island) and *Granoturris* Fargo (*in* Olsson and Harbison, 1953, p. 394; type (orthotype): *Granoturris padolina* Fargo, Pliocene, Florida) may be treated as synonyms of *Kurtziella*. The siphonal canal of all the species is not notched and the siphonal fasciole is not inflated or barely inflated.

Subgenus Kurtziella s.s.

The reticulately sculptured, minutely noded protoconch is a readily recognized feature of *Kurtziella* s.s. Though the subgenus has been found in the Miocene of the Dominican Republic, Costa Rica, and Panamá, and in the Pliocene of Costa Rica and Venezuela, the Venezuelan occurrence is the only one heretofore recorded.

Kurtziella (Kurtziella) pagella Woodring, n. sp.

Plate 60, figure 5; plate 64, figure 6

Very small, slender, spire whorls subangulated. Protoconch a wide-based cone of 3 to 3½ whorls, tip acute (generally broken), last whorl (or little more or less) generally subcarinate near base, bearing gradually strengthened reticulate, minutely noded sculpture. End marked by appearance of heavier axial ribs. Post-protoconch whorls sculptured with widely spaced, narrow axial ribs (10 or 11 on first whorl, 8 on body whorl), and primary and secondary minutely frosted spiral threads. Three or four primary threads on and below periphery of spire whorls, peripheral thread slightly stronger than others. Closely spaced secondary threads between suture and periphery and between primary threads. Anal sinus wide and moderately deep, as shown by growth lines.

Height 4 mm, diameter 1.8 mm (type). Height 4.9 mm, diameter 1.7 mm (exceptionally large specimen).

Type: USNM 645816.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

This minute *Kurtziella* was collected at 12 localities in the lower and middle parts of the Gatun formation, but, like many other small species, is abundant only at the type locality, which yielded 90 specimens. It occurs also in middle Miocene deposits in Costa Rica (USGS 5882h). The single Costa Rican shell has an intact outer lip, whereas the lip is broken on all of the some 130 Panamá specimens.

The combination of small, slender outline and widely spaced axial ribs distinguish *K. pagella* from other species. A similar, but more inflated, species is found in the Cercado formation of the Dominican Republic (USGS 8525).

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138a, 138c, 138d, 138e. Middle part, eastern area, localities 139b, 139c, 146, 147b, 147g, 147h, 153a.

Kurtziella (Kurtziella) stenotella Woodring, n. sp.

Plate 60, figure 6; plate 64, figure 9

Very small, moderately inflated, spire whorls subangulated. Protoconch like that of *Kurtziella pagella*, last to last 1½ whorls sculptured. Axial ribs narrow on first post-protoconch whorl, moderately wide on succeeding whorls, widely spaced; 11 or 12 (generally 12) on first whorl, 7 to 9 (generally 8) on body whorl. Spiral sculpture on and below periphery and above pillar consisting of closely spaced flat bands; 4 to 6

on penult whorl; a fine thread between some bands. Spiral threads between periphery and suture and a wider thread adjoining suture. Frosting greatly subdued. Growth lines indicating a wide, moderately deep anal sinus.

Height 4.5 mm, diameter 1.9 mm (type).

Type: USNM 645818.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

Kurtziella stenotella is of about the same size as *K. pagella* and has the same kind of protoconch, but its post-protoconch sculpture is notably different. It is associated with *K. pagella* at the type locality and at three other localities in the middle part of the Gatun formation. Like *K. pagella*, it is abundant only at the type locality, where 30 of the 45 specimens were collected. One specimen is in an upper Gatun collection.

In general sculptural plan *K. stenotella* is similar to the living Panamic species "*Mangelia*" *cymatias* Pilsbry and Lowe (1932, p. 56, pl. 3, fig. 10). The axial ribs of that species, however, are narrower and are angulated at the periphery.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene), eastern area. Middle part, localities 146, 147b, 147f, 147g, 147h, 155. Upper part, eastern area, locality 177b.

Subgenus Cryoturris Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 178, 1928.
Type (orthotype): *Cryoturris engonia* Woodring, Miocene, Jamaica.

Cryoturris, which was proposed at the generic level, is similar to *Kurtziella* s.s., but lacks spiral sculpture on the protoconch. *Saccharoturris* (Woodring, 1928, p. 182; type (orthotype): *Mangilia consentanea* Guppy, Miocene, Jamaica), characterized by a noded carina on the last two protoconch whorls and by strongly shouldered post-protoconch whorls, also may be treated as a subgenus of *Kurtziella*.

The earliest species of *Cryoturris* now known occur in the Chipola formation of Florida and the Thomonde formation of Haiti, both of late early Miocene age. The Oligocene species described as *Cryoturris? hillsboroughensis* (Mansfield, 1937, p. 92, pl. 2, figs. 7, 10) evidently is a turriculine turrid.

Kurtziella (Cryoturris) habra Woodring, n. sp.

Plate 60, figure 15

Small, slender, early whorls angulated, later whorls bulging, anal fasciole constricted. Protoconch acute, 3½-whorled, last half whorl bulging and bearing slightly arcuate riblets, at first closely spaced, later more widely spaced. End not sharply defined, marked by strengthening of axial ribs and appearance of faint spiral threads below periphery. First post-protoconch whorl sculptured with about 15 narrow, angulated axial ribs and faint spiral threads. At later stages axial ribs progressively less angulated, extending onto lower part of anal fasciole in attenuated form; 11 on body whorl. Spiral sculpture consisting of not well differentiated, minutely frosted, primary and secondary threads; 5 primary threads on penult whorl. Peripheral primary thread swollen on crest of ribs, others somewhat swollen. A secondary thread on anal fasciole almost as strong as primary threads. Anal fasciole constricted. Anal sinus wide, of moderate depth.

Height 5.2 mm, diameter 1.9 mm (type).

Type: USNM 645820.

Type locality: 138a (Stanford University 2656, Transisthmian Highway, latitude 9° 21′ N., plus 5,000 feet (1,525 meters), longitude 79° 50′ W., plus 1,000 feet (300 meters), Panamá; same as USGS 16909), lower part of Gatun formation.

Kurtziella habra is based on a specimen from the lower part of the Gatun formation. Its constricted anal fasciole sets it apart from other species of *Cryoturris*. Aside from that feature, it is similar to *Turris* (*Bela*) *dominicensis* Gabb (Pilsbry, 1922, p. 322, pl. 35, fig. 1), although the primary spiral threads of the Gatun fossil are stronger and its secondary spiral threads are weaker. "*Turris*" *dominicensis* is found in the Cercado formation of the Dominican Republic.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138a.

Kurtziella (Cryoturris) species

Plate 60, figure 8

Very small, slender, whorls angulated. Protoconch acute (tip broken after description was written), 3-whorled, last ¾ whorl carinate near base and bearing slightly arcuate axial riblets extending from carina to suture. End marked by abrupt appearance of axial and spiral sculpture. Post-protoconch whorls sculptured with axial ribs (10 on first whorl and 9 on last complete whorl) and closely spaced, coarsely frosted spiral threads. Peripheral spiral thread stronger than others. Those between periphery and suture of essentially uniform rank, those below periphery less uniform. Outer lip broken back, anal sinus not outlined.

Height 2.5 mm, diameter 1.2 mm (figured specimen).

This unnamed species, like the preceding, is represented by one specimen from the lower part of the Gatun formation. It doubtless is immature. It is un-

like any known species of *Cryoturris;* in fact, the coarsely frosted spiral sculpture suggests species of *Kurtziella* s.s.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138d.

Genus Nannodiella Dall

Dall, U.S. Natl. Mus. Proc., v. 56, p. 59, 1919.

Type (orthotype): *Nannodiella nana* (Dall) [*Philberta* (*Nannodiella*) *nana* Dall], living, Gulf of California.

The extraordinarily large anal sinus of *Nannodiella* is unique among American mangeline turrids. The aperture is armed with denticles of varying strength or unarmed. The genus has been found in the lower Miocene of Florida; the middle Miocene of Trinidad, the Dominican Republic, Jamaica, the Caribbean coastal area of Panamá, and Florida; the upper Miocene of the Bocas del Toro area, Panamá, Florida, and Ecuador; and the Pliocene of Ecuador and Florida; and is living in western Atlantic and eastern Pacific waters, and also, according to Powell (1966, p. 115) in the western Pacific Ocean. Of the three species, other than the type species, assigned, or doubtfully assigned, by Dall (1919, p. 60–61) to *Nannodiella*, only *Philbertia* (*Nannodiella*) *fraternalis* is acceptable as *Nannodiella.*

Nannodiella rintriada (Mansfield)

Plate 60, figure 10; plate 64, figure 7

Glyphostoma amicta rintriada Mansfield, U.S. Natl. Mus. Proc., v. 66, art. 22, p. 27, pl. 4, figs. 2, 3, 1925 (Miocene, Trinidad).

Very small, slender, anal fasciole constricted. Protoconch 4-whorled, tip acute and minute, last whorl to last 1½ whorls carinate below middle of whorl. End marked by appearance of sculpture. First post-protoconch whorl carinate, succeeding whorls progressively less carinate. Post-protoconch whorls sculptured with 10 to 13 (generally 10 to 12) narrow axial ribs, pinched on anal fasciole, but continuing to suture. Primary spiral sculpture consisting of 2 subequal threads below anal fasciole on spire whorls (exceptionally 3 on penult whorl), 3 on body whorl, overriding ribs and slightly swollen on their crests. Anal fasciole bearing 4 to 6 very narrow threads; wider, more closely spaced threads on lower part of body whorl. Body whorl swollen adjoining outer lip. Anal sinus extraordinarily large for size of shell and aperture, apex and upper limb heavily bordered. Aperture short. Outer and columellar lips bearing moderately strong denticles. Siphonal canal very short, barely emarginate; siphonal fasciole barely inflated.

Height 4.5 mm, diameter 1.9 mm (figured specimen).

Type material: Lectotype, herewith designated, larger of 2 syntypes, USNM 352642.

Type locality: USGS 8302, a mile south of Brasso railway station, Trinidad, flood-wash from stream bank, Brasso formation.

The middle part of the Gatun formation yielded 32 specimens—all except seven from the rich locality 147b—of this small mangeline. The axial ribs on the single specimen from the upper part of the formation are more subdued than on the other shells.

Nannodiella rintriada is more slender than *N. amicta* (Guppy) (Woodring, 1928, p. 195, pl. 8, fig. 12), a middle Miocene Jamaican species; its primary spiral threads are of subequal strength; and its apertural denticles are stronger. The type material of *N. rintriada*, like that of 30 other species and subspecies named by Mansfield, was collected from float along Caparo River above Brasso railway station: a convenient collecting locality, but a poor type locality. Eight specimens are in an outcrop collection from Mayo River (USGS 21234, *Globorotalia fohsi robusta* zone) and seven in an outcrop collection from Cascade River (USGS 19856, upper part of *Globorotalia fohsi* zone s.l.), both deposited by H. G. Kugler. The shells from locality 21234 have heavier apertural denticles than Gatun shells, whereas those from locality 19856 have weaker denticles than those from the Gatun formation.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139c, 147b, 147g, 155, 155c; western area, locality 161. Upper part, eastern area, locality 163. Early middle Miocene part of Brasso formation, Trinidad.

Nannodiella cf. N. melanitica (Dall)

Two specimens found at locality 139b represent a second species of *Nannodiella*, although *N. rintriada* occurs in another collection (139c) from the same locality in strata near the base of the middle part of the Gatun formation. It is smaller (height 3.5 mm) and more slender than *N. rintriada* and its sculpture is more subdued. The axial ribs are narrower and more numerous (14 or 16 on penult whorl), and the primary spiral threads are narrower. Both shells are somewhat chalky and cannot be cleaned properly for photographing.

This unnamed species has stronger axial and spiral sculpture than *Mangilia melanitica* Dall (in Dall and Simpson, 1901, p. 390, pl. 58, fig. 10), which ranges from Cape Hatteras to the eastern Gulf of Mexico and Puerto Rico.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139b.

Genus Euclathurella Woodring

Subgenus Euclathurella s.s.

Woodring, Carnegie Inst. Washington Pub. 385, p. 187, 1928.
Type (orthotype): *Clathurella vendryesiana* Dall, Miocene, Jamaica.

When *Euclathurella* was named and compared with *Paraclathurella* (Boettger, 1895, p. 56; type (orthotype): *Pleurotoma gracilenta* Reeve, living, western Pacific Ocean) on the basis of Reeve's unsatisfactory illustration of the type species, it was not realized that Hedley had published a satisfactory illustration (Hedley, 1909, p. 456, pl. 44, fig. 91), recently reproduced by Powell (1966, p. 108, pl. 17, fig. 1). That illustration shows, as was suspected, that *Euclathurella* s.s. closely resembles *Paraclathurella* in general facies. To be sure, differences in post-protoconch sculpture are apparent, but they are not greater than may be expected in species of the same genus. The protoconch plan, however, is so different that it is unlikely they are closely related. As described by Powell, the last protoconch whorl of *Paraclathurella* is sculptured with four or five granulose spiral threads, whereas the last half whorl of *Euclathurella* s.s. is sculptured with faint, closely spaced, arcuate axial riblets. The treatment of *Kurtziella* and other genera shows that in the present account protoconch details are not given undue weight in distinguishing turrid genera. Nevertheless, protoconch plan is considered to be significant.

So far *Euclathurella* s.s. is represented only by two middle Miocene Caribbean species: an undescribed species from the Cercado formation of the Dominican Republic and the following species. *Euclathurella? liveoakensis* Mansfield (1937, p. 92, pl. 2, figs. 2, 6), of late Oligocene age, probably is a turriculine.

Euclathurella (Euclathurella) vendryesiana (Dall)

Plate 60, figures 2, 3

Clathurella vendryesiana Dall, *in* Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 306, pl. 27, fig. 1, 1896 (Miocene, Jamaica). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 62, pl. 9, fig. 18, 1917 (Miocene, Dominican Republic).
Euclathurella vendryesiana (Dall), Woodring, Carnegie Inst. Washington Pub. 385, p. 189, pl. 8, fig. 1, 1928 (Miocene, Jamaica).
Pleurotoma (Genota) gertrudis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 708, pl. 25, fig. 17, 1909 (Miocene, Canal Zone).
Pleurotoma gertrudis Toula, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 345, 1911 (Miocene, Canal Zone; Toula's record).

No specimens of this species are in the Gatun collections now being studied. The type of *Pleurotoma (Genota) gertrudis* (height 12 mm, incomplete diameter 3.8 mm), now at the Technische Hochschule in Vienna, is illustrated. The worn protoconch is 2¼-whorled. The early post-protoconch whorls are sculptured with fewer axial ribs than those of specimens from Bowden, Jamaica: 10 on the antepenult whorl (the last whorl to bear wide axial ribs), as compared with 14 to 16. The outer lip is broken far back.

A shell from the Cercado formation has nine antepenult axial ribs and the ribs continue in subdued form almost to the end of the penult whorl. The anal fasciole of that specimen, and also of Maury's from the Gurabo formation, is slightly less constricted than on Bowden shells.

Type: USNM 107086.

Type locality: Bowden, Jamaica, Bowden formation.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, Gatun Locks excavation. Bowden formation (middle Miocene), Jamaica. Cercado and Gurabo formations (middle Miocene), Dominican Republic.

Subgenus Miraclathurella Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 189, 1928.
Type (orthotype): *Miraclathurella vittata* Woodring, Miocene, Jamaica.

I agree with Powell (1966, p. 109) that it is better to assign *Miraclathurella* to subgeneric rank under *Euclathurella* than to retain the generic rank originally proposed.

The sculptured part of the protoconch of *Miraclathurella* consists of less than a quarter whorl to an entire whorl. It is bulging to distinctly carinate below the middle of the whorl and bears a few strong, widely spaced, strongly arcuate axial riblets. In post-protoconch axial sculpture *Miraclathurella* is more similar to *Paraclathurella* than to *Euclathurella* s.s. The sutural cord of *Miraclathurella*, which recalls the cord of many clavine genera, is a readily recognized feature.

The stromboid notch, mentioned in the original description of *Euclathurella* and *Miraclathurella*, is not as conspicuous as the notch of *Clathrodrillia* and other clavine genera. It is an indistinct to distinct, narrow to wide indentation, or is absent.

Unlike *Euclathurella* s.s., *Miraclathurella* is widely distributed in the middle Miocene of Trinidad, the Dominican Republic, Jamaica, the Caribbean coastal area of Panamá, southeastern Costa Rica, and Darién; and the upper Miocene of Trinidad, the Bocas del Toro area of Panamá, the Limón Peninsula of Costa Rica, and probably the Tehuantepec area of México. It is still living in the western Atlantic and eastern Pacific

Oceans. It is represented in the western Atlantic by *Mangilia aguadillana* Dall and Simpson (1901, p. 389, pl. 57, fig. 22) and an undescribed species dredged off southern Florida (USNM 412149), and in the eastern Pacific, by a species from the Gulf of California described in manuscript by Bartsch (USNM 212366, 348242).

Euclathurella (Miraclathurella) eucharis Woodring, n. sp.

Plate 60, figure 21; plate 66, figure 8

Relatively large, slender, anal fasciole constricted, bordered by sutural cord. Protoconch acute (tip generally broken), 3- to 4-whorled. About last ½ whorl bulging below middle, last ¼, or less, sculptured with a few (as few as 2) strong, widely spaced, strongly arcuate axial riblets. End marked by abrupt appearance of axial ribs, a sutural spiral thread, and 2 other spiral threads overriding ribs; 7 to 10 ribs (generally 8 or 9) on first post-protoconch whorl. Axial ribs on post-protoconch whorls wide, suppressed on lower part of anal fasciole; 9 or 10 (generally 10) on antepenult and penult whorls; reduced, narrower, and more numerous on body whorl. Sutural spiral cord strong. Spiral threads below anal fasciole narrow, overriding axial ribs, slightly swollen on crest of ribs on body and penult whorls; 4 to 6 (generally 4) on penult whorl; an additional weaker thread on lower part of anal fasciole of some specimens. Microscopic, faintly crimped spiral threads on anal fasciole and on upper part of body whorl below anal fasciole. Aperture long, narrow. Outer lip varicose; anal notch wide, deep, apex semicircular, upper limb heavily bordered; stromboid notch distinct, narrow.

Height 9 mm, diameter 3.6 mm (type). Height 11.2 mm, diameter 4 mm (largest specimen).

Type: USNM 645825.

Type locality 138c (USGS 21956, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

Euclathurella eucharis occurs in the lower and middle parts of the Gatun formation and in the upper part in the western area. Eleven of the 55 specimens were found at the type locality and 12 at locality 147b. The single incomplete specimen from the upper part is more inflated than the others. Four specimens are in a Darién collection (USGS 8477).

This species is closely related to *E. entemna* (Woodring, 1928, p. 190, pl. 8, figs. 5, 6), from the Bowden formation of Jamaica. It is slightly smaller than the Jamaican species and has narrower spiral threads, which are not as strongly swollen on the crests of the axial ribs, and less distinct microscopic spiral threads.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137a, 138, 138a, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 146, 147b, 147f, 147g, 147h, 159d. Upper part, western area, locality 183. Middle Miocene deposits, Darién, Panamá.

Genus Dolostoma Woodring, n. gen.

Type: *Dolostoma anorhepes* Woodring, n. sp., Gatun formation, Canal Zone and Panamá, Miocene.

Relatively large (height 13 to 15 mm), moderately inflated, anal fasciole wide or moderately wide, slightly concave. Protoconch a wide-based cone, tip acute, 3- to 3½-whorled, last whorl, or last ¾ whorl, bulging near base and bearing protractive, arcuate axial riblets. At first riblets closely spaced, at later stage more widely spaced and spiral threads appearing between them. End marked by a strong axial rib. Post-protoconch spire whorls sculptured with axial ribs, overridden below anal fasciole by narrow, closely spaced spiral threads. Ribs pinched on anal fasciole, but extending to suture, arcuate on fasciole, except on first few whorls. Ribs of body whorl like those of spire whorls, or subdued, more numerous, and closely spaced. Spiral sculpture on anal fasciole limited to closely spaced microscopic threads, faintly crimped under high magnification, or consisting of threads almost as wide as those below fasciole. Microscopic threads present or absent between those of primary rank on body whorl between anal fasciole and pillar, and on corresponding part of preceding two whorls. Outer lip strongly varicose, anal sinus wide and deep, apex semicircular. Aperture long, narrow. Siphonal canal slightly notched, siphonal fasciole slightly inflated.

The protoconch suggests that of *Kurtziella* s.s., but the sculptured part is not subcarinate, and the weaker spiral threads do not override the axial riblets. The mature facies is entirely different. Though *Dolostoma* resembles *Lioglyphostoma* (p. 399) in mature facies, the protoconch and sculptured plan are not similar. So far *Dolostoma* has been recognized in the Gatun formation, in strata of middle Miocene age in Darién (USGS 8477), and in the San José calcareous silt member of the Manzanilla formation of Trinidad, also of middle Miocene age.

In preliminary sorting immature specimens of *Dolostoma anorhepes*, like that shown on pl. 60, fig. 9, and mature shells of *Kurtiziella stenotella* may be confused. They occur together in the middle part of the Gatun formation. On closer examination, however, they are seen to differ in every diagnostic feature.

Dolostoma anorhepes Woodring, n. sp.

Plate 60, figures 9, 20; plate 66, figure 2

Outline, protoconch, sculptured plan, outer lip, and aperture as described under the genus. Spire whorls moderately bulging, anal fasciole wide. Axial ribs on body whorl generally of about same width and spacing as on spire whorls, exceptionally, as on type, narrower and secondary ribs intercalated between them on lower part of whorl; 9 or 10 ribs on first post-protoconch whorl, 9 to 11 on penult whorl. Penult whorl bearing 4 to 6 primary spiral threads. On body whorl spiral threads on pillar more closely spaced and coarser than elsewhere. Spiral sculpture on anal fasciole limited to closely spaced faint microscopic threads. Similar threads between primary threads visible on last three whorls of well-preserved mature shells. Anal fasciole appearing at beginning of first post-protoconch whorl, or on a later part of that whorl (as late as half a whorl), in that event preceding part rounded and sculptured with closely spaced spiral threads like those below fasciole at later stage. A faint swelling on interior of outer lip below anal sinus.

Height (almost complete) 15.5 mm, diameter 6 mm (type).

Type: USNM 645822.

Type locality: 138 (USGS 16909, North and south sides of Transisthmian Highway, 1.6 kilometers northeast of Canal Zone boundary, Panamá), lower part of Gatun formation.

Dolostoma anorhepes occurs in the lower and middle parts of the Gatun formation. Locality 147b, mentioned as a rich locality for many of the mangeline turrids, yielded 30 of the 52 specimens. Perfect preservation is needed to show the microscopic spiral sculpture. It is shown by the type, but not to good advantage. A mature specimen (locality 139c) has an intact siphonal canal, which is broken on the type. A varicose outer lip is preserved on two immature shells, even at a height of five millimeters. The shells from the lower part of the Gatun and from strata near the base of the middle part are more inflated than those from higher horizons.

This species is found also in the middle Miocene San José calcareous silt member of the Manzanilla formation of Trinidad (USGS 21745 and four other localities). All the specimens are slender, but not more slender than some from the middle part of the Gatun.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138b, 138c, 138d. Middle part, eastern area, localities 139c, 146, 147b, 147g, 147h, 153a, 159d. San José calcareous silt member of Manzanilla formation (middle Miocene), Trinidad.

Dolostoma dinota Woodring, n. sp.

Plate 61, figure 4

Moderately large, moderately inflated, spire whorls strongly bulging, anal fasciole moderately wide. Anal fasciole not distinguishable on first three post-protoconch whorls, flat on fourth, slightly concave on fifth, more distinctly concave on sixth (body whorl). Tip of protoconch broken, remainder exfoliated. Post-protoconch spire whorls sculptured below anal fasciole with narrow axial ribs (12 on antepenult whorl, 16 on penult), overridden by flat spiral threads (5 or 6 on penult whorl), slightly swollen on crest of ribs. Ribs subdued, narrower, more numerous, and closely spaced on body whorl. On spire whorls ribs slightly narrower and slightly arcuate on anal fasciole; on body whorl subdued, more strongly arcuate, and interspersed with exaggerated growth threads. Spiral threads on anal fasciole a little narrower than those below fasciole; 5 or 6 on penult whorl. On body whorl between anal fasciole and pillar microscopic growth threads visible between spiral threads. Spiral threads on pillar more closely spaced than those elsewhere on body whorl. A strong swelling on interior of outer lip below anal sinus.

Height (practically complete) 12.9 mm, diameter 5.3 mm (type).

Type: USNM 645829.

Type locality: 175 (USGS 8410, cuts on north [west] side of French Canal [East Diversion], Mount Hope, Canal Zone), upper part of Gatun formation.

The type and the body whorl of a specimen of about the same size as the type, both found in the upper part of the Gatun formation near Mount Hope, are the only representatives of *Dolostoma dinota.*

The spire whorls of this species bulge more strongly than those of *D. anorhepes*; the anal fasciole appears at a later stage and is sculptured with spiral threads almost as strong as those below the fasciole; and the axial ribs are more numerous and, except on the earliest whorls, are narrower.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 175.

Genus Glyphostoma Gabb

Gabb, Acad. Nat. Sci. Philadelphia Proc., v. 24, p. 270, 1872 (1873).

Type (monotype): *Glyphostoma dentifera* Gabb [*dentiferum*], Miocene, Dominican Republic.

Some 70 late Tertiary and living species of *Glyphostoma*, all American, have been described and three

more are now added. As suggested by Powell (1966, p. 115), non-American species are suspect. The genus includes the largest American mangeline turrids, reaching a maximum height of about 45 millimeters. All the species have one feature in common. Although the protoconch is blunt and paucigyrate or acute and polygyrate, the last half whorl to last whorl and a half (exceptionally two and a half), depending on the total number of whorls, are carinate. To be sure, they are weakly carinate or merely bulging in one subgenus: *Lioglyphostoma*. The other essential features are gradational. The apertural armature runs from strong through weak or faint to complete absence. The axial sculpture on the anal fasciole ranges from strong puckers through weak puckers or exaggerated growth threads to ordinary growth threads. Owing to gradation, the main subdivisions are regarded as subgenera. They may be arranged as follows:

Subgenera of Glyphostoma

Aperture armed	
Strong to weak puckers on anal fasciole	*Glyphostoma* s.s.
Exaggerated or ordinary growth threads on anal fasciole.	
On late whorls spiral sculpture limited to pillar	*Euglyphostoma*.
On late whorls spiral sculpture not limited to pillar	*Rhiglyphostoma*.
Aperture unarmed	
Pillar slightly or moderately constricted	*Lioglyphostoma*.
Pillar strongly constricted	*Glyphostomops*.

The earliest species occur in the Thomonde formation of Haiti (USGS 9907), the outcrop La Rosa formation of Venezuela (USGS 18007), and the Chipola formation of Florida, all of late early Miocene age. Even at that time *Glyphostoma* s.s., *Rhiglyphostoma*, and *Lioglyphostoma* are represented.

Glyphostoma s.s. may be divided arbitrarily into a group of large species (height 24 to about 45 mm) and a group of small species (height 9.5 to 23 mm). Twelve of the 15 large species are found in the middle and late Miocene Caribbean province, one in the early Miocene of Florida, one in the middle Miocene of Florida, and the other is living in the Caribbean region: *G. epicasta* Bartsch (1934, p. 14, pl. 4, figs. 4, 7, 9). Ten of the large fossil species, including the type species and also the first to appear (*G. locklini*), have been described recently by Olsson (1964, p. 105–109). The 17 small species are more evenly distributed in the Miocene of the Caribbean region, the Miocene and Pliocene of Florida, and in western Atlantic and eastern Pacific waters at low latitudes. One species occurs in the Pliocene of North Carolina—the northernmost record for the subgenus.

Euglyphostoma is a minor, but morphologically distinctive, new subgenus embracing a Gatun species and two living eastern Pacific species.

The new subgenus *Rhiglyphostoma* includes a Gatun species, a not closely related species from the northern part of the late Miocene Caribbean province—*Pleurotoma* (*Glyphostoma*) *mexicana* Toula (1911, p. 483, pl. 29, fig. 16)—20 overnamed Miocene and Pliocene species from Florida, two Miocene species from North Carolina, and one each from the Miocene of Maryland and New Jersey. Like *Cymia* (p. 223), *Rhiglyphostoma* reached New Jersey in middle Miocene time, but, unlike *Cymia*, did not bypass the Chesapeake embayment. As pointed out by Pilsbry and Harbison (1933, p. 113), the New Jersey record is the northernmost for the genus. A species, *G. conradiana* (Gabb), occurs in the Pliocene and Pleistocene of California. Living species are found in the western Atlantic and eastern Pacific Oceans, extending to higher latitudes in the eastern Pacific than *Glyphostoma* s.s.

Lioglyphostoma (Woodring, 1928, p. 193; type (orthotype): *Lioglyphostoma adematum* Woodring, Miocene, Jamaica) includes five fossil species: one in the late early Miocene of Florida and four (two undescribed) in the middle and late Miocene of the Caribbean region. It is now represented at the south end of the Florida Keys and in the Caribbean Sea by a small species misidentified by Dall (1889, p. 111) as *Mangilia lavelleana* (d'Orbigny) and in Galápagos waters by *Glyphostoma sirena* Dall (1919, p. 53, pl. 17, fig. 3). Other fossil and living species assigned to *Lioglyphostoma* are to be referred to *Glyphostoma* s.s. or *Rhiglyphostoma*, or even to other genera.

Glyphostomops (Bartsch, 1934, p. 17; type (orthotype): *Glyphostoma (Glyphostomops) hendersoni* Bartsch, living, southern Florida) is another minor subgenus embracing two, possibly three, living western Atlantic species and a doubtful Pliocene species from Florida.

Subgenus Glyphostoma s.s.

Glyphostoma (Glyphostoma) dentiferum Gabb

Plate 60, figures 22, 25; plate 66, figure 3

Glyphostoma dentifera Gabb, Acad. Nat. Sci. Phila. Proc., v. 24, p. 971 [271], pl. 11, fig. 4, 1872 (1873) (Miocene, Dominican Republic). Gabb, Am. Philos. Soc. Trans., vol. 15, p. 210, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 61, pl. 9, fig. 16, 1917 (Miocene, Dominican Republic).

Glyphostoma dentiferum Gabb, Pilsbry and Brown, Acad. Nat. Sci. Phila. Proc., v. 64, p. 501 (list), 1913 (Miocene, Canal Zone). Pilsbry, Idem, v. 73, p. 324, pl. 17, fig. 15, 1922 (Miocene, Dominican Republic). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 571, pl. 77, figs. 9, 10, 1965 (Miocene, Venezuela). Olsson, Neogene mollusks from northwestern Ecuador, p. 105, pl. 17, fig. 1, 1964 (Miocene, Dominican Republic).

Clathurella (*Glyphostoma*) *dentifera* (Hinds), Cossman, Jour. Conchyliologie, v. 61, p. 31, pl. 2, figs. 15–17, not figs. 18–20, 1913 (Miocene, Dominican Republic).

Not *Glyphostoma dentifera* Gabb, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 76, 1922 (Miocene, Costa Rica; = *G. guppyi* Woodring).

Large, moderately slender, spire not strongly turreted. Protoconch blunt, 1½- to 2-whorled, last half whorl carinate. End marked by gradual appearance of sculpture. First post-protoconch whorl sculptured with 7 wide axial ribs, angulated in alinement with protoconch carina, overridden by a peripheral spiral thread and another below periphery. Sculpture changing on body whorl, or on penult, or even on antepenult, depending principally on size of shell. Before changing, axial ribs wide and swollen, gradually disappearing near anal fasciole, 8 to 11 on last whorl preceding change. Ribs overridden by narrow spiral cords, swollen on ribs, 5 or 6 cords on penult whorl, not including a narrower thread adjoining anal fasciole. Change in sculpture due to narrowing of ribs, introduction of a narrow rib between them, and downward bifurcation of main ribs, all the ribs eventually of about same width, as many as 25 on mature body whorl. At same stage spiral cords somewhat suppressed between ribs, forming spirally elongate nodes on ribs. Spiral cords reduced in width on pillar. Anal fasciole constricted, bearing strong, arcuate, axial puckers and faint spiral threads. Puckers appearing on fourth or fifth post-protoconch whorl. Outer lip strongly varicose. Anal sinus narrow, deep, everted at semicircular apex. Apertural armature strong on both lips. Siphonal canal slightly notched, according to growth lines. Siphonal fasciole slightly inflated, sculptured with smooth or slightly noded spiral cords.

Height (incomplete) 38.2 mm (estimated height 43 mm), diameter (including outer lip) 15.2 mm, (not including outer lip) 11.5 mm (larger figured specimen).

Type: Acad. Nat. Sci. Phila. 2910.

Type locality: Dominican Republic, presumably Cercado or Gurabo formation.

Seventeen specimens of *Glyphostoma dentiferum* were found in the lower and middle parts of the Gatun formation, but only one (pl. 60, fig. 22) is a mature shell. Much of the face of its outer lip is damaged and the end of the siphonal canal is missing. A more complete immature shell is shown on plate 60, figure 25. An incomplete, doubtfully identified specimen has a varicose outer lip and complete apertural armature at an estimated height of seven millimeters.

These Gatun fossils are consistently more slender than the type. As noted by Pilsbry (1922, p. 324), however, Gabb's nine specimens [now eight] at the Academy of Natural Sciences of Philadelphia show some variation in outline. Gabb collected all the Dominican Republic shells in American museums. That at Cornell University, illustrated by Maury, is immature, and so is the one illustrated by Cossmann. The incomplete shell from the Angostura formation of Ecuador, illustrated by Olsson (1964, pl. 17, fig. 8) as *Glyphostoma* sp., closely resembles Gatun specimens, so far as it goes.

G. woodringi Olsson (1964, p. 106, pl. 18, figs. 1–1c), which occurs in the Cercado formation of the Dominican Republic, is more slender and more delicately sculptured than *G. dentiferum*. *Lioglyphostoma woodringi* Fargo (*in* Olsson and Harbison, 1953, p. 405, pl. 21, figs. 7–7b; Caloosahatchee formation, Florida) is a small species of *Rhiglyphostoma* that has weak, or faint, apertural armature. If the view that *Rhiglyphostoma* is to be assigned to subgeneric rank under *Glyphostoma* is adopted, Olsson's species needs a new name.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138e (immature, identification doubtful). Middle part, eastern area, localities 139c, 155, 155a, 155c, 156, 157. Miocene, Dominican Republic. Cantaure formation (middle Miocene), Venezuela.

Glyphostoma (Glyphostoma) pyrgota Woodring, n. sp.

Plate 60, figures 23, 24

Large, very slender, strongly turreted. Protoconch and early post-protoconch whorls missing. Sculpture of late whorls like that of *Glyphostoma dentiferum*. Eleven wide, swollen axial ribs on last whorl preceding change in sculpture. Eight similar ribs on upper part of early two-thirds of mature body whorl; 20 narrow ribs on lower part of mature body whorl. Eight spiral cords on penult whorl, lowermost two noded, uppermost two noded and narrower than others. Microscopic, irregularly trending, axial vermiculation visible on well-preserved whorls. Anal fasciole strongly constricted, sculptured with strong, arcuate, axial puckers. Outer lip strongly varicose, edge serrated by short projections opposite spaces between spiral cords. Anal sinus like that of *G. dentiferum*. End of siphonal canal missing.

Height (incomplete, 2 whorls) 37.3 mm (estimated height 45 mm), diameter (including outer lip) 15 mm, (not including outer lip) 7.4 mm (type).

Type: USNM 645833.

Type locality: 157 (USGS 16926, westernmost cut on Panama Railroad cutoff south of Fort Davis, 1.2 miles (1.9 kilometers) northeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

Although this handsome species is represented by only two incomplete specimens, it is named, as the slender, strongly turreted outline and microscopic, irregularly trending, axial vermiculation are unique in the genus. Both specimens occur in the middle part of the Gatun formation in association with *Glyphostoma dentiferum*. The type is the larger of the two. The other, which is somewhat worn and does not show the vermiculation, has an estimated height of 36 millimeters. The estimated height of the type indicates that it is the largest known *Glyphostoma*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155c, 157.

Subgenus Euglyphostoma Woodring, n. subgen.

Type: *Glyphostoma parteflosa* Dall, living, Gulf of California and west coast of Baja California.

Of medium size (height 11 to 14 mm), moderately slender, anal fasciole moderately to strongly constricted. Protoconch acute, 3- to 3½-whorled, last whorl to last 1¼ whorls carinate. Axial ribs wide-based and swollen, crest continuing in subdued form across anal fasciole, or absent on fasciole. Spiral sculpture above pillar limited to first 2 to 4 post-protoconch whorls. Pillar sculptured with spiral cords, decreasing in width downward, those above siphonal fasciole slightly undulated by subdued continuation of axial ribs. Outer lip varicose, its edge slightly serrate. Anal fasciole bearing subdued, arcuate, exaggerated growth threads. Anal sinus wide for size of shell, deep, everted at semicircular apex. Apertural armature moderately strong. Siphonal canal moderately notched. Siphonal fasciole slightly inflated, sculptured with narrow spiral cords. Radula consisting of a pair of long, slender, needlelike, nonbarbed marginals.

The absence of spiral sculpture on late whorls, except on the pillar, is the most distinctive feature of *Euglyphostoma*. The protoconch, apertural features, and radula are like those of *Glyphostoma* s.s. Fresh dredged shells are vitreous. The three lots of the type species in the USNM collections represent a depth range of 10 to 44 fathoms.

I am indebted to J. P. Morrison, of the U. S. National Museum, for the opportunity to examine his drawing of the radula of the type species. The radula was extracted from the animal in a worn shell dredged at a depth of 44 fathoms off Cedros Island, Baja California (USNM 97029).

Glyphostoma (Euglyphostoma) olssoni Woodring, n. sp.

Plate 60, figure 7

Size, outline, sculptural plan, and apertural features as described under the subgenus. Anal fasciole strongly constricted. Protoconch acute, 3-whorled, last whorl to last 1¼ whorls carinate. End marked by thin varix or appearance of first axial rib. First post-protoconch whorl sculptured with 8 or 9 axial ribs and 2 weak spiral cords: one at periphery and one below periphery. Cords suppressed between ribs, disappearing on third or fourth whorl. Nine or 10 ribs on penult whorl. Several axial puckers on anal fasciole adjoining anal sinus, somewhat exaggerated, arcuate growth threads elsewhere on fasciole.

Height 13.6 mm, diameter (including outer lip) 5.7 mm, (not including outer lip) 4.7 mm (type).

Type: USNM 645834.

Type locality: 176 (USGS 8358, Road bordering French Canal [East Diversion], near Mount Hope, Canal Zone), upper part of Gatun formation.

The upper part of the Gatun formation yielded three specimens of this species. One, an immature shell of 4½ whorls (height 6 mm), shows to good advantage the sculpture of early whorls. Even at that stage the outer lip is varicose and the apertural armature is fully formed. The wide, swollen, smooth axial ribs of all except the first few whorls recall those of *Eumetadrillia* (p. 387).

Glyphostoma olssoni is more inflated than *G. parteflosa* Dall (1919, p. 53, pl. 17, fig. 4), the type species of *Euglyphostoma*, and has a more constricted anal fasciole and heavier axial ribs. In outline and constriction of anal fasciole the fossil species is more similar to *Clavatula candida* Hinds (1844–45, p. 20, pl. 6, fig. 18, 1844), another living Panamic species. Hinds' illustration, however, shows narrower axial ribs.

This species, the only fossil species of *Euglyphostoma* now known, is named for A. A. Olsson as a tribute to his long and exceptionally productive career as a paleontologist and zoologist. He collected the type 50 years ago.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, localities 173, 176, 177c.

Subgenus Rhiglyphostoma Woodring, n. subgen.

Type: *Glyphostoma xeston* Gardner, Miocene, Florida.

Very small to of medium sibe (height 5.5 to 17 mm), slender or moderately slender, pillar slightly to decidedly constricted, anal fasciole slightly to strongly constricted. Protoconch acute and polygyrate (as in type species), or blunt and paucigyrate, last half whorl to last whorl carinate. Sculpture consisting of moderately wide axial ribs, overridden by spiral threads. Anal fasciole bearing exaggerated, or ordinary, arcuate growth threads, or sculptured with fine spiral threads. Outer lip varicose, or exceptionally nonvaricose and flaring. Anal sinus narrow, deep, semi-

circular apex everted. Apertural armature heavy for size of shell to weak, or faint. Exceptionally absent on some specimens of species that normally have weak, or faint, armature. Siphonal canal moderately notched. Siphonal fasciole slightly inflated, sculptured with closely spaced spiral threads.

As is evident from the description, *Rhiglyphostoma* is interpreted to embrace species of diverse features. It includes the smallest species of the genus and also some of moderate size. The change from the anal-fasciole puckers of *Glyphostoma* s.s. to exaggerated growth threads is gradational. In fact, the exaggerated growth threads of some species of *Rhiglyphostoma* are about as strong as the weak puckers of some species of *Glyphostoma* s.s. Though the range of variation in strength of apertural armature is pronounced, *Rhiglyphostoma* includes all the species of the genus that have faint armature. It may be so faint that it is barely discernible. The name *Glyphostoma zoster mansfieldi* (Gardner, 1943 (1944)–48, p. 273, pl. 37, fig. 17, 1948; Duplin formation, North Carolina) was proposed for specimens of *G. zoster* that have barely perceptible swellings on the lower part of the columellar lip and no armature on the outer lip, which is nonvaricose and flaring. The same aberrant features are shown by Fargo's *Lioglyphostoma woodringi* subspecies (Fargo in Olsson and Harbison, 1953, p. 406, pl. 21, figs. 6, 6a; Caloosahatchee marl, Florida). Normal specimens of both species have weak armature on both lips and a varicose outer lip.

Glyphostoma (Rhiglyphostoma) allodapum Woodring, n. sp.

Plate 60, figure 1; plate 66, figure 6

Very small, moderately slender, pillar and anal fasciole slightly constricted. Protoconch acute, 2½- to 2¾-whorled, last whorl carinate. First post-protoconch whorl sculptured with 8 narrow axial ribs, a weak peripheral spiral thread, and a weak spiral thread below periphery, both slightly swollen on ribs. Axial ribs of succeeding whorls progressively wider, 8 on each whorl. Spiral threads weak throughout, 4 on penult whorl. Anal fasciole bearing only ordinary growth threads, generally obscure. Outer lip varicose. Anal sinus narrow, deep, semi-circular apex everted. Apertural armature heavy for size of shell. Siphonal canal moderately notched. Siphonal fasciole slightly inflated, sculptured with closely spaced spiral threads.

Height (incomplete) 7 mm (estimated height 8 mm), diameter (including outer lip) 3.3 mm (type).

Type: USNM 645835; paratype 645836.

Type locality: 138d (USGS 22016, About 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of locality 138), lower part of Gatun formation.

The type of this small Gatun species evidently is mature. The features of the early whorls, missing on the type, are shown by the immature paratype. It is from the type locality and consists of the protoconch and four post-protoconch whorls. The early whorls are shown also by another minute shell collected at locality 147b.

Though the three specimens constitute a meager sample, *Glyphostoma allodapum* is not closely related to any known species. In general plan it resembles *G. typhon* Gardner (1926–47, p. 350, pl. 42, figs. 11, 12, 1938), from the Chipola formation of Florida. That species is smaller (height 5.5 mm, the smallest species of the genus), much more slender, and its anal fasciole is more constricted.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138d. Middle part, eastern area, locality 147b.

Subfamily DAPHNELLINAE

Genus Daphnella Hinds

Hinds, The zoology of the voyage of H.M.S. *Sulphur*, v. 2, Mollusca, p. 25, 1844.

Type (logotype, Herrmannsen, Indicis generum malacozoorum, vol. 1, p. 370, 1847): *Pleurotoma lymneiformis* Kiener, living, Florida, Bahamas, and West Indies.

The representation of daphnelline turrids in the Tertiary Caribbean province is meager. In fact, the two unnamed middle Miocene species of *Daphnella* from Bowden, Jamaica, described as *Daphnella?* sp. and "*Daphnella*" sp. (Woodring, 1928, p. 198–199, pl. 8, figs. 15, 16) are the only unequivocal representatives heretofore recorded. In addition to the Bowden and Gatun specimens, the Cercado formation of the Dominican Republic yielded an immature shell of *Daphnella*. Though Eocene and Pliocene turrids from southeastern United States have been referred to *Daphnella*, no daphnellines are known in the Tertiary deposits of that region.

In outline and aperture the Caribbean fossils are notably different from *Pleurotoma lymneiformis* Kiener (1839–40, p. 62, pl. 22, fig. 3), the type species of *Daphnella*. That species is ovate in outline and the base of its aperture is wide and flaring. On the contrary, the pillar of the fossils is constricted and the aperture ends in a short siphonal canal. Some species, however, such as *Daphnella bartschi* Dall (1919, pl. 19, figs. 4, 5), are intermediate between *D. lymneiformis* and these fossil and related living species.

Daphnella pagera Woodring, n. sp.

Plate 61, figure 2

Of medium size, slender, pillar constricted. Early protoconch whorls missing, last whorl of small diameter, bearing diagonally cancellate sculpture. First post-protoconch whorl sculptured with 9 narrow axial ribs, overridden by 2 peripheral spiral threads; other narrower threads gradually added. On succeeding whorls axial ribs moderately strong to end of penult whorl, disappearing on body whorl; 13 on penult whorl. Three widely spaced primary spiral threads on penult whorl, upper two stronger than other, and many secondary threads, all strongly frosted by fine axial threads. Secondary spiral threads and slightly arcuate, protractive axial threads on anal fasciole. Outer lip broken back. As shown by axial threads, anal sinus narrow, shaped like a reclining L. Aperture relatively narrow, siphonal canal short, narrow, not notched, according to growth threads. Siphonal fasciole slightly inflated, sculptured with slightly frosted, closely spaced spiral threads.

Height (almost complete) 12.3 mm, diameter 4.7 mm (type).

Type: USNM 135580.

Type locality: 173a (USGS 2689, [French Canal], 10.5 kilometers from Colón, Canal Zone), upper part of Gatun formation.

The type, the only specimen, was collected from the upper part of the Gatun formation by R. T. Hill in 1895.

Daphnella pagera is closely related to an undescribed species dredged by Henderson off the coast of southern Florida at depths of 16 and 25 fathoms (USNM 318809, 318806). The fossil is smaller and its primary spiral threads are stronger. In outline and sculpture both species closely mimic *Asperdaphne versivestita* (Hedley) (1912, p. 148, pl. 43, fig. 33), but the protoconch of that living Australian species is spirally sculptured.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 173a.

Daphnella species

The lower part of the Gatun formation at locality 138a yielded a minute, incomplete very slender *Daphnella*, consisting of the protoconch and four post-protoconch whorls. The protoconch is an acute, wide-based cone of 3¾ whorls, the last 2½ of which are diagonally cancellate. The first post-protoconch whorl is sculptured with nine axial ribs, overridden by two spiral threads. The last whorl bears 12 axial ribs and four spiral threads. The anal fasciole is scupltured with fine spiral threads. The height, minus the aperture, is 3.5 millimeters and the diameter 1.7 millimeters.

The affinities of this species are undetermined.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138a.

Daphnella? species

A second minute, incomplete unnamed daphnelline was collected at the same locality as the preceding species, but at a later date. It consists of the protoconch and two post-protoconch whorls. The protoconch is an acute, wide-based cone of 4¼ whorls, the last half whorl of which is subcarinate. Much of the entire protoconch is so worn that the sculpture is effaced. It can be seen, however, that on the last half whorl the part below the subdued carina bears diagonally reticulate sculpture and the part above the carina bears arcuate riblets. Traces of the same kind of sculpture are visible on the next to last whorl. The post-protoconch whorls are somewhat turreted. They are sculptured with 10 strong, narrow, high axial ribs, overridden by three (later four) strong, narrow spiral threads. The ribs continue in subdued form across the gently sloping anal fasciole. The height, minus the aperture, is 2.7 millimeters and the diameter 1.5 millimeters.

This daphnelline may represent a new subgenus of *Daphnella*, or a new genus. Its protoconch and cancellarid-like post-protoconch sculpture are unique, at least among American daphnellines.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138.

Family TEREBRIDAE

Genus Terebra Bruguière

Bruguière, Encyclopédie méthodique, Histoire naturelle des vers, v. 1, p. XV, 1789 (genus without species).

Type (monotype, Lamarck, Soc. Histoire Nat. Paris Mém., p. 71, 1799): *Buccinum subulatum* Linné, living, western Pacific Ocean.

The American late Tertiary and living large terebrids are difficult to classify. Every feature that has been used to group them into subgenera shows a practically continuous spectrum. Nevertheless, a grouping into subgenera is desirable, even though agreement concerning boundaries is not to be expected.

In the present account the subgenera are arranged in order of increasing loss of sculpture.

Subgenus Oreoterebra Olsson

Olsson, Some Tertiary mollusks from south Florida and the Caribbean, p. 15, Paleontological Research Inst., 1967.

Type (orthotype): *Terebra maurya* Olsson (= *T. haitensis* Dall), Miocene, Dominican Republic.

The type species (Olsson, 1967, p. 15, pl. 4, figs. 8, 8a) is a synonym of *Terebra haitensis* Dall (1895 (1896), p. 35; 1890–1903, pl. 59, fig. 30, 1903), which, as shown by topotypes of both, is variable in the strength or absence of secondary spiral sculpture. It is fairly common in the Gurabo formation, but has not been found in the Cercado formation.

Oreoterebra embraces slender species, including the most slender of the large American terebrids. Typically the sculpture of *Oreoterebra* is strong throughout, but is subdued on the late whorls of some species. As interpreted in the present report, the sculpture is tripartate or bipartate and the columella is uniplicate or biplicate.

The age range of *Oreoterebra* is early Miocene to the present time. A tripartate, uniplicate species—*T. floridana* Dall (1889, p. 63; 1902, p. 503, pl. 29, fig. 9; Abbott, 1954a, p. 38, pl. 2, fig. 7)—is living in the western Atlantic Ocean. A tripartate, biplicate species, described in manuscript by Bartsch, ranges from Guaymas, México, to Panamá.

Terebra (Oreoterebra) dicheres Woodring, n. sp.

Plate 50, figure 3

Moderately large, very slender, sculpture bipartate. Sutural band wide, separated from remainder of whorl by deep, narrow groove. Axial sculpture consisting of narrow, closely spaced riblets, retractive on sutural band, slightly arcuate on remainder of whorl. Siphonal canal not preserved. Columella weakly uniplicate.

Height (body whorl, minus siphonal canal, and three preceding whorls) 35 mm, (estimated restored height 55 mm), diameter 11.5 mm (type).

Type: USNM 645870.

Type locality: 115a (USGS 6515, West side of Culebra [Gaillard] Cut, about one-third mile (500 meters) north [northwest] of Paraiso, Canal Zone), La Boca formation.

This species is represented by two incomplete specimens from the La Boca formation. The shell material is replaced by calcite. The sculptural plan is similar to that of the much smaller, weakly biplicate *Terebra odopoia* Gardner (1926–47, p. 280, pl. 38, fig. 2, 1938), a species from the Chipola and Shoal River formations of Florida. The La Boca fossils show no faint secondary spiral sculpture, like that of the Florida fossils, but the absence may be a matter of preservation. The sutural band of a middle Miocene Colombian species (USGS 7857, Tenerife area, Magdalena) is wider than that of *T. dicheres*. The Limón formation at Limon, Costa Rica, contains an undescribed, exceptionally slender, bipartate, biplicate *Oreoterebra*, the axial ribs of which are practically vertical across the entire whorl.

T. dicheres is the oldest species of *Oreoterebra* now known. It is considered to be a little older than the Chipola species and the forms from the Pirabas formation of Brazil (Maury, 1925a, p. 195, 197, 397, pl. 10, figs. 5, 9, 10, 11, 13, 18, 19), which probably represent one species.

Occurrence: La Boca formation (early Miocene), locality 115a.

Terebra (Oreoterebra) subsulcifera subsulcifera Brown and Pilsbry

Plate 61, figures 3, 7, 8, 9

Terebra subsulcifera Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 339, pl. 22, fig. 7, 1911 (Miocene, Canal Zone).

Terebra (Myurella) subsulcifera Brown and Pilsbry, Cossmann, Jour. Conchyliologie, v. 61, p. 14, pl. 1, fig. 25, 1913 (Miocene, Canal Zone).

Terebra (Myurellina) subsulcifera Brown and Pilsbry, Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 77, pl. 10, fig. 2, not fig. 2a, 1964 (Miocene, Ecuador).

?Terebra sp. ind., Toula, K. k. Geol. Reichsanstalt Jahrb., vol. 58, p. 707, pl. 25, fig. 15, 1909 (Miocene, Canal Zone).

Not *Terebra subsulcifera* Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 35, 1922 (Miocene, Canal Zone).

Terebra bipartita Sowerby, Olsson, Idem, p. 35, pl. 1, fig. 2, not fig. 1, 1922 (Miocene, Costa Rica).

Moderately large, very slender, sculpture tripartate. Sutural band moderately wide, separated by a groove of variable width from a narrow band of variable strength; both bands making up about half of spire-whorl height, or a little more. Axial riblets narrow, retractive on spiral bands, vertical and straight on remainder of whorl, except on late whorls, where they are slightly arcuate. Riblets fading off into low lamellæ on lower part of body whorl. Weak secondary spiral sculpture on some specimens. Siphonal notch deep. Siphonal fasciole limited by a narrow thread, bearing arcuate axial lamellæ. Columella strongly biplicate.

Height (almost complete) 68.5 mm, diameter 12.8 mm (largest figured specimen). Estimated restored maximum height 80 mm, diameter 15 mm.

Type: Acad. Nat. Sci. Phila. 1679.

Type locality: Gatun Locks excavation, middle part of Gatun formation.

The nominate subspecies of *Terebra subsulcifera* ranges through the Gatun formation in the Canal Zone. Most of the 45 specimens consist of a few whorls, generally late whorls that have a damaged body whorl. The most nearly complete shell is shown on plate 61, figures 8, 9.

Variation affects the degree of slenderness, the coarseness of sculpture, the width and depth of the

groove between the spiral bands, the strength of the lower spiral band, especially on the body whorl, the spacing of the axial riblets, and the stage at which they become slightly arcuate. A coarsely sculptured form is shown on plate 61, figure 3. A fragment of seven early whorls from locality 155b has exceptionally coarse sculpture for that growth stage. The axial riblets of the largest lower Gatun shell (12 whorls, height 51 mm, diameter 12 mm, locailty 138c) are nonarcuate up to the beginning of the body whorl. Cossmann's illustration shows a very narrow band below the sutural band and fairly distinct secondary spiral sculpture. Toula's poorly preserved specimen is missing from his collection.

T. subsulcifera subsulcifera occurs in the southwestern part of the present Caribbean area and at nearby eastern Pacific localities. The coaresly sculptured form occurs in the middle Miocene Angostura formation of Ecuador. The living Panamic species already mentioned closely resembles the nominate subspecies. The four specimens in the USNM collections are badly worn. The one in best condition (USNM 123083, Gulf of Panama, 322 fathoms) suggests that the sculpture is subdued on the last three whorls.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c, 138d, 138e. Middle part, eastern area, localities 139c, 139f, 151, 155, 155a, 155b, 159, 159d. Upper part, eastern area, localities 175, 176, 176a, 177, 177b, 177c. Angostura formation (middle Miocene), Ecuador. Middle Miocene deposits, Costa Rica, Colombia (USGS 7852, 10927), Darién (USGS 8479) and Chiriquí (USGS 7955) areas, Panamá.

Terebra (Oreoterebra) subsulcifera cembra Olsson

Plate 61, figure 5

Terebra (Paraterebra) cembra Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 76, pl. 10, fig. 3, 1964 (Miocene, Ecuador).

Similar to *Terebra subsulcifera subsulcifera*, but sculpture bipartate. Width of sutural band about half of spire-whorl height. Axial sculpture fairly coarse. Upper end of axial riblets on lower half of earliest preserved whorls slightly swollen to form subdued nodes. Nodes not connected across space between riblets to form narrow band, like that of nominate subspecies.

Height (almost complete) 48 mm, diameter 10.8 mm (figured specimen). Estimated restored maximum height 65 mm, diameter 12.5 mm.

Type: USNM 643915.

Type locality: Cueva de Angostura, Río Santiago, Esmeraldas, Ecuador, Angostura formation.

Fourteen specimens from the lower part of the Gatun formation are referred to this bipartate subspecies of *T. subsulcifera*. The axial sculpture is consistently fairly coarse. The earliest preserved whorls are almost tripartate. The upper end of the axial ribs on the lower half of early whorls of the type are not slightly noded, like those of Gatun shells at the same stage. That is, the type is strictly bipartate throughout.

A 3½-whorled, uniplicate shell (height 31 mm), more coarsely sculptured than the others, collected at locality 138e, is doubtfully referred to *T. subsulcifera cembra*. It is more likely to be an aberrant form of that subspecies than a different species or subspecies.

T. subsulcifera cembra is known only in Panamá and Ecuador. The two subspecies occur together at localities 138c and 138d (actually two collections of different date from the same locality).

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 138c, 138d, 138e (identification doubtful), 138f. Angostura formation (middle Miocene), Ecuador.

Terebra (Oreoterebra) isaacpetiti Maury

Plate 61, figures 12, 13

Terebra Petiti Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 31, pl. 4, fig. 4, 1917 (Miocene, Dominican Republic). Not *T. Petitii* Kiener.

Terebra isaacpetiti Maury, Idem, v. 10, no. 42, p. 184 1925 (Miocene, Dominican Republic). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 296, 1960 (Miocene, Colombia).

Terebra isaacpetiti? Maury, Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 52, pl. 6, fig. 3, 1929 (Miocene, Colombia).

Terebra (Paraterebra) isaacpetiti Maury, Perrilliat Montoya, México Univ. Nac. Inst. Geología Paleontología Mexicana, no. 8, p. 31, pl. 4, figs. 15, 16, 1960 (Miocene, México).

Terebra (Oreoterebra) isaacpetiti Maury, Olsson, Some Tertiary mollusks from south Florida and the Caribbean, Paleontological Research Inst., p. 16, pl. 3, figs. 4, 4a, 1967 (Miocene, Dominican Republic).

Large, very slender or slender, tripartate or weakly tripartate, finely sculptured. Sutural band moderately wide, separated by a deep or shallow groove from a well defined or poorly defined narrow band, both bands making up a little more than half of spire-whorl height. Lower band strong throughout, or subdued and even absent on late whorls. Axial riblets narrow, closely spaced, retractive on spiral bands, vertical or slightly protractive, and straight on remainder of whorl, slightly arcuate on some late whorls, disappearing on lower part of body whorl. Weak or faint secondary spiral sculpture on some specimens. Columella uniplicate; behind the fold a swelling on some specimens.

Height (almost complete) 99.5 mm, diameter 17.5 mm (larger figured specimen).

Type: Cornell University 36891.

Type locality: Los Quemados, Río Gurabo, Dominican Republic, Gurabo formation.

This large, tripartate or weakly tripartate, uniplicate, finely sculptured species, which reaches a height of 120 mm elsewhere, occurs in the middle and upper parts of the Gatun formation. It is represented by 15 specimens. The largest (pl. 61, fig. 12), a shell from the upper part of the Gatun in the western area, is worn. The sculpture is shown to better advantage by the middle Gatun shell shown on plate 61, figure 13. The degree of slenderness and the strength of the lower spiral band or its absence are variable. It is absent on late whorls of one specimen (locality 155). The occurrence of this species in Gatun collections was recognized by A. A. Olsson.

Terebra isaacpetiti evidently is rare in the Gurabo formation. Only one specimen, of seven whorls, is in the USNM collections. Colombian shells are somewhat more coarsely sculptured. Those from Tehuantepec have slightly arcuate riblets on the lower part of intermediate and late whorls. Some have distinct spiral sculpture.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139c, 147h, 155, 155b, 155c, 157. Upper part, eastern area, localities 175, 177a, 177d; western area, locality 182, 182a. Gurabo formation (middle Miocene), Dominican Republic. Tubará formation (middle Miocene), Colombia. Agueguexquite formation (middle Miocene), Tehuantepec, México.

Subgenus Paraterebra Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 135, 1928.

Type (orthotype): *Terebra texana* Dall (= *T. flammea* Lamarck=*Epitonium feldmanni* Röding=*Buccinum taurinum* Lightfoot), living, Florida, Bahamas, and Gulf of Mexico to northern Brazil.

For several decades only two specimens of *Terebra texana* were recognized: the type, a worn shell collected on Matagorda Island, Texas, and a battered kitchen-midden shell from northern Brazil. The first dredged specimens came from Barbados (J. B. Henderson in Nutting, 1919, p. 89, pl. 40, fig. 5) and Puerto Plata, Dominican Republic (Clench, 1938, p. 114, pl. 9, figs. 1, 2), identified as *T. texana* and *T. flammea*, respectively. It was soon realized that *T. texana* is *T. flammea* (Clench, 1939). Later *Buccinum taurinum* was found to be the earliest name for this species (Rehder and Abbott, 1951a, p. 66). In the meantime it has been dredged at localities off both coasts of Florida, in the northern Gulf of Mexico, and the Caribbean Sea. The depth range of USNM specimens is 6 to 20 fathoms.

Paraterebra is distinguished from *Oreoterebra* by its less slender outline and the suppression or loss of sculpture on late whorls. In both features, however, these subgenera more or less intergrade. The age range of *Paraterebra* is the same as that of *Oreoterebra*.

Terebra (Paraterebra) species

Of medium size, slender. Early and intermediate whorls missing. Upper two-thirds of last three whorls inflated. Entire whorl bearing exaggerated growth lines, retractive on inflated part, vertical to slightly protractive on remaining part. Faint traces of spiral sculpture on inflated part. Columella strongly uniplicate.

Height (3 whorls, minus siphonal canal) 20 mm, diameter 16.5 mm.

Unlike the condition of most of the aragonite-shelled fossils from the Culebra formation, the shell material of the single, incomplete specimen of this species is preserved. The inflated upper two thirds of the almost smooth whorls indicate that they are mature whorls of a small *Paraterebra* allied to a middle Miocene Venezuelan species identified as *Terebra inæqualis* Sowerby (Jung, 1965, p. 581, pl. 79, figs. 1–3, 9). The Venezuelan species, however, evidently is not Sowerby's species (Sowerby, 1850, p. 47). The illustrations indicate that it is not similar to the specimen designated the lectotype of *T. inæqualis* (Jung, 1965, pl. 78, fig. 14). It is more like what was selected as the lectotype of *T. sulcifera* Sowerby (Jung, 1965, pl. 78, fig. 13). Some of the labels in the Heneken collection at the British Museum (Natural History) are suspect. Anyone considering designation of lectotypes for species other than those illustrated by Sowerby should read Sherborn's remarks in his manuscript register of the Heneken collection, mentioned on page 347.

Occurrence: Culebra formation (early Miocene), locality 111b.

Terebra (Paraterebra) aff. T. taurina (Lightfoot)

Plate 61, figures 1, 14

Large, moderately slender, tripartate, finely sculptured. Early whorls missing. Intermediate whorls tripartate, late whorls weakly tripartate. Sutural band moderately wide, separated by a relatively shallow groove from a poorly defined narrow band set off from remainder of whorl by a very shallow groove that almost disappears, or entirely disappears, on late whorls. Both bands making up a little more than half of spire-whorl height. Axial riblets narrow and closely spaced,

or very narrow and very closely spaced, retractive on spiral bands, practically vertical and straight on remainder of intermediate whorls, slightly arcuate on body whorl, or last three whorls, fading off into growth lines on lower part of body whorl. Siphonal notch deep. Siphonal fasciole limited by a narrow thread, bearing arcuate lamellæ and growth lines. Columella weakly uniplicate at mature stage, strongly uniplicate at earlier stage.

Height (incomplete, 3½ whorls) 43 mm (estimated restored height 95 mm), diameter 16.5 mm (finely sculptured figured specimen).

Four incomplete specimens from the middle and upper parts of the Gatun formation closely resemble *Terebra taurina*. The degree of slenderness is uniform, but one upper Gatun shell (pl. 61, fig. 1) is not as finely sculptured as the others, one of which is illustrated (pl. 61, fig. 14). The aperture of the illustrated finely sculptured specimen is well preserved, except that the outer lip is slightly broken.

So far as these incomplete fossils go, they may represent a small subspecies of *T. taurina* that shows a greater range of variation in width and spacing of the axial riblets than *T. taurina* itself, which reaches a height of 125 to 145 mm. As shown under occurrence, comparable specimens are in collections from middle Miocene deposits in southeastern Costa Rica and Colombia, and from upper Miocene in Costa Rica, Panamá, and Venezuela. All of these fossils are incomplete. None exceeds an estimated restored height of 100 mm. The numbers under occurrence are USGS locality numbers.

A fine large species (height 110 mm) that occurs in the *Globorotalia fohsi barisanensis* zone of the Brasso formation in Trinidad (USGS 21234, Mayo River) has stronger sculpture on late whorls.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 155. Upper part, eastern area, locality 171; western area, locality 179. Middle Miocene deposits Costa Rica (5882i, 5883e), Colombia (10156, 11325, 11321, 11348, 11356, 8637, 10102). Limón formation (late Miocene), Costa Rica (21036), Bocas del Toro area, Panamá (8318). Savaneta glauconitic sandstone member of Springvale formation (late Miocene), Trinidad.

Subgenus Panaterebra Olsson

Olsson, Some Tertiary mollusks from south Florida and the Caribbean, p. 14, Paleontological Research Inst., 1967.

Type (orthotype): *Terebra robusta* Hinds, living, Gulf of California to northern Perú.

The type species loses its sculpture on intermediate whorls, but otherwise is similar to *Paraterebra*. *Panaterebra* is another subgenus that formerly lived in the western Atlantic part of the Tertiary Caribbean province, but now is extinct there and lives in the eastern Pacific Ocean.

Terebra (Panaterebra) cucurrupiensis Oinomikado

Plate 61, figures 10, 11, 15, 16

Terebra (Paraterebra) cucurrupiensis Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 626, pl. 29, fig. 1, 1939 (Miocene, Colombia).

?Terebra (Paraterebra) cf. *T. cucurrupiensis* Oinomikado, Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 123, 1951 (Miocene, Ecuador).

Large, early whorls slender, intermediate whorls more inflated, late whorls still more inflated, generally producing a slightly concave profile. Early whorls tripartate. Sutural band moderately wide, separated by a groove from a narrow band, both bands making up half of spire-whorl height or more than half. Axial riblets of variable width and spacing, retractive on spiral bands, protractive or vertical on remainder of whorl. Spiral bands coalescing, widening, and suppressed at variable stage on intermediate whorls, disappearing on late whorls, but leaving a narrow, slightly depressed area at base of late spire whorls, representing wider part of whorl below bands at earlier stage. Axial riblets fading off into growth lines on intermediate and late whorls. Faint secondary spiral sculpture on some specimens. Siphonal notch and fasciole like that of preceding species. Columella strongly uniplicate.

Height (incomplete) 75.5 mm (estimated restored height 115 mm), diameter 22 mm (largest figured specimen). Height (almost complete) 65.5 mm, diameter 15.5 mm (figured slender specimen).

Type: Geological Survey of Japan.

Type locality: Río San Juan, about 6 kilometers above Río Cucurrupí, Chocó Procince, Colombia, middle Miocene deposits.

Terebra cucurrupiensis is the most distinctive large terebrid in the Gatun formation, distinctive on account of the early loss of sculpture and the slightly concave profile shown by most of the mature specimens. It is especially characteristic of the lower part of the Gatun, which yielded 64 of the 73 specimens, but ranges up into the middle part.

As partly shown by the illustrations, it is a variable species: variable in outline, in the stage at which the sculpture disappears, and in width and spacing of the axial riblets. Only one specimen (locality 138c, height 62.5 mm, estimated restored height 85 mm, diameter 27.5 mm) is exceptionally inflated.

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Oinomikado realized that *T. cucurrupiensis* is closely related to *T. gabbi* Dall (1895 (1896), p. 34; 1890–1903, pl. 59, fig. 31, 1903), which occurs in the Gurabo formation of the Dominican Republic. The type (height 68.5 mm) is the only specimen in USNM collections. It is smaller than *T. cucurrupiensis*, its early whorls increase in diameter at a less rapid rate, and its combined spiral bands are narrower.

T. loroisii Guérin-Méneville (1854, p. 218, pl. 4, fig. 5; not *T. loroisi* Deshaves, 1859), known only from the Pacific coast of Panamá, is the only living species comparable to *T. cucurrupiensis*. The living species is larger (height up to 150 mm), loses its sculpture at an earlier stage, and the combined spiral bands are narrower. A few years ago *T. loroisii* was described as a new species: *T. dumbauldi* Hanna and Hertlein (1961, p. 77, pl. 6, fig. 2, pl. 7, figs. 2–5). Hanna and Hertlein (p. 72) accepted Reeve's opinion that *T. loroisii* is *T. robusta*. Though Guérin-Méneville named his species without locality data, his illustration is unmistakable, as H. A. Rehder realized when he identified the species in the USNM collections. Those collections contain six lots, four from Panamá, presumably near the city, one from Venado Beach in the Canal Zone, and one from the mouth of Rio Maje, in Darien near the Gulf of San Miguel. The three earliest lots are labelled in Dall's writing *Terebra cratera* Dall—a name that was not validated, perhaps because Dall was suspicious that such a large, striking species had already been named.

The distribution of *T. cucurrupiensis* illustrates the effects of a branch of the Miocene North Equatorial Current sweeping through the Atrato Trough.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137a, 138, 138a, 138c, 138d, 138f, 138g. Middle part, eastern area, localities 139c, 139e, 140. Middle Miocene, Darién area, Panamá (USGS 8477), southwestern Columbia, Daule formation (middle Miocene), Ecuador (identification doubtful). Early middle Miocene part of Brasso formation, Trinidad (USGS 18260).

Genus Strioterebrum Sacco

Sacco, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 10, p. 33, 1891.

Type (orthotype): *Terebra basteroti* Nyst, Miocene, western Europe.

Twenty-six names have been proposed or used for species of *Strioterebrum* from the Tertiary Caribbean province. Many of them, however, are difficult to recognize and they doubtless are overnamed.

The genus has a meager representation in the Bohio, Caimito, Culebra, and La Boca formations and Chagres sandstone, but is abundant in the Gatun formation. Though some 1,100 specimens are in collections from the Gatun, three species (*S. spiriferum*, *S. wolfgangi*, and *S. indocayapum*) account for 93 per cent of them. The number of specimens from the three parts of the Gatun is shown in the following table.

Specimens of Strioterebrum *from Gatun formation*

Species	Lower part	Middle part	Upper part	Total
S. spiriferum (Dall)	392	45	127	564
S. wolfgangi (Toula)	4	2	123	129
S. gausapatum (Brown and Pilsbry)	18	12	------	30
S. indocayapum Olsson	221	125	1	347
S. oresignum oresignum Olsson	------	21	------	21
S. oresignum hadrum Woodring, n. subsp	39	------	------	39
S. monidum (Woodring)	3	1	------	4
S. aff. *S. raptum* (Gardner)	1	------	------	1
Total	678	206	251	1, 135

In addition to the described species the Culebra, La Boca, and Gatun formations and Chagres sandstone contain unidentified species listed as *Strioterebrum* sp.

Strioterebrum listrotum Woodring, n. sp.

Plate 48, figure 22

Very small, very slender, whorls practically flat. Protoconch acute, 3-whorled. Sutural band narrow, appearing on third post-protoconch whorl, indistinct throughout, owing to very narrow, very shallow groove setting it off. Groove hardly indenting axial ribs. Axial riblets narrow, closely spaced, slightly protractive. Faint traces of spiral sculpture between crests of axial riblets below sutural band. Siphonal notch deep. Siphonal fasciole limited by a narrow thread. Columella not exposed.

Height 10 mm, diameter 2.3 mm (type).

Type: USNM 645869.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth, Canal Zone), Bohio formation.

The upper part of the Bohio formation of Barro Colorado Island yielded the type, the only specimen, of this small, very slender, *Turbonilla*-like species—the first Oligocene unequivocal *Strioterebrum* from the Tertiary Caribbean province. It resembles the diminutive *S. ischnum* (Woodring, 1928, p. 142, pl. 3, fig. 18, pl. 4, fig. 1; Bowden formation, Jamaica) which has similar obscure spiral sculpture and is even more slender.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d.

Strioterebrum species

Four specimens of a few whorls each, found in the moderately deep-water facies of the Caimito formation on Barro Colorado Island and in a somewhat shallower facies on Pato Horqueto Island, represent a species that is larger and more coarsely sculptured than *Strioterebrum listrotum* and evidently has a wider apical angle. This small sample shows a considerable range of variation in width and spacing of the axial riblets.

In general features this inadequate material is similar to larger Miocene species.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), localities 54h, 54k, 55a.

Strioterebrum cf. S. clethra (Maury)

Plate 50, figure 4

Of medium size, slender, whorls practically flat. Protoconch not preserved. Sutural band narrow, set off by wide, shallow depression. Axial riblets narrow, widely spaced, vertical on earliest preserved whorls, slightly arcuate on late whorls. Narrow spiral bands between crests of riblets below sutural band; on late spire whorls uppermost band doubled, other three widely spaced. Similar bands in subdued form on sutural band of late whorls. Siphonal canal missing. Columella not exposed.

Height (5 whorls less siphonal canal) 25.8 mm (estimated restored height 40 mm), diameter 9 mm (figured specimen).

An incomplete specimen of five late whorls and another of five early whorls from the La Boca formation at locality 115b are referred to an unnamed species. The smaller specimen shows that the apical angle is exceptionally narrow. The depression setting off the sutural band is as shallow as the depressions between the minor spiral bands below the sutural band. According to Maury's illustration, *Strioterebrum clethra* (Maury 1925a, p. 199, pl. 10, fig. 3), an early Miocene Brazilian species, has a narrow apical angle and coarse spiral sculpture, but the whorls are slightly bulging; the sutural band is stronger and narrower; and the axial riblets are narrower. Maury evidently derived the trivial name from a Greek noun.

Occurrence: La Boca formation (early Miocene), locality 115b.

Strioterebrum spiriferum (Dall)

Plate 62, figures 25, 31, 32, 36; plate 66, figure 4

Terebra dislocata Say (part), Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 225, 1873 (Miocene, Dominican Republic).

Terebra (Acus) bipartita spirifera Dall, U.S. Natl. Mus. Proc., v. 18, p. 38, 1895 (1896) (Miocene, Dominican Republic, [Canal Zone]).

Terebra (Oxymeris) bipartita spirifera Dall, Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 1,632, pl. 59, fig. 13, 1903 (Oligocene, Dominican Republic [Canal Zone]).

Terebra (Strioterebrum) spirifera Dall, Gardner, U.S. Geol. Survey Prof. Paper 142, p. 281, pl. 38, figs. 6 (Dall's illustration), 7 (lectotype), 1938 [Miocene, Canal Zone; not Shoal River formation and Oak Grove sand member; = *Strioterebrum waltonense* (Gardner)].

Terebra spirifera Dall, Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 298, 1960 (Miocene, Colombia).

Not *Terebra spirifera* Dall, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 24, pl. 3, figs. 15, 16, 1917 [Miocene, Dominican Republic; = *Strioterebrum lævifasciolum* (Maury)?].

Not *Terebra spirifera* Dall, Olsson, Idem, v. 9, no. 39, p. 38, pl. 1, fig. 13, 1922 (Miocene, Costa Rica, Panamá).

Not *Terebra (Strioterebrum) spirifera* Dall, Perrilliat Montoya, México Univ. Nac. Inst. Geología, Paleontología Mexicana, no. 14, p. 31, pl. 5, figs. 6, 7, 1963 (Miocene, México).

Terebra (Oxymeria) gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 705, pl. 25, fig. 14, 1909 (Miocene, Canal Zone).

Terebra gatunensis Toula, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 339, pl. 22, fig. 2, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 31, pl. 4, fig. 5, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., vol. 73, p. 316, 1922 (Miocene, Dominican Republic). Olsson Bull. Am. Paleontology, v. 9, no. 39, p. 36, pl. 1, figs. 4–6, 1922 (Miocene, Canal Zone). Weisbord, Idem, v. 14, no. 54, p. 51, pl. 6, fig. 4, 1929 (Miocene, Colombia). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 106, 1929 (Miocene, Colombia). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 297, 1960 (Miocene, Colombia).

Terebra (Myurella) gatunensis Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 13, pl. 1, figs. 26–29, 1913 (Miocene, Canal Zone, Martinique).

Terebra (Strioterebrum) gatunensis Toula, Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 626, pl. 29, fig. 7, 1939 (Miocene, Colombia).

Strioterebrum gatunense (Toula), Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 77, pl. 10, fig. 5 (*S. telembiense* in explanation of plate), 1964 (Miocene, Ecuador).

Strioterebrum cf. *gatunense* (Toula), Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 558, pl. 60, fig. 3, 1969 (Miocene, Trinidad).

Not *Terebra gatunensis* Maury (error for Toula), Li, Geol. Soc. China Bull., v. 9, p. 273, pl. 8, fig. 65, 1930 (Miocene, Panama Bay; = *Strioterebrum asperum* (Hinds), fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 433, 1931, living, Panamá Bay).

Terebra (Strioterebrum) gatunensis kugleri Rutsch, Schweizer. Palaeont. Gesell. Abh., v. 54, p. 106, pl. 8 figs. 18, 19, pl. 9, figs. 12, 13, 1934 (Miocene, Venezuela).

Not *Terebra (Strioterebrum) gatunensis kugleri* Rutsch, Weisbord, Bull. Am. Paleontology, v. 42, no. 193, p. 428, pl. 40,

figs. 12, 13, pl. 45, figs. 24, 25, 1962 [Pliocene, Venezuela; = *Strioterebrum dislocatum* (Say)].

Terebra wolfgangi Toula, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 340, pl. 22, figs. 1, 3–6, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 33, pl. 4, fig. 6, 1917 (Miocene, Dominican Republic).

Strioterebrum colombianum Olsson, Some Tertiary mollusks from south Florida and the Caribbean, Paleontological Research Inst., p. 18, pl. 4, figs. 1, 1a, 1967 (Miocene, Colombia).

Large, moderately slender, late whorls flat or slightly bulging. Protoconch blunt, 1½- to 1¾-whorled. Sutural band appearing on second or third post-protoconch whorl. Sutural band narrow, set off by shallow groove, not modifying whorl profile, or slightly modifying profile. Axial riblets narrow, closely spaced, slightly retractive on sutural band of late whorls, slightly arcuate on remainder of whorl; entire pattern forming an asymmetric arc on mature whorls. Spiral bands below sutural band narrow, slightly swollen on crest of riblets. Similar bands absent on sutural band, or present in subdued form. Siphonal notch deep, according to growth lamellæ on fasciole. Siphonal fasciole limited by a low, narrow thread. Columella uniplicate; behind the fold a swelling of variable strength and width. Both fold and swelling indistinct at aperture of some shells, including the largest.

Height (almost complete) 30.1 mm, diameter 7.8 mm (lectotype). Height (incomplete) 58.5 mm (estimated restored height 72 mm), diameter 14.5 mm (large, flat-whorled figured specimen).

Lectotype: USNM 113654.

Type locality: Recorded as Pontón, Dominican Republic, but that record is rejected in favor of Mount Hope, Canal Zone, upper part of Gatun formation.

It is a minor misfortune to lose Toula's name *Terebra gatunensis*, which has been used widely in Caribbean paleontological publications. Many years ago, however, Gardner reached the conclusion that it is to be suppressed as a junior synonym of *T. bipartita spirifera*. As a matter of fact, her decision was more objective than she realized. She had no reason to doubt that the type lot of *T. bipartita spirifera* is from Pontón, Dominican Republic, as alleged by Dall. Actually there is no reasonable doubt that, like the type lot of *Phos metuloides* (p. 266), it is from Mount Hope, Canal Zone. Dall identified the Gatun specimens from locality 159 as his form. The type lot of *T. bipartita spirifera* consists of 16 specimens, all incomplete and immature. They can be duplicated by immature shells from Mount Hope. The lectotype (pl. 62, fig. 25), selected and illustrated by Gardner, is the most complete shell. It agrees with the dimension cited by Dall for his illustrated specimen, although in his drawing the aperture is restored and the axial riblets are too closely spaced, like those of other specimens in the type lot.

This large species, represented by some 560 specimens, is the most abundant *Strioterebrum* in the Gatun formation, especially at locality 138e (185 specimens), and ranges through the formation. The typical flat-whorled, finely sculptured form, which includes all the mature shells from the middle part of the Gatun, is shown on plate 62, figure 32, an illustration of a topotype of *Terebra gatunensis*. Only 7 percent of almost 400 specimens collected from the lower part of the Gatun resemble the typical form. The others, like that illustrated on plate 62, figure 31, are not as flat-whorled or as finely sculptured. Some intermediates in the lower part (pl. 62, fig. 36), however, are apparent.

The flat, or almost flat, late whorls, sculptural pattern, blunt, cylindrical, paucigyrate protoconch, and uniplicate columella are distinctive of *Strioterebrum spiriferum*. The species ranges from early to late Miocene. In the western Atlantic part of the Miocene Caribbean province its distribution extends from Trinidad to Panamá and includes the Dominican Republic; in the eastern Pacific part from Darién to Ecuador. *Terebra gatunensis kugleri* was based chiefly on its large size, but in the type region *S. spiriferum* reaches a size as large as Rutch's specimens from Punta Gavilán. *S. guanabanum* (Olsson) (1942, p. 46, pl. 11, fig. 4; 1964, p. 78, pl. 10, figs. 1, 1a, 1b) is a moderately deep-water ally, possibly a subspecies, that occurs in the late Miocene or early Pliocene Esmeraldas formation of Ecuador and the Pliocene Charco Azul formation of southwestern Panamá.

A living species collected at Farfan, at the Pacific entrance to the Panama Canal, labelled *Terebra radula* Hinds (USNM 589792), is more similar to *S. spiriferum* than any living western Atlantic species, but its axial riblets are wider. According to Hind's illustration (1845, p. 174, pl. 44, fig. 95), the eastern Pacific species is not *T. radula*.

Occurrence: Lower, middle and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137 (fragment, identification doubtful), 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g, 139 (mold, identification doubtful). Middle part, eastern area, localities 139c, 141, 147g, 155, 155b, 155c, 157, 159, 159d, 160 (preservation poor, identification doubtful); western area, localities 161a, 161d, 162a, 170 (last three localities fragments only, identification doubtful). Upper part, eastern area, localities 172, 173, 175, 176, 176a, 177a, 177b, 177c, 177d, 177e, Dall's collection alleged to be from Pontón, Dominican Republic; western area, localities 179 (immature, identification doubtful), 182, 183 (immature, identification doubtful). Baitoa

formation (early Miocene), Dominican Republic (USGS 8668). Deposits of early Miocene age, Sinú area, Colombia (USGS 11594, 11612). Cercado formation (middle Miocene), Dominican Republic. Middle Miocene deposits, northeastern and southwestern Colombia, Darién, Panamá (USGS 8429, 8430). Middle(?) Miocene deposits, Martinique. Angostura formation (middle Miocene), Ecuador. Punta Gavilán formation (late Miocene), Venezuela. Melajo clay member of Springvale formation (late Miocene), Trinidad.

Strioterebrum wolfgangi (Toula)

Plate 62, figures 29, 30; plate 66, figure 1

Terebra (Acus) bipartita Sowerby, variety *bipartita* s.s. (part), Dall, U.S. Natl. Mus. Proc., v. 18, p. 38, 1895 (1896) (Miocene, Dominican Republic [Canal Zone]).

Terebra wolfgangi Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 705, pl. 28, fig. 7a, 7b, 1909 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 37, pl. 1, figs. 11, 12, 1922 (Miocene, Canal Zone).

Not *Terebra wolfgangi* Toula, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 340, pl. 22, figs. 1, 3–6, 1911 [Miocene, Canal Zone; = *Strioterebrum spiriferum* (Dall)]. Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 33, pl. 4, fig. 6, 1917 [Miocene, Dominican Republic; = *Strioterebrum spiriferum* (Dall)].

Terebra gausapata Brown and Pilsbry, Olsson, Idem, v. 9, no. 39, p. 38, pl. 1, figs. 8, 10, 1922 (Miocene, Canal Zone, Panamá).

Of medium size, moderately slender to slender, late whorls slightly bulging. Protoconch acute, 3- to 3½-whorled. Sutural band appearing on first or second post-protoconch whorl. Sutural band narrow, set off by relatively shallow groove, slightly modifying whorl profile. Axial riblets narrow, relatively widely spaced, slightly retractive on sutural band of late whorls, slightly arcuate on remainder of whorl. Spiral bands below sutural band narrow, separated by shallow or moderately shallow depressions; slightly swollen on axial riblets. Similar bands absent on sutural band, or present in subdued form. Apertural features like those of *Strioterebrum spiriferum*.

Height (almost complete) 38.8 mm, diameter 9.5 mm (moderately slender figured specimen). Height (incomplete) 37 mm (estimated restored height 42 mm), diameter 8.2 mm (slender figured specimen). Height (incomplete) 42.7 mm (estimated restored height 55 mm), diameter 10 mm (largest specimen).

Type: Technische Hochschule, Vienna.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Four immature specimens from the lower part of the Gatun formation, two immature from the middle part, some 110 from four localities in the upper part in the Mount Hope area, and 12 additional specimens from the same area, alleged to be from Pontón in the Dominican Republic (Dall's *Terebra bipartita*), are identified as *Strioterebrum wolfgangi*. Unfortunately no mature specimens from the middle part other than the type are available, and the protoconch of the type is not preserved. As shown by Toula's illustration, the type is a slender form. Though some of the upper Gatun fossils, like that shown on plate 62, figure 29, are as slender as the type, the prevailing form (pl. 62, fig. 30), and the only form in the small lower Gatun sample, is less slender. The axial riblets of the upper Gatun fossils are not as closely spaced as those of the type.

In general features *S. wolfgangi* is similar to *S. spiriferum*, with which it is associated at localities 175, 177b, and the locality alleged to be in the Dominican Republic. *S. wolfgangi*, however, is smaller and its whorls are not so flat-sided. The protoconch of the upper Gatun fossils and of an immature middle Gatun specimen is acute and polygyrate, whereas that of *S. spiriferum* is blunt and paucigyrate, and the axial riblets of mature shells (but not those of the type) are more widely spaced.

S. waltonense Gardner (1926–47, p. 282, pl. 38, figs. 8–10, 1938; Shoal River formation, Fla.) also has an acute, polygyrate protoconch, but its whorls are flat-sided and its sutural band is wider than that of *S. wolfgangi*. The middle Miocene Tehuantepec species identified as *S. waltonense* (Perrilliat Montoya, 1963, p. 31, pl. 5, figs. 9, 10) is similar to the upper Gatun *S. wolfgangi*, except for its blunt, paucigyrate protoconch.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 136. Middle part, locality 155, Gatun Locks area (Toula's record). Upper part, eastern area, localities 173a, 174, 175, 177b, Dall's collection alleged to be from Pontón, Dominican Republic. Limón formation (late Miocene), Bocas del Toro area, Panamá.

Strioterebrum gausapatum (Brown and Pilsbry)

Plate 62, figures 23, 24

Terebra gausapata Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 340, pl. 22, figs. 8, 9, 1911 (Miocene, Canal Zone). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 297, 1960 (Miocene, Colombia).

Not *Terebra gausapata* Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 38, pl. 1, figs. 8, 10, 1922 [Miocene, Canal Zone, Panamá; = *Strioterebrum wolfgangi* (Toula)].

Not *Terebra (Strioterebrum) gausapata* Brown and Pilsbry, Gardner, U.S. Geol. Survey Prof. Paper 142, p. 281, pl. 38, fig. 4, 1937 (1938) (Miocene, Fla.).

Terebra acuaria Toula, K. k. Geol. Reichsanstalt, Jahrb., v. 61, p. 505, pl. 31, fig. 19, 1911 (Miocene, Canal Zone).

Terebra (Myurella) acuaria Toula, Cossmann, Jour. Conchyliologie, v. 61, p. 12, pl. 1, figs. 19–24, 1913 (Miocene, Canal Zone, Martinique).

Terebra gausapata herviderana Spieker, Johns Hopkins Univ. Studies in Geol., no. 3, p. 35, pl. 1, fig. 1, 1922 (Miocene, Perú).

?Terebra (Strioterebrum) herviderana Spieker, Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 148, pl. 15, figs. 3, 7, 1932 (Miocene, Perú).

Terebra (Strioterebrum) sp. b, Woodring, Carnegie Inst. Washington Pub. 385, p. 140, pl. 3, fig. 15, 1928 (Miocene, Jamaica).

Terebra (Strioterebrum) pavonia Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 146, pl. 15, figs. 8, 9, 1932 (Miocene, Perú).

Terebra (Strioterebrum) sp. A, Jung, Idem, v. 49, no. 223, p. 590, pl. 79, figs. 7, 8, 1965 (Miocene, Venezuela).

Of medium size, slender, late whorls slightly bulging. Protoconch acute, 3¼- to 4-whorled. Sutural band appearing on first post-protoconch whorl, strong and strongly noded on succeeding early whorls. Sutural band narrow, set off by deep groove of variable width, modifying whorl profile. Axial riblets narrow, relatively widely spaced, slightly retractive on sutural band of late whorls, slightly arcuate on remainder of whorl. Spiral bands below sutural band few and widely spaced, or more numerous and crowded; if numerous, that adjoining sutural band wider than others; slightly swollen on crest of riblets, or absent on crest. Similar bands generally absent on sutural band, exceptionally present, as on type. Columella weakly uniplicate; behind the fold a wide, low swelling.

Height (incomplete) 33.6 mm (estimated restored height 38 mm), diameter 7.5 mm (larger figured specimen). Height (almost complete) 27.3 mm, diameter 6.7 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 1678.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Unlike the preceding two species, *Strioterebrum gausapatum* is relatively rare. Though it is found in the lower and middle parts of the Gatun formation, only 30 specimens are assigned to it, and half of them, all from the lower part, are immature shells consisting of the protoconch and a few post-protoconch whorls. The larger figured specimen (pl. 62, fig. 24) is worn.

In protoconch and apertural features *S. gausapatum* is indistinguishable from the slender form of *S. wolfgangi*. *S. gausapatum*, however, is consistently slender; the sutural band more strongly modifies whorl profile; and on early whorls the sutural band is stronger and more strongly noded by the axial riblets. Moreover, *S. gausapatum* is the only Gatun species of the genus including specimens that have distinct, though weak, spiral sculpture on the sutural band. That, however, is an exceptional feature, shown by only two available specimens: the type—a small, incomplete shell, illustrated by Brown and Pilsbry in two views of different magnification—and a somewhat larger topotype (locality 159d).

The type of *Terebra acuaria*, like the type of *S. gausapatum*, is small (height 7.6 mm).

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a. Middle part, eastern area, localities 146, 151, 155b, 155c, 159d. Bowden formation (middle Miocene), Jamaica. Middle Miocene deposits, Colombia. Cantaure formation (middle Miocene), Venezuela. Zorritos formation (middle Miocene), Perú.

Strioterebrum indocayapum Olsson

Plate 62, figure 28; plate 66, figure 10

Strioterebrum indocayapum Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 79, pl. 11, figs. 2, 2a, 1964 (Miocene, Ecuador).

Of medium size, slender, whorl profile slightly modified by sutural band. Protoconch acute, 3½- to 4½-whorled. Sutural band appearing on first or second post-protoconch whorl. Sutural band moderately wide, slightly bulging, set off by deep, narrow groove. Axial riblets narrow, slightly retractive on sutural band of late whorls, straight or slightly arcuate, on remainder of whorl. Spiral bands below sutural band of variable width and spacing, that adjoining sutural band generally wider than others; slightly swollen on crest of riblets or absent on riblets, generally absent on sutural band. Similar bands exceptionally present in subdued form on sutural band of early whorls. Columella strongly biplicate, upper fold alined with thread limiting siphonal fasciole.

Height (almost complete) 36.8 mm, diameter 8.7 mm (figured specimen). Height (incomplete) 39.2 mm (estimated restored height 45 mm), diameter 9 mm (largest specimen).

Type: USNM 644128.

Type locality: Telembi, Río Cayapas, Ecuador, Angostura formation.

Though the Gatun specimens reach a size twice as large as those in the type lot, they are identified as *Strioterebrum indocayapum*. The groove setting off the sutural band of the type is wider and shallower than on Gatun shells. That feature is variable on other specimens in the type lot, but not on Gatun specimens.

Among the Gatun species of the genus that have an essentially similar sculptural pattern, *S. indocayapum* is readily distinguished by its acute, polygyrate protoconch, and strongly biplicate columella, strongly biplicate even on immature shells of a few post-proto-

conch whorls. It occurs in the three parts of the Gatun formation, a total of some 340 specimens. All of the 125 specimens from the middle part are small, having a restored estimated height of 30 mm or less. In that respect they are similar to the shells from the type locality. Seventy-four of these small shells, 44 of which have preserved protoconchs, were collected at locality 147b.

Though the sculpture and columella of Olsson's *Terebra spirifera* (Olsson, 1922, p. 38, pl. 1, fig. 13; Miocene, Costa Rica, Bocas del Toro area, Panamá) suggest *S. indocayapum*, its spire is long, acute, and evenly tapering. *Terebra spirifera midiensis* (Olsson, 1922, p. 39, pl. 1, fig. 7; Miocene, Costa Rica) has only two spiral bands below the sutural band and strong axial threads between them.

At first glance *S. indocayapum* might be identified as *S. lævifasciolum* (Maury) (1917, p. 27, pl. 3, fig. 19; Cercado formation, Dominican Republic), which reaches a size as large as the lower Gatun shells. Its protoconch, however, is blunt and paucigyrate, and its sutural band is slightly narrower than that of the Gatun species. *S. lævifasciolum* may be a small subspecies of the common western Atlantic *S. dislocatum* (Say), which has an age range of late Miocene to the present time in southeastern United States. In the Caribbean region *S. dislocatum* is unknown before early Pliocene time. The early Pliocene Venezuelan species described as *S. gatunense kugleri* (Weisbord, 1962, p. 428, pl. 40, figs. 12, 13, pl. 45, figs. 24, 25) is identified as *S. dislocatum*.

S. coleri (Engerrand and Urbina) (1910, p. 120, pl. 59, figs. 35, 36), based on small, incomplete shells from middle Miocene deposits near Palenque, Chiapas, may be related to *S. dislocatum*, as Engerrand and Urbina thought, or may be related to *S. indocayapum*. Its protoconch is unknown. The same reservation is applicable to the small Chipola species *S. pupiforme* (Gardner, 1926–47, p. 280, pl. 38, fig. 3, 1938).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g. Middle part, eastern area, localities 139b, 139c, 146, 147b, 147f, 147g, 147h, 159d; western area, locality 161c. Upper part, eastern area, locality 178. Middle Miocene deposits, Darién, Panamá (USGS 8434). Angostura formation (middle Miocene), Ecuador.

Strioterebrum oresignum oresignum Olsson

Plate 62, figure 37

Strioterebrum oresignum Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 78, pl. 10, figs. 6, 6a, 6b, 1964 (Miocene, Ecuador).

Of medium size, slender, sutural band modifying whorl profile. Protoconch not preserved. Sutural band relatively wide, set off by narrow, shallow groove. Axial riblets narrow, closely spaced, slightly retractive on sutural band of late whorls, slightly arcuate on remainder of whorl. Spiral bands below sutural band weak to moderately strong, separated by shallow depressions. Similar bands absent on sutural band. Columella smooth, or indistinctly uniplicate and bearing an indistinct, wide swelling behind the fold.

Height (incomplete) 43.5 mm (estimated restored height 48 mm), diameter 10.2 mm (figured specimen).

Type: USNM 643923.

Type locality: Cueva de Angostura, Río Santiago, Ecuador, Angostura formation.

The somewhat worn figured specimen, the most nearly complete shell among 21 found in the middle part of the Gatun formation, closely resembles the type of *Strioterebrum oresignum*, except that the sutural band of the Gatun shell is slightly less swollen. Despite the wide sutural band of *S. oresignum oresignum*, well shown on mature shells, some immature specimens assigned to that form may be misidentified *S. gausapatum*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 139c, 139e, 139f, 155. Angostura formation (middle Miocene), Ecuador.

Strioterebrum oresignum hadrum Woodring, n. subsp.

Plate 62, figures 22, 35

Sutural band more swollen than that of *Strioterebrum oresignum oresignum*, producing a turreted whorl profile. Axial riblets wider and more widely spaced.

Height (incomplete) 46.4 mm (estimated restored height 55 mm), diameter 12.8 mm (type). Height (incomplete) 24.2 mm (estimated restored height 35 mm), diameter 8.2 mm (figured paratype).

Type: USNM 646045; paratype, USNM 646046.

Type locality: 136 (USGS 16912, north side of Transisthmian Highway, knoll about 30 meters north of highway, 1.2 kilometers northwest of Sabanita, Panamá), lower part of Gatun formation.

As compared with other Gatun forms, the sutural band of this lower Gatun *Strioterebrum* is exceptionally swollen and the axial sculpture is coarse. The type, like all the other 38 specimens, except the paratype, is worn, although the type is one of the few Gatun specimens of the genus that has an almost complete aperture. Therefore the spiral sculpture below the sutural band appears to be weak. A better idea of that sculpture is afforded by the immature, incomplete paratype (pl. 62, fig. 22), which is only slightly worn.

The swollen sutural band suggests alliance to *S. nelsoni* (Hanna and Israelsky), but the apical angle of that species is wider and its axial ribs are distinctly arcuate. *S. nelsoni* occurs in the late Miocene Tumbes formation of Perú and in deposits of Pliocene age in Ecuador. The type has been illustrated by Pilsbry and Olsson (1941, p. 14, pl. 1, fig. 3). *S. armillatum* (Hinds) (*in* Sowerby, 1845, p. 173, pl. 43, fig. 49) is a close living ally of *S. nelsoni*.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 136a, 137a.

Strioterebrum monidum (Woodring)

Plate 63, figures 3, 4

Terebra (*Strioterebrum*) *monida* Woodring, Carnegie Inst. Washington Pub. 385, p. 141, pl. 3, fig. 17, 1928 (Miocene, Jamaica).

Small, moderately slender, whorls flat. Protoconch not preserved. Sutural band exceptionally wide, making up a little less to a little more than half of whorl height, set off by deep, narrow groove. Axial ribs wide, slightly protractive, separated by narrow V-shaped depression, gradually attenuated downward and slightly sigmoidal on body whorl. Closely spaced, narrow spiral bands of variable strength on flanks of riblets below sutural band, stronger on last few whorls than elsewhere. Similar bands present or absent on sutural band. Columella uniplicate.

Height (almost complete) 23.5 mm, diameter 5.8 mm (figured specimen).

Type: USNM 369347.

Type locality: Bowden, Jamaica, Bowden formation.

The exceptionally wide sutural band and closely spaced axial ribs of this species are unmistakable. It is represented by three specimens from the lower part of the Gatun formation and one from the middle part in the western area. The sutural band of the lower Gatun shells makes up half or a little more than half of whorl height, whereas that of the middle Gatun shell makes up a little less than half.

The extraordinary number of bore holes, made by an unknown predator, in some shells of this species from Jamaica and Panamá, 1,000 kilometers apart, is noteworthy. All of some 20 Jamaican shells have more than one hole and one has 13. The illustrated lower Gatun shell has 14 holes, only a few of which penetrate the entire shell wall. Five and two holes, respectively, are shown by the other two lower Gatun shells, but the middle Gatun specimen, the smallest of all, has none.

Two specimens from the Cercado formation of the Dominican Republic represent a slender form of *S. monidum*, possibly a subspecies. Middle Miocene deposits in southeastern Costa Rica yielded one specimen that has narrower and more numerous axial riblets than those so far mentioned. It presumably is to be assigned to a distinct species. The treatment of the Cercado and Costa Rican forms is slightly different from that adopted in 1928.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d. Middle part, western area, locality 161c. Bowden formation (middle Miocene), Jamaica. Cercado formation (middle Miocene), Dominican Republic, slender form (USGS 8534).

Strioterebrum aff. S. raptum (Gardner)

Plate 61, figure 6

Small, slender, late whorls slightly bulging. Protoconch unknown. Sutural band set off only by pits between axial riblets. Axial riblets narrow, closely spaced, extending uninterruptedly from suture to suture, protractive, slightly arcuate on late whorls. Spiral bands below sutural band weak on last few whorls, indistinct or absent on earlier whorls. Similar bands absent on sutural band. Columella weakly uniplicate.

Height (almost complete) 10 mm, diameter 3.5 mm (figured specimen).

A small, presumably immature, lower Gatun shell is characterized by the weakly set off sutural band—set off only by pits between the axial riblets. In that feature it is similar to *Strioterebrum raptum* (Gardner, 1926–47, p. 285, pl. 38, figs. 18, 19, 1938), a species of the Shoal River formation of Florida. The whorl height of the Gatun fossil increases at a less rapid rate and its spiral sculpture below the sutural band is more distinct and coarser. The spiral sculpture is discernible on only a few well preserved Florida shells, and even on them it is very weak and fine.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c.

Family PYRAMIDELLIDAE

The pyramidellids are omitted. With the exception of Miocene species from the Dominican Republic, the fossil species of that family in the Caribbean region, and many of those still living there, are undescribed or inadequately covered.

Pyramidellids occur in the marine member of the Bohio(?) formation, the Bohio formation, the moderately deep-water facies of the Caimito formation on Barro Colorado Island, and the La Boca and Gatun formations—a total of about 17 species, 12 of which are found in the Gatun. Brown and Pilsbry (1913, p. 509–510, figs. 4a–4c) proposed two names for Gatun representatives of *Turbonilla: T. bartschiana* and *T.*

gatunensis. They probably are forms of one species. Like many other small species, pyramellids are most abundant at locality 147b.

Family ACTEONIDAE

Genus Acteon Montfort

Montfort, Conchyliologie systématique, v. 2, p. 315, 1810.
Type (orthotype): *Voluta tornatilis* Gmelin (*Voluta tornatilis* Linné), living, eastern Atlantic Ocean.

Subgenus Acteon s.s.

Acteon (Acteon) aff. A. tampae Dall

The upper part of the Bohio formation on Barro Colorado Island yielded a small, inflated, incomplete *Acteon*. The sculpture, as usual, consists of narrow spiral grooves, which are obscurely pitted on the calcite-replaced shell. The inflated outline and small size suggest alliance to *A. tampæ* (Dall, 1915, p. 32, pl. 4, fig. 10), of the early Miocene Tampa limestone of Florida. The body whorl of the type of that species—the only specimen—has two relatively wide spiral grooves near the suture.

The estimated restored height of the Bohio fossil is 7 mm, the estimated restored diameter 4 mm.

Occurrence: Bohio formation (late Oligocene), locality 42.

Acteon (Acteon) punctostriatus (C. B. Adams)

Plate 62, figure 11

Tornatella puncto-striata C. B. Adams, Boston Jour. Nat. History, v. 3, p. 323, pl. 3, fig. 9, 1840 (living, Mass.). Clench and Turner, Harvard Univ. Mus. Comp. Zoology, Occasional Papers on Mollusks, v. 1, p. 333, pl. 40, figs. 5, 6, 1950 (living, Massachusetts).

Actæon punctostriatus (C. B. Adams), Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 1, p. 14, 1890 (Miocene to present time). Pilsbry, Manual Conchology, v. 15, p. 157, pl. 19, figs. 22, 23, 1893 (1894) (living, Massachusetts to West Indies).

Acteon punctostriatus (C. B. Adams), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 310, 1922 (Miocene, Dominican Republic). Olsson and Harbison, Acad. Nat. Sci. Philadelphia Mon. 8, p. 157, 1953 (Pliocene, Florida).

Tornatella punctata d'Orbigny [*Acteon*], in de la Sagra, Ramon, Histoire physique, politique et naturelle de l'île de Cuba, Mollusques, v. 1, p. 230, pl. 17, figs. 10–12, 1842 (living, Cuba). Not *Acteon punctatus* Lea, 1833.

Actæon cubensis Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 245, 1873 (Miocene, Dominican Republic).

Tornatella (Actæon) cubensis (Gabb), Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 518, 1876 (Miocene, Dominican Republic).

Acteon riomœnsis Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 11, pl. 3, fig. 1, 1917 (Miocene, Dominican Republic). Woodring, Carnegie Inst. Washington Pub. 385, p. 118, pl. 2, fig. 3, 1928 (Miocene, Jamaica).

Very small, moderately slender, suture slightly channeled. Early protoconch whorls submerged, about one whorl visible, merging into first post-protoconch whorl. Sculpture consisting of finely engraved, microscopically pitted, spiral striæ, limited to about lower two-thirds of body whorl. Columellar fold strong for size of shell.

Height 3.7 mm, diameter 2 mm (figured specimen).

Type: Mus. Comp. Zool. 155925.

Type locality: Living, New Bedford, Mass.

Twenty-two specimens of this small species were found in the lower and middle parts of the Gatun formation, but half of them are minute shells consisting of the protoconch and one or two post-protoconch whorls. The largest shell (height almost 7 mm) was badly damaged during handling.

If *Acteon punctostriatus* now ranges from Massachusetts to the Gulf of Mexico and the West Indies, *A. riomœnsis* cannot be distinguished satisfactorily from it, contrary to the view that was adopted in 1928. The typical form, at the north end of the range, is thin shelled and has a weak columellar fold. Lots collected farther south include shells that are thicker and have a correspondingly stronger fold. *A. riomœnsis* appears to be indistinguishable from such shells. The Gatun fossils are more slender than topotypes of *A. riomœnsis* and the usual run of dredged shells. Unlike some topotypes of *A. riomœnsis*, and also some Jamaican fossils and living shells, none of the few Gatun fossils has spiral sculpture extending over the entire body whorl.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c. Middle part, eastern area, localities 139b, 139c, 147b. Cercado formation (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Caloosahatchee marl (Pliocene), Florida. Living, Massachusetts to Gulf of Mexico and West Indies.

Subgenus Lissacteon Monterosato

Monterosato, Naturalista Siciliano, v. 9, p. 188, 1890.
Type (monotype): *Actæon exilis* Jeffreys, living, eastern and western North Atlantic Ocean.

Acteon (Lissacteon?) species

Mature size and shape unknown. Exposed part of protoconch (one whorl) exceptionally large, almost flat topped. End marked by abrupt appearance of sculpture. First post-protoconch whorl inflated. Sculpture covering entire whorl, consisting of narrow, closely spaced, spiral grooves, pitted by fine axial threads. Columella nonplicate.

Height 2 mm, diameter 1.3 mm.

The minute shells from the middle part of the Gatun formation include five specimens, all consisting only of the protoconch and the first post-protoconch whorl, of a noteworthy *Acteon*—noteworthy for its exceptionally large protoconch and nonplicate columella. The large protoconch and strong, abruptly appearing sculpture indicate that it is not closely allied to *A. exilis*, the type of *Lissacteon*. In fact, it has no known close allies.

The validity of *Lissacteon* as a subgenus is questionable. The type species has a suggestion of a weak columellar fold, but there is no discontinuity in the strength of the fold shown by species of the genus.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 147b; western area, localities 161c, 170a.

Genus Rictaxis Dall

Dall, Am. Jour. Conchology, v. 7, p. 136, 1871.

Type (orthotype): *Rictaxis punctocœlata* (Carpenter), (*Tornatella punctocœlata* Carpenter), living, eastern Pacific Ocean.

Rictaxis oryza (Gabb)

Actæonidea oryza Gabb, Acad. Nat. Sci. Phila. Proc., v. 24, (1872), p. 273, pl. 11, figs. 8, 8a, 1873 (Miocene, Dominican Republic). Gabb, Am. Philos. Soc. Trans., v. 15, p. 245, 1873 (Miocene, Dominican Republic).

Rictaxis oryza (Gabb), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 310, pl. 23, fig. 12, 1922 (Miocene, Dominican Republic).

Small, slender. Visible part of protoconch consisting of one whorl. End marked by appearance of sculpture. Sculpture, of narrow, closely spaced, spiral grooves, pitted by fine axial threads, covering entire whorl. Aperture long, narrow. Columella bearing well up a narrow fold, merging downward into long, narrow columellar lip.

Estimated restored height 6 mm, diameter 2.7 mm.

Type: Acad. Nat. Sci. Phila. 3181.

Type locality: Dominican Republic, Miocene.

Though this rare species, heretofore represented only by the type, is unequivocally identified, the seven specimens—all from the lower and middle parts of the Gatun formation—are unsatisfactory for illustrating. Four minute shells show the protoconch and first or first and second, post-protoconch whorl. A mature body whorl (locality 139c), which has more closely spaced spiral grooves than the type, shows the apertural features.

Rictaxis oryza is the monotype of *Actæonidea* Gabb, proposed when the species was described. It is sole named Caribbean species of a genus that survived until Pliocene time in Florida, where it is represented by *R. myakkanus* (Dall) (Olsson and Harbison, 1953, p. 158, pl. 25, figs. 5, 5a), and is now living in the eastern Pacific Ocean. An immature shell from the late Miocene Melajo clay member of the Springvale formation of Trinidad (height 3.3 mm), which has a large protoconch, may represent a second Caribbean species.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138e. Middle part, eastern area, localities 139b, 139c, 139g. Miocene (presumably Cercado or Gurabo formation), Dominican Republic.

Family RINGICULIDAE

Genus Ringicula Deshayes

Deshayes *in* Lamarck, Histoire naturelle des animaux sans vertèbres, 2d ed., vol. 8, p. 342, 1838.

Type (logotype, Gray, Zool. Soc. London Proc., p. 140, 1847): *Auricula ringens* Lamarck, Eocene, western Europe.

Subgenus Ringiculella Sacco

Sacco, I Molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 12, p. 16, 1892.

Type (logotype, Cossmann, Essais de paléoconchologie comparée, pt. 1, p. 115, 1895): *Marginella auriculata* Ménard, Miocene to present time, western Europe.

Ringicula (Ringiculella?) species

A crushed inflated *Ringicula* was found in the Caimito formation on Pato Horqueto Island. The outer lip is not preserved. Both columellar folds are narrow. The parietal callus is thick, but the inner part of the upper parietal wall, where the parietal fold of *Ringiculella* is seated, cannot be exposed without risk of damaging the shell. All except the uppermost part of the body whorl is sculptured with finely engraved, spiral striæ. The height is 3.3 mm, and the diameter, minus the outer lip, but somewhat increased by crushing, 2.5 mm.

Occurrence: Caimito formation, Gatun Lake area, locality 55a.

Ringicula (Ringiculella) semistriata d'Orbigny

Plate 62, figure 12

Ringicula semi-striata d'Orbigny, in de la Sagra, Histoire physique, politique, et naturelle de l'île de Cuba, Mollusques, v. 2, p. 103, pl. 21, figs. 17–19, 1841 (living, Jamaica).

Ringicula semistriata d'Orbigny, Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 358, 1881 (Pliocene, Costa Rica). Pilsbry, Manual Conchology, v. 15, p. 399, pl. 46, figs. 43, 44, 1893 (1894) (living, Jamaica).

Ringicula tridentata Guppy, Sci. Assoc. Trinidad Proc., vol. 2, no. 2, p. 76, 1873 (Miocene, Jamaica); reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 60, 1921.

Ringicula (Ringiculella) tridentata Guppy, Woodring, Carnegie Inst. Washington Pub. 385, p. 132, pl. 2, fig. 22, 1928 (Miocene, Jamaica).

Ringicula hypograpta Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 505, fig. 2, 1913 (Miocene, Canal Zone).

Small, inflated. Protoconch not distinguishable from first post-protoconch whorl. Lower half to two-thirds of whorl, exceptionally entire early whorl, sculptured with faint, finely engraved, spiral striæ. Outer lip strongly thickened, inner edge extending toward aperture below middle; or moderately thickened and inner edge not extending toward aperture. Parietal callus relatively thin. Basal columellar fold wide or narrow. Upper columellar and parietal folds narrow.

Height 3 mm, diameter 2 mm (figured specimen).

Type: British Museum (Natural History).

Type locality: Living, Jamaica.

The three parts of the Gatun formation yielded 46 specimens of *Ringicula*. All except three are minute or otherwise immature. Two of the relatively large shells, including that illustrated, have a thick outer lip. The other (locality 138c) has a thinner lip and narrower basal columellar fold. It is improbable, however, that it represents a different species. The entire second or third whorl of some minute well-preserved shells is faintly sculptured.

No topotypes of *R. semistriata* are available. The illustrated specimen closely resembles shells from southern Florida that doubtless are to be referred to that species, despite the exaggerated apertural features shown in d'Orbigny's illustration. It also resembles topotypes of *R. tridentata*, although they have more uniformly heavy apertural features. *R. tridentata* was formerly accepted as a valid species.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c, 138d, 138e, 138g. Middle part, eastern area, localities 139b, 139c, 139g, 147b, 147i, 153a, 159d; western area, locality 170a. Upper part, eastern area, locality 177. Gurabo formation (middle Miocene), Dominican Republic (USNM 113750, USGS 8702). Bowden formation (middle Miocene), Jamaica. Moín formation (Pliocene), Costa Rica. Living, North Carolina to Gulf of Mexico and West Indies.

Family SCAPHANDRIDAE

Genus Acteocina Gray

Gray, Zool. Soc. London Proc., p. 160, 1847.

Type (orthotype): *Acteon wetherellii* [*wetherilli*] Lea, Miocene, New Jersey.

An incomplete shell and several minute ones from the La Boca formation are listed as *Acteocina* sp.

The type of *Acteon wetherilli*—apparently the only specimen—was illustrated by Lea (1833, p. 213, pl. 6, fig. 224) and by Richards and Harbison (1942, p. 221, pl. 21, fig. 21). Despite the features shown in Lea's drawing, the shell is now in poor condition: corroded and the protoconch is missing. Olsson and Harbison (1953, p. 159) thought it is *Acteocina canaliculata* (Say). That species is the type of *Utriculastra*, proposed as a subgenus of *Retusa* (Thiele, 1925, p. 269).

The northern *A. canaliculata* and the southern *A. candei*, which overlap in North Carolina, have frequently been confused. Wells and Wells (1962) found, however, that they do not overlap ecologically and that they are distinguishable on shell and radular features. Though the type of *Retusa* (cited on p. 423 of present report) differs in shell features and is not known to have a radula, they assigned *A. canaliculata* to that genus, as has been done by others.

Acteocina cf. A. bullata (Kiener)

Plate 48, figures 4, 6

Relatively large, slender, subcylindrical. Spire moderately high. Protoconch small, missing on most specimens. Fold at base of columella of moderate width.

Height 5.3 mm, diameter 2.4 mm (larger figured specimen).

The protoconch is preserved on only three of the 25 specimens of this *Acteocina*, which occurs in the upper part of the Bohio formation of Barro Colorado Island. The shell material is replaced by calcite. It probably is an early form of *A. bullata*, the next species described. It is unlikely that the calcite would reproduce the faint spiral sculpture of that species.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Acteocina bullata (Kiener), small form

Plate 62, figures 7, 9

Tornatella bullata Kiener, Spécies général et iconographie des coquilles vivantes, Genre Tornatelle, p. 5, pl. 1, fig. 4, 1834 (living, West Indies).

Tornatina bullata (Kiener), Pilsbry, Manual Conchology, v. 15, p. 183, pl. 22, figs. 17–19, pl. 50, fig. 30, 1893 (1894) (living, Florida Keys to West Indies). Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 305, 1896 (Oligocene [Miocene], Jamaica).

Acteocina subbullata Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 150, 1917 (Miocene, Dominican Republic [Jamaica]). Pilsbry, Idem, vol. 73, p. 310, fig. 5, 1922 (Miocene, Dominican Republic [Jamaica]). Woodring, Carnegie Inst. Washington Pub. 385, p. 120, pl. 2, fig. 4, 1928 (Miocene, Jamaica).

Acteocina cf. *subbullata* Pilsbry and Johnson, Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 74, pl. 22, fig. 8, 1964 (Miocene, Ecuador).

Acteocina subbullata costaricana Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 34a, pl. 15, figs. 20–21, 1922 (Miocene, Costa Rica).

Relatively large, slender, subcylindrical. Spire low, even so low that almost nothing except protoconch shows above body whorl in apertural view. Protoconch small. Faint microscopic spiral lineation visible on body whorl. Fold at base of columella narrow or moderately narrow.

Height 4.9 mm, diameter 2.2 mm (figured specimen). Height 6.4 mm, diameter 2.7 mm (largest specimen).

Type: Presumably at Museum of Natural History, Geneva.

Type locality: Living, West Indies.

Eight specimens, collected at localities in the middle and upper parts of the Gatun formation, are identified as *Acteocina bullata*. Though the largest are not much more than half as large as large living shells, they show no basic features to distinguish them from small living shells, and some lots of living shells consist of specimens not much larger than the Gatun fossils. The fossils are similar also to small specimens of the Miocene Jamaican *A. subbullata*, which reaches a height of 10 mm. *A. subbullata* formerly was accepted as a valid species, but that view is now rejected.

Three of the Gatun fossils, including that illustrated, have a low spire, but the spire of the others is higher.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139b, 147b, 147e, 147g, 159d. Upper part, eastern area, locality 177b. Thomonde formation (early Miocene), Haiti (USGS 9907). Bowden formation (middle Miocene), Jamaica. Middle Miocene deposits, Costa Rica. Angostura formation (middle Miocene), Ecuador. Limón formation (late Miocene), Costa Rica USGS 18693). Living, Florida Keys to West Indies.

Acteocina elachista Woodring, n. sp.

Plate 62, figures 1, 2

Bullina (Tornatina) aff. *candei* (d'Orbigny), Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 510, pl. 31, fig. 24, 1911 (Miocene, Canal Zone).

Very small, slender, rounded subcylindrical, spire moderately high. Last half of body whorl more or less loosely coiled. Protoconch large. Narrow band adjoining suture depressed, its outer edge sharply defined. Middle part of outer lip slightly constricted. Fold at base of columella narrow.

Height 2.3 mm, diameter 1.2 mm (type).

Type: USNM 646052.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

If this minute *Acteocina* were represented by a few specimens, it might be appropriate to consider them an aberrant small race of the living Caribbean species *A. candei* (d'Orbigny) (Pilsbry, 1893–1894, p. 185, pl. 22, figs. 21, 22, pl. 50, figs. 27–29, 1894). It is represented, however, by 49 specimens collected at eight localities in the lower and middle parts of the formation, as many as 22 at one locality (138a). Moreover, the loose coiling of the body whorl of the largest indicates that they are mature. The small size, slender outline, and exceptionally large protoconch are uniform features that distinguish these fossils from *A. candei*. The same features distinguish them from the Miocene Jamaican fossils described as *A. anetaspira* (Woodring, 1928, p. 121, pl. 2, fig. 6). It is suggested that *A. anetaspira* be suppressed as a synonym of *A. candei*.

Toula's specimen is missing in his collection.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138e, 138f. Middle part, eastern area, localities 147b, 159d; western area, localities 161c, 170a.

Acteocina rusa Gardner

Plate 62, figures 3, 4

Acteocina rusa Gardner, U.S. Geol. Survey Prof. Paper 142, p. 264, pl. 37, fig. 17, 1937 (1938) (Miocene, Florida).

Very small, slender, subcylindrical. Spire moderately high, turreted. Last half of body whorl more closely coiled than first half. Protoconch large. Post-protoconch spire whorls and uppermost part of body whorl sculptured with narrow, low axial threads. Fold at base of columella narrow.

Height 2.8 mm, diameter 1.3 mm (figured specimen).

Type: USNM 351030.

Type locality: USGS 3742, Shell Bluff, Shoal River, 5 or 6 miles west of Mossyhead, Walton County, Florida, Shoal River formation.

Two specimens of this axially sculptured *Acteocina* were found in the Gatun formation: a minute shell, consisting of the protoconch and first post-protoconch whorl (the apertural face of which is missing), in the lower part of the Gatun formation and the illustrated specimen in the middle part.

The illustrated specimen is a little smaller and more slender than the type of *A. rusa*, and has a higher spire. Almost 100 Florida fossils, however, show that the height of the spire is variable and that the Gatun specimen closely resembles some Florida shells that are a little smaller than the type.

A. harpa (Dall) (1871, p. 136, pl. 15, fig. 1, an inadequate representation), living in the eastern Pacific Ocean from British Columbia to San Diego, is the only species with which *A. rusa* needs to be compared. *A.*

harpa is larger; mature, but not immature, shells are less cylindrical; and the axial threads are more closely spaced and extend down to the middle of the body whorl. Moreover, the slender fold at the base of the columella disappears on mature shells. It seems strange that no comparable form has turned up in the eastern Pacific Panamic province.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 139b. Shoal River formation (middle Miocene), Florida.

Genus Cylichnella Gabb

Gabb, Acad. Nat. Sci. Philadelphia Proc., v. 24 (1872), p. 273, 1873.

Type (monotype): *Cylichnella bidentata* (d'Orbigny) (*Bulla bidentata* d'Orbigny), living, West Indies.

The radula and anatomy of *Cylichnella bidentata*, based on Brazilian specimens that are larger than those from the West Indies, were described by Marcus (1958, p. 1–9).

Cylichnella atacata stibara Woodring, n. subsp.

Plate 62, figure 13

Cylichna? aff. *Cylichnella bidendata* d'Orbigny (error for *bidentata*), Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 510, pl. 31, fig. 25, 1911 (Miocene, Canal Zone).

Moderately large, moderately inflated, rounded subcylindrical. Apex slightly depressed, covered with thin coat of callus. About lower third of body whorl sculptured with finely engraved, spiral striæ. Upper columellar fold strong, basal fold moderately strong.

Height 3.2 mm, diameter 1.8 mm (type).

Type: USNM 646054.

Cylichnella atacata stibara is the most abundant and most widely distributed cephalaspid in the Gatun formation. Some 130 of the 365 specimens were collected at the type locality and 80 at locality 138c.

It is larger than the nominate subspecies of *Cylichnella atacata* (Woodring, 1928, p. 124, pl. 2, fig. 9; Bowden formation, Jamaica), and the columellar folds are stronger, even at the size of the nominate subspecies. On mature shells of *C. triticumtritonis* (Maury) (1917, p. 14, pl. 3, fig. 4; Cercado formation, Dominican Republic) the basal columellar fold disappears, or almost disappears. The species now living in the Carribbean region, *C. bidentata* (d'Orbigny) (Warmke and Abbott, 1961, p. 144, pl. 27, fig. c), is more slender and its basal columellar fold is weak or absent. The identification of the living species is long-standing, despite d'Orbigny's illustrations (1841–47(?), p. 125, pl. 4, figs. 13–16, 1841), which show spiral striæ over the entire body whorl and a basal columellar fold stronger than the upper fold.

Two slender shells from the Gurabo formation of the Dominican Republic are identified as *C. atacata stibara*, on the basis of the columellar folds (USGS 8702).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138c, 138d, 138e. Middle part, eastern area, localities 139b, 139c, 139f, 139g, 146, 147b, 147f, 147g, 147h, 147i (identification doubtful), 155, 155c; western area, localities 161c, 162. Upper part, eastern area, localities 163, 173a; western area, locality 185. Gurabo formation (middle Miocene), Dominican Republic.

Genus Roxania Leach

Leach, Annals and Mag. Nat. History, v. 20, p. 268, October, 1847.

Type (monotype): *Bulla cranchii* Leach (= *Bulla utriculus* Brocchi), Miocene to Pliocene, western Europe, living, eastern Atlantic Ocean.

Roxania chipolana (Dall)

Plate 62, figure 14

Bullina (*Abderospira*) *chipolana* Dall, U.S. Natl. Mus. Proc., v. 18, p. 32, 1895 (1896) (Miocene, Florida, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 339, 1911 (Miocene, Canal Zone, Dall's record).

Micromelo (*Abderospira*) *chipolana* (Dall), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1,632, pl. 59, fig. 23, 1903 (Oligocene [Miocene], Florida)

Abderospira chipolana (Dall), Gardner, U.S. Geol. Survey Prof. Paper 142, p. 274, pl. 37, fig. 37 (Dall's illustration), 1937 (1938) (Miocene, Florida).

Small, inflated, ovate, tapering toward apical end. Apex narrowly perforate. Entire body whorl sculptured with finely engraved, microscopically pitted, spiral striæ. Sculpture strongest at both ends of whorl, faint on middle part of some mature shells. Columellar lip detached, forming an umbilical depression.

Height 3.5 mm, diameter 2.2 mm (figured specimen).

Type (lectotype, herewith designated): USNM 113894.

Type locality: USGS 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Florida, Chipola formation.

Though *Roxania chipolana* was collected at eight localities in the three parts of the Gatun formation, it is abundant only at locality 147b (26 specimens). Dall identified the specimen from locality 177 as his species. It is rare in Florida. In the USNM collections it is represented only by the type lot of five specimens. The lectotype is the largest in the type lot and was illustrated by Dall. None of the Gatun shells is as large as

the lectotype (height 4.6 mm). That illustrated is more ovate than Florida shells. Others, however, closely resemble a small Florida shell.

R. chipolana is the type of *Abderospira*, proposed by Dall when the species was described. The type of *Roxania* is much larger than this fossil species.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139c, 146, 147b, 147g. Upper part, eastern area, localities 173a, 177, 177c. Chipola formation (early Miocene), Florida.

Genus Scaphander Montfort

Montfort, Conchyliologie systématique, v. 2, p. 335, 1810.
Type (orthotype): *Scaphander lignarius* (Linné) (*Bulla lignaria* Linné), living, eastern Atlantic Ocean.

Subgenus Scaphander s.s.

Scaphander (Scaphander) cf. S. jacksonensis Palmer

Plate 48, figures 1, 2, 12

Of medium size, narrowly ovate, apex depressed. Immature shells of moderate size, and presumably mature shells, sculptured with finely engraved, widely spaced, spiral striæ. On smaller immature shells striæ of varying spacing limited to both ends of shell, intervening part showing closely spaced, microscopic spiral lineation.

Height (incomplete) 15 mm (estimated restored height 20 mm), diameter 10.5 mm (largest specimen). Height (incomplete) 11 mm (estimated restored height 14 mm), diameter 7.5 mm (larger figured specimen).

Eighteen specimens of this *Scaphander* were found in the marine member of the Bohio(?) formation. Eleven, however, including the largest, lack, or almost completely lack, shell material. The specimens that retain shell material range in height from 4 to an estimated 14 mm. One of them, a slender immature specimen, is questionably identified.

Though it evidently is a new species, it would be inappropriate to designate an immature specimen as the type. It is more narrowly ovate—that is, more subcylindrical—than the late Eocene *S. jacksonensis* Palmer (in Harris and Palmer, 1946–47, p. 449, pl. 64, figs. 6, 7, 1947), but is sculptured like that species. It is even more narrowly ovate than the early Oligocene *S. primus* Aldrich (1885, p. 148, pl. 2, figs. 7a, 7b), and has more closely spaced spiral striæ.

The subgeneric name *Mirascapha* has been proposed for a narrowly ovate Eocene species (Stewart, 1927, p. 438; type (orthotype): *Cylichna costata* Gabb, Eocene, Calif.). Fossil and living species of *Scaphander*, however, show a great range in diversity of outline.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), localities 40a, 40d, 41, 41b.

Scaphander (Scaphander) cryus Woodring, n. sp.

Plate 48, figures 5, 10, 11

Of medium size, narrowly ovate, apex depressed. Sculpture consisting of closely spaced, shallowly engraved, spiral striæ and closely spaced, microscopic, axial threads, weakly overriding threads between striæ.

Height 13.5 mm, diameter 7.8 mm (type).

Type: USNM 646093.

Type locality 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth, Canal Zone), Bohio formation.

The upper part of the Bohio formation at the type locality yielded 25 specimens of *Scaphander cryus*, all replaced by calcite. They range in altitude from 2.5 to 13.5 mm. Ten additional specimens, which have practically no shell material, were collected at locality 42g.

The axial sculpture, which shows to better advantage on the paratype than on the type, is exceptionally pronounced. It presumably was stronger on the original aragonite than on the replacing calcite.

Five poorly preserved fossils from the La Boca formation are doubtfully referred to this species.

Occurrence: Upper part of Bohio formation (late Oligocene), localities 42d, 42g. La Boca formation (early Miocene; identification doubtful), localities 99b, 115a, 116a.

Family PHILINIDAE

Genus Floribella Woodring, n. gen.

Type.—Dolabella aldrichi Dall, early Miocene, Florida, Canal Zone, Cuba.

Exceptionally large, reaching height of 80 mm, circular ovate. Earliest part (½ to 1 whorl) tightly coiled, remainder (½ to ¾ whorl) separated from tightly coiled part by gradually widening gap. Early part thick, remainder progressively thinner. Earliest part more or less covered by callus, crudely sculptured spirally, remainder bearing low, narrow, closely spaced spiral undulations, generally replaced by more or less exaggerated growth lines on about last half whorl. Callus extending along outer margin of thin part as wide, thin band. Aperture greatly expanded. Excessively thin outer lip broken and nicked, growth lines showing short projection at upper margin. Inner (columellar) margin bordered by swollen ridge on thick part of shell, disappearing on thin part.

At first, doubtless under the influence of Dall's assignment, *Floribella* was thought to be an aplysid related to *Dolabella*. On further consideration, prompted by A. A. Olsson, the conclusion was reached, chiefly on the basis of shell outline, that it is a remarkable philinid. The shell outline and sculpture of spiral undulations indicate alliance to a much smaller late Eocene species from the Paris basin: *Philine corrugata* Cossmann (1889, p. 315, pl. 11, fig. 16; Cossmann and Pissarro, 1910–13, pl. 54, fig. 240–5). The enormous size of *Floribella* and its wide band of callus extending along the outer margin of the shell are unique.

Floribella aldrichi (Dall)

Plate 50, figures 1, 2, 5–8

Dolabella aldrichi Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 18, pl. 10, fig. 7a, 1890 (Miocene, Florida). Gardner, U.S. Geol. Survey Prof. Paper 142, p. 276, pl. 37, fig. 45 (Dall's illustration), 1938 (Miocene, Florida).

Shell from La Boca formation small, only early part preserved, thick (7.5 mm, not including inner marginal swollen ridge). Swollen ridge strong, 5 mm wide. Callus moderately thick. Low, narrow, closely, spaced undulations on part not covered with callus.

Height (incomplete) 33.5 mm, diameter (incomplete) 31 mm (figured La Boca specimen). Height (almost complete) 80 mm, diameter (not quite complete) 72 mm (largest Florida specimen).

Type (lectotype, herewith designated): USNM 328453.

Type locality: USGS 2564, Chipola River on McClelland farm, 1 mile below bridge at old Bailey's Ferry, Chipola River, Calhoun County, Florida, Chipola formation. Through an error Dall mentioned only Alum Bluff (USGS 2211), on Apalachicola River, Liberty County, Fla.

Dall had five small, incomplete specimens of his *Dolabella aldrichi*. The specimen used for the drawing is designated the lectotype. An additional somewhat larger, incomplete shell (USGS 7183, Alum Bluff) was available to Gardner, who used Dall's illustration. Another small one is in the Aldrich collection, formerly at John Hopkins University, but now in the U.S. National Museum. In 1951 C. R. Locklin collected eight fine shells, five of them large, at the type locality. Two of the large shells were nested so neatly that they looked like an abnormal double shell. Two of his shells are shown on plate 50, figures 5–8. The fragile outer lip is missing on all. How far the band of callus extended along the outer margin is indeterminable, as it ends in a callus break. Where the inner edge of the callus is intact on several shells, the band has a width of 11.5 to 16.5 mm. An intact inner edge is shown on plate 50, figure 6.

The single La Boca shell (pl. 50, figs. 1, 2), replaced by calcite, is thick, but the thickness (7.5 mm) falls within the range of Florida specimens at the same growth stage (3.5 to 8mm). A large mold from the Güines limestone of Cuba (incomplete height 65 mm), recognized by Druid Wilson, is identified as *Floribella aldrichi*, although its undulations are coarser than those of mainland specimens. Wherever the species has been found its age is early Miocene.

Occurrence: La Boca formation (early Miocene), locality 115a. Güines limestone (early Miocene), Cuba (USGS 4290, Vento, Habana Province). Chipola formation (early Miocene), Florida.

Family BULLIDAE

Genus Bulla Linné

Linné, Systema naturæ, 10th ed., p. 725, 1758.
Type (Opinion 196, Internat. Comm. Zool. Nomenclature, 1954): *Bulla ampulla* Linné, living, western Pacific Ocean.

A minute shell from the moderately deep-water facies of the Caimito formation on Barro Colorado Island is listed as *Bulla?* sp.

Bulla umbilicata Röding, small form

Plate 62, figure 18

Bulla paupercula Sowerby, Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 246, 1873 (Miocene, Dominican Republic).
Bullaria paupercula (Sowerby), Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 18, pl. 3, fig. 8, 1917 (Miocene, Dominican Republic). Maury, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 1, p. 75, 1920 (Miocene, Puerto Rico). Hubbard, Idem, pt. 2, p. 163, 1920 (Miocene, Puerto Rico). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 313, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 34c, pl. 4, fig. 14, 1922 (Miocene, Costa Rica).

Small, almost symmetrically elliptical. Apex narrowly perforate, border of perforation rounded. Wall of perforation sculptured with spiral striae. Other parts of shell too chalky to show whether they are sculptured.

Height 8.5 mm, diameter 5.2 mm (figured specimen).

The widespread small Miocene form of *Bulla umbilicata* is represented by four chalky and somewhat corroded Gatun shells that are even smaller than those from other localities, and presumably are immature. Better preservation at other localities shows that the base of the shell is weakly striate. Many of several hundred specimens from the Cercado formation of the Dominican Republic retain traces of mottled coloration. They have a maximum height of 16 mm, but Maury (1917, p. 236) cited 21 mm for her illustrated

specimen. Some Costa Rican shells also show traces of mottled coloration.

This small form of *B. umbilicata* has been identified as the unillustrated and inadequately described *B. paupercula* Sowerby (1850, p. 52). Sowerby's species, however, is large and rounded (height 38 mm, diameter 25.8 mm). It evidently is *B. solida* Gmelin, which, as noted by Pilsbry (1922, p. 313), was named *B. sarahberlinerœ* by Maury (1917, p. 19, pl. 3, fig. 9).

Should it be considered desirable to have a name for the small form of *B. umbilicata*, perhaps *B. umbilicata waltonensis* Gardner (1926–47, p. 272, pl. 37, figs. 34, 35, 1938; Shoal River formation, Florida), described as a subspecies of *B. striata* Bruguière, is available, although Florida shells have a narrower apical perforation than those from the Caribbean region.

B. umbilicata (Röding, 1798, p. 15) is traditionally known as *B. amygdala* (Dillwyn, 1817, p. 480). As pointed out by Rehder (1962, p. 585), Röding's name has many years precedence.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 136. Middle part, eastern area, locality 159d; western area, localities 161, 161c. Thomonde formation (early Miocene), Haiti (USGS 9907). Quebradillas (now Aymamón) limestone and Ponce limestone (early Miocene), Puerto Rico. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Middle Miocene deposits, Costa Rica.

Family ATYIDAE

Genus Atys Montfort

Montfort, Conchyliologie systématique, v. 2, p. 343, 1810.
Type (orthotype): *Atys cymbulus* Montfort (= *Bulla nancum* Linné) living, western Pacific Ocean.

Subgenus Roxaniella Monterosato

Monterosato, Nomenclatura generica e specifica di alcune conchiglie mediterranee, p. 145, 1884.
Type (monotype): *Roxaniella jeffreysi* (Weinkauff) (*Cylichna jeffreysi* Weinkauff), living, Mediterranean Sea.

It is by no means certain that *Roxaniella* is properly allocated as a subgenus of *Atys*.

Atys (Roxaniella) rhadina Woodring, n. sp.

Plate 48, figure 17

Of medium size, exceptionally slender, subcylindrical. Apical depression moderately wide. Faint traces of spiral striæ at both ends of shell. Aperture exceptionally narrow. Outer lip rising well above apex. Columellar lip molded against shell wall.

Height 6.8 mm, diameter 2.6 mm (type).

Type: USNM 646095.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth, Canal Zone), Bohio formation.

The type, replaced by calcite, is the only specimen of this slender, *Cylichna*-like species, found in the upper part of the Bohio formation of Barro Colorado Island. It occurs also in the Mint Spring marl member of the Marianna limestone of Mississippi, although the Bohio specimen is slightly more slender than those from the Mint Spring. *Atys gracilis* Dall (Gardner, 1926–47, p. 270, pl. 37, fig. 30, 1938), of the Miocene Alum Bluff group of Florida, is considerably smaller (height 5 mm).

The outer lip of both species rises to a greater height above the apex than that of the type species of *Roxaniella*.

Occurrence: Bohio formation (late Oligocene), locality 42d. Mint Spring marl member of Marianna limestone (middle Oligocene), Mississippi.

Subgenus Aliculastrum Pilsbry

Pilsbry, Manual of Conchology, v. 16, p. 237, 1896. Substitute name for *Alicula* Ehrenberg, 1831, not *Alicula* Eichwald, 1830.
Type (monotype of *Alicula* Ehrenberg): *Bulla cylindrica* Helbling, living, western Pacific Ocean.

The Caimito formation yielded a small, crushed shell listed as *Atys* sp., and the La Boca formation a poorly preserved shell listed as *Atys?* sp.

Atys (Aliculastrum) eurys Woodring, n. sp.

Plate 62, figure 10

Of medium size, almost symmetrically elliptical. Apical depression moderately wide. Both ends of shell sculptured with finely engraved, spiral striæ. Outer lip rising high above apex. Basal lip slightly drawn out along emergence of narrow, slight swelling resembling prosobranch siphonal fasciole. Columellar lip detached, enclosing relatively wide umbilicus.

Height 7.3 mm, diameter 3.6 mm (type).

Type: USNM 646057.

Type locality: 159d (USGS 24173, Gatun [presumably Gatun Locks excavation], Canal Zone), middle part of the Gatun formation.

Four specimens of *Atys eurys* were collected in the middle part of the Gatun formation, but only the type is mature. It is a distinctive species, characterized by its high outer lip, siphonal fasciole-like swelling, and wide umbilicus. These features, as well as the larger size distinguish it from *A. dalli* (Woodring, 1928, p.

128, pl. 2, figs. 17, 18; Bowden formation, Jamaica). *A. caribæa* (d'Orbigny) (Pilsbry, 1893–94, p. 274, pl. 48, fig. 12a, 1894), now living in the Caribbean region, is similar to *A. eurys* in outline, but has no siphonal fasciole-like swelling and is not umbilicate. In fact, no closely allied species is recognized.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d; western area, localities 161c, 170a.

Subgenus Weinkauffia Monterosato

Monterosoto, Nomenclatura generica e specifica di alcune conchiglie mediterranee, p. 145, 1884.

Type (monotype): *Weinkauffia diaphana* (Aradas) (*Bulla diaphana* Aradas and Maggiore, 1839, not *Bulla diaphana* Montagu, 1803, = *Bulla turgidula* Forbes, 1844), living, Mediterranean Sea.

Atys (Weinkauffia) cadus Woodring, n. sp.

Plate 62, figures 8, 16

Very small, inflated, middle part bulging. Apical depression wide. All except middle third of shell sculptured with spiral striæ, finely engraved toward middle of shell, wider at extreme ends, especially apical end. Outer lip rising high above apex. Apertural features like those of *Atys eurys*, but umbilicus narrower.

Height 2.1 mm, diameter 1.4 mm (type). Height 3.6 mm, diameter 1.9 mm (paratype).

Type: USNM 646058; paratype, USNM 646059.

Type locality: 139b (USGS 22017, East side of road leading from Transisthmian Highway to refinery site on Payardi Island, Panamá, about 100 meters southwest of refinery gate), middle part of Gatun formation.

Atys cadus is represented by three specimens collected at the type locality. The outer lip of the type is broken back. The apertural face of the paratype—the largest specimen—is damaged.

This species is distinguished from *A. œdemata* Dall (Gardner, 1926–47, p. 269, pl. 37, fig. 28, 1938; Chipola formation, Florida) by its high outer lip, distinct siphonal fasciole-like swelling, and wide umbilicus. *A. doliolum* Maury (1917, p. 18, pl. 3, fig. 7, an inadequate illustration; Cercado formation, Dominican Republic) has no suggestion of a siphonal fasciole-like swelling, but has a small, slender fold at the base of the columella. *A. sulculorum* Pilsbry and Johnson (Pilsbry, 1922, p. 313, fig. 12) is considered to be a synonym of *A. doliolum*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139b.

Family RETUSIDAE

Genus Retusa Brown

Brown, Illustrations of the conchology of Great Britain and Ireland, pl. 38, figs. 1–6, 1827.

Type (logotype, Gray, Zool. Soc. London Proc., p. 161, 1847): *Bulla obtusa* Montagu, living, eastern Atlantic Ocean.

Subgenus Cylichnina Monterosato

Monterosato, Nomenclatura generica e specifica di alcune conchiglie mediterranee, p. 143, 1884.

Type (logotype, Bucquoy, Dautzenberg, and Dollfus, Les mollusques marins du Rousillon, v. 1, p. 524, 1886): *Cylichna umbilicata* (Montagu) (*Bulla umbilicata* Montagu, 1803, not *Bulla umbilicata* Röding, 1797,=*Volvaria subcylindrica* Brown, 1827), living, eastern Atlantic Ocean.

Poorly preserved shells from the La Boca formation are listed as *Retusa?* sp.

Retusa (Cylichnina) aff. R. adamsi (Palmer)

Very small, inflated, subcylindrical. Apical depression funnel-shaped. Both ends of shell faintly striate, remaining part showing faint, microscopic, spiral lineation. Top of outer lip almost flush with apex. Basal lip rounded. Columellar lip not exposed.

Height 3.3 mm, diameter 2 mm.

A minute, barrel-shaped shell, replaced by calcite, from the marine member of the Bohio(?) formation closely resembles *Retusa adamsi* (Palmer, 1937, p. 482, pl. 75, figs. 22, 23) in size and outline. Whether the resemblance is as close in features of the columellar lip is indeterminable. *R. adamsi* is a middle Eocene species. No comparable late Eocene or Oligocene species is known in southeastern United States.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 41b.

Retusa (Cylichnina) quercinensis biforis Pilsbry and Johnson

Plate 62, figure 6

Retusa biforis Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 151, 1917 (Miocene, Dominican Republic). Pilsbry, Idem, v. 73, p. 311, fig. 8, 1922 (Miocene, Dominican Republic).

Very small, moderately slender, subcylindrical. Apical depression funnel-shaped. Base faintly striate or apparently not sculptured. Outer lip rising slightly above apex. Basil lip rounded. Columellar lip detached, narrow or wide.

Height 2.8 mm, diameter 1.5 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3192.

Type locality: Dominican Republic, Miocene, presumably Cercado or Gurabo formation.

Thirty-nine minute shells, collected at localities in the middle and upper parts of the Gatun formation—29 at locality 147b—are referred to *Retusa biforis*.

They are regarded as representing a small Caribbean race of *R. quercinensis* Dall (Gardner 1926–47, p. 271, pl. 37, fig. 32, 1938). The type of the nominate subspecies is from the Oak Grove sand member of the Shoal River formation of Florida. As noted by Gardner, it is an immature shell. Nevertheless her only illustration is a reproduction of Dall's drawing. The maximum height of mature shells among hundreds of topotypes is five millimeters, whereas the type is only half as large.

Though the Caribbean subspecies is distinguished only by its small size, the Gatun material and the type seem to represent a fair sample. The variation in the width of the columellar lip is duplicated by Florida shells.

A similar species is living in the Caribbean region, but is represented in the USNM collections by only one shell, dredged off Barbados at a depth of 90 to 100 fathoms (USNM 502054, height 2.8 mm). It is thin-shelled, slender, and slightly more cylindrical than the fossils. *R. verrillii* (Dall) (1889, p. 54; 1902, p. 502, pl. 29, fig. 1), from depths of 50 to 124 fathoms off North Carolina, is larger than any of the fossils (height 7.2 mm) and has a very narrow columellar lip.

R. decapitata Dall (Gardner, 1926–47, p. 271, pl. 37, fig. 31, 1938; Chipola formation) and *R. anthera* (Gardner) (Idem, p. 271, pl. 37, fig. 33; Shoal River formation) are considered to by synonyms of *R. quercinensis*. Despite page precedence, *R. quercinensis* is given precedence over *R. decapitata*, as it is represented by far more specimens.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139b, 147b, 147g, 147h; western area, locality 170a. Upper part, eastern area, locality 175. Miocene, Dominican Republic.

Genus Sulcoretusa Burch

Burch, Conchological Club Southern Calif. Minutes, no. 47, p. 16, 1945. Substitute name for *Sulcularia* Dall, 1921, not *Sulcularia* Rafinesque, 1831.

Type (orthotype of *Sulcularia* Dall): *Retusa sulcata* (d'Orbigny) (*Bulla sulcata* d'Orbigny), living, North Carolina to West Indies.

Sulcoretusa, unlike the other cephalaspid genera under consideration, has a limited geographic and age range. It is an endemic American genus, now living in western Atlantic and eastern Pacific waters, and is unknown earlier than Miocene.

Sulcoretusa sulcata lipara (Woodring)

Plate 62, figure 5

Sulcularia lipara Woodring, Carnegie Inst. Washington Pub. 385, p. 123, pl. 2, fig. 8, 1928 (Miocene, Jamaica).

Moderately small, moderately slender, subcylindrical, lower half swollen. Apical perforation funnel-shaped. Axial threads narrow, closely spaced. Outer lip rising slightly above apex. Columellar lip narrow.

Height 2.7 mm, apical diameter 0.9 mm, basal diameter 1.3 mm (figured specimen).

Type: USNM 369323.

Type locality: Bowden, Jamaica, Bowden formation.

Four names have been proposed for Miocene forms of *Sulcoretusa: Retusa sulcata fossilis* Pilsbry (1922, p. 311; Cercado formation, Dominican Republic), *Sulcularia lipara*, *Sulcularia prosulcata* Gardner (1926–47, p. 265, pl. 37, fig. 19, 1938; Chipola and Shoal River formations, Florida), and *Sulcularia sulcata harveyensis* Mansfield (1930), p. 27, pl. 1, figs. 6, 7; Mansfield's late Miocene *Cancellaria* zone, Florida). The differences between them, as well as those distinguishing them from the western Atlantic *Sulcoretusa sulcata* (d'Orbigny) (Pilsbry, 1893–94, p. 221, pl. 23, figs. 73, 74, 1894) and the eastern Pacific *Sulcoretusa paziana* (Dall) (1919a, p. 297) are subtle, perhaps too subtle. In any event the Miocene forms are treated as subspecies of *Sulcoretusa sulcata*. *S. sulcata lipara* is the most distinctly swollen form.

Nineteen specimens are from the middle part of the Gatun formation and one from the lower part. Though they are not as uniformly swollen as Jamaican shells, they are identified as *S. sulcata lipara*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138a. Middle part, eastern area localities 139b, 139c, 139g, 146, 147b. Bowden formation (middle Miocene), Jamaica.

Genus Volvulella Newton

Newton, Systematic list of the Frederick E. Edwards collection of British Oligocene and Eocene Mollusca, British Mus. (Nat. History), p. 268, 1891. Substitute name for *Volvula* A. Adams, 1850, not *Volvula* Gistl, 1848. (Newton thought *Volvula* A. Adams is a homonym of *Volvulus* Oken, 1815.)

Type (logotype of *Volvula* A. Adams, A. Adams, Annals and Mag. Nat. History, 3d ser., v. 9, p. 154, 1862): *Volvula acuminata* (Bruguière) (*Bulla acuminata Bruguière*), living, eastern Atlantic Ocean. The type designation was first recorded by Harry (1967, p. 133).

During recent years *Rhizorus* Montfort (1810, p. 338; type (orthotype): *Rhizorus adelaidis* Montfort, living, Mediterranean Sea) has come into usage for this genus, presumably following Iredale's lead (1936, p. 332). As implied many years ago by Bucquoy, Dautzenberg, and Dollfus (1882–86, p. 533, 1886), and Dall (1889, p. 51), and recently by Harry (1967, p. 133), *Rhizorus* is to be treated as a nomen dubium. In any event, Montfort's description and illustration of the

type species is not convincing as a species of *Volvulella*.

Subgenus Volvulella s.s.

Volvulella (Volvulella) aff. V. conradiana (Gabb)

Very small, slender. Apical spine short. Basal third of shell sculptured with faint spiral striæ.

Height 2.7 mm, diameter 1 mm.

A minute *Volvulella*, collected at locality 40d in the marine member of the Bohio(?) is similar to the middle Eocene *V. conradiana* (Palmer, 1937, p. 494, pl. 74, figs. 15–18) in size and outline. It is a little more slender than an unnamed Oligocene species in the Mint Spring marl member of the Marianna limestone and the Byram formation. No comparable species is so far recorded from late Eocene deposits in southeastern United States. A more adequate sample is needed for identification of the Bohio(?) species.

A more inflated, imperfect specimen (height 2.8 mm, diameter 1.4 mm) from locality 42 is identified as *Volvulella?* sp.

Occurrence: Marine member of Bohio(?) formation, locality 40d.

Volvulella (Volvulella) oxytata (Bush)

Plate 62, figures 19, 20

?Volvula persimilis Mörch, Malak, Blätter, v. 22, p. 179, 1875 (living, West Indies).

Volvula cylindrica Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 246, 1873 (Miocene, Dominican Republic; not *Volvula cylindrica* Carpenter, 1865). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 16, pl. 3, fig. 5, 1917 (Miocene, Dominican Republic). Olsson, Idem, v. 9, no. 39, p. 34c, 1922 (Miocene, Costa Rica).

Volvula oxytata Bush, Connecticut Acad. Arts and Sci. Trans., v. 6, p. 468, pl. 45, fig. 12, 1885 (living, N. Car.). Dall, Harvard Univ. Mus. Comp. Zoology Bull., v. 18, p. 50, 1889 (living, North Carolina, West Indies). Pilsbry, Manual of Conchology, v. 15, p. 235, pl. 26, fig. 63, 1894 (living, North Carolina to West Indies). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 312, 1922 (Miocene, Dominican Republic). Woodring, Carnegie Inst. Washington Pub. 385, p. 125, pl. 2, fig. 10, 1928 (Miocene, Jamaica). Gardner, U.S. Geol. Survey Prof. Paper 142, p. 267, pl. 37, figs. 23, 24, 1937 (1938) (Miocene, Florida).

Bulla (Volvula) cf. *oxytata* Bush, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 709, pl. 28, fig. 4, 1909 (Miocene, Canal Zone).

Volvula cercadensis Van Winkle, Bull. Am. Paleontology, v. 8, no. 36, p. 6, 1921; new name for *Volvula cylindrica* Gabb, 1873, not *Volvula cylindrica* Carpenter, 1865.

Volvulella persimilis (Mörch), Harry, Veliger, v. 10, p. 136, fig. 4, 1967 (living, North Carolina to West Indies).

Of medium size, subcylindrical, slender or moderately slender. Apical spine moderately long. Both ends of shell sculptured with faint spiral striæ, generally more distinct on basal part than on apical part, or even absent on apical part.

Height 3.4 mm, diameter 1.2 mm (figured slender specimen). Height 3.6 mm, diameter 1.4 mm (figured moderately slender specimen).

Type: Peabody Museum, Yale University.

Type locality: Off Cape Hatteras, N. Car., depth 7–17 fathoms.

In his 1889 publication Dall expressed the opinion that it is highly probable that *Volvula oxytata* is *V. persimilis*, and Harry recently suppressed *V. oxytata* in favor of *V. persimilis*. His identification of Mörch's species, however, was based chiefly on a process of elimination. Until Mörch's specimen is found in Copenhagen or London and illustrated, Miss Bush's unequivocal name is preferred.

Volvulella oxytata is a long ranging and widely distributed species. It is represented in the Gatun formation by 70 specimens. As for many other small species, it is abundant at locality 147b (27 specimens), but none from that locality is quite as large as the two illustrated. The moderately slender illustrated shell has an imperfect outer lip that was damaged and repaired during life. The apical part therefore is abnormal.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138c, 138e, 138g. Middle part, eastern area, localities 139b, 139c, 147b, 147g, 147i, 155c; western area, localities 161, 161c (identification doubtful), 162, 170a. Early Miocene part of Uscari shale, Costa Rica. Thomonde formation (early Miocene), Haiti (USGS 9945, 9946). Chipola formation (early Miocene), Florida. Middle Miocene deposits, Costa Rica. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Límon formation (late Miocene), Bocas del Toro area, Panamá. Duplin formation (late Miocene), North Carolina. Caloosahatchee formation (Pliocene), Florida. Living, North Carolina to West Indies.

Volvulella (Volvulella) micratracta Brown and Pilsbry

Volvulella micratracta Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 504, fig. 1, 1912 (1913) (Miocene, Canal Zone).

Very small, inflated. Apical spine moderately long. Both ends of shell sculptured with strong, widely spaced, spiral striæ: three on basal part, two on apical part of type.

Height 1.5 mm, diameter 0.7 mm (type).

Type: Acad. Nat. Sci. Phila. 3842.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The type is the only Gatun specimen of this inflated, distinctive species: distinctive on account of its strong, widely spaced, spiral striæ. The "appearance of very shallow longitudinal plication" on the swollen part of the shell, recorded by Brown and Pilsbry, presumably is the result of slight difference in shell composition. If the type is mature, it is a minute species.

A minute translucent shell, from the Limón formation in Puerto Limón, Costa Rica (USGS 21036), is identified as *Volvulella micratracta*. It is a little more slender than the type, and has five basal spiral striæ and six apical and a more acute apical spine. The main part of the shell bears microscopic spiral lineation.

Brown and Pilsbry compared their species with *V. minuta* Bush (1885, p. 469, pl. 45, fig. 11), a similar small, inflated western Atlantic species that lacks strong, widely spaced, spiral striæ, I am unable to confirm the apical, axial sculpture shown in Harry's (1967, p. 138, fig. 11) drawing of a specimen of *V. minuta* identified by Bush (USNM 44773), and such sculpture is not apparent on other specimens of her species. Therefore Harry's synonymizing of *V. minuta* with the larger, apically sculptured western Atlantic species (*Bulla acuta* d'Orbigny, a junior homonym), for which he adopted the name *V. recta* (Mörch), is rejected. *V. recta*, however, is a name of debatable availability, as it is based on a lapsus calami.

Occurrence: Middle part of Gatun formation (middle Miocene), Gatun Locks excavation (Brown and Pilsbry's record). Limón formation (late Miocene), Costa Rica.

Volvulella (Volvulella) cylindrica parallela (Pilsbry and Johnson)

Plate 62, figure 17

Volvula parallela Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 151, 1917 (Miocene, Dominican Republic). Pilsbry, Idem, v. 73, p. 313, fig. 11, 1922 (Miocene, Dominican Republic).

Moderately large, cylindrical, very slender, height three times diameter. Apical spine short. Shell bearing microscopic spiral lineation, and at both ends faint spiral striæ, those on apical part more distinct and more widely spaced than those on basal part.

Height 4.7 mm, diameter 1.6 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3188.

Type locality: Dominican Republic, presumably Cercado or Gurbao formation.

A polished, cylindrical shell from the middle part of the Gatun formation (presumably from the Gatun Locks excavation) is referred to *Volvulella cylindrica parallela*, which was based on three specimens in Gabb's Dominican Republic collection. It is doubtful whether these Miocene fossils can be distinguished from the nominate subspecies of Carpenter's eastern Pacific species (Harry, 1967, p. 141, figs. 6–9). They closely resemble shells from the Panamic part of the range of the nominate subspecies. No similar species is living in the Caribbean region.

V. cylindrica parallela occurs also in strata of middle Miocene age in southeastern Costa Rica (USGS 5882g and other collections from Río Banana).

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d. Miocene, presumably Cercado or Gurabo formation, Dominican Republic. Middle Miocene deposits, Costa Rica.

Volvulella (Volvulella) phoinicoides (Gardner)

Plate 62, figure 15

Volvula phoinicoides Gardner, U.S. Geol. Survey Prof. Paper 142, p. 268, pl. 37, fig. 26, 1937 (1938) (Miocene, Florida).

Of medium size, cylindrical, very slender, height three times diameter. Apical spine very short or absent. Entire shell bearing microscopic spiral lineation, generally somewhat coarser on basal part. Apical end of aperture wide, outer lip extending to apex with gentle slope.

Height 3.3 mm, diameter 1.1 mm (figured specimen).

Type: USNM 351037.

Type locality: USGS 3742, Shell Bluff, Shoal River, Walton County, Florida, Shoal River formation.

Volvulella phoinicoides has the outline of *V. cylindrica parallela*, but differs in apical features and sculpture. Immature shells and mature shells that are broken back show that a short spine is present at an early stage regardless of its presence or absence at maturity. The apical features are more or less intermediate between those of *Volvulella* s.s. and those of the subgenus *Paravolvulella* (Harry, 1967, p. 141; type (orthotype): *Volvulella (Paravolvulella) texasiana* Harry, living, western Gulf of Mexico). The apical end of the outer lip of *Paravolvulella* extends horizontally to the apex of the shell and is slightly concave.

None of the 21 shells from the Gatun formation is as large as the largest Florida shells, which reach a height of 4.5 mm. This species evidently left no descendents.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139b, 139c, 147b, 147g. Upper part, eastern area, locality 177b. Shoal River formation (middle Miocene), Florida.

Family SPIRATELLIDAE

Genus Spiratella Blainville

Blainville, Dictionnaire des sciences naturelles, v. 9, p. 407, 1817.

Type (monotype): *Clio helicina* Phipps, living, Atlantic and Pacific Oceans.

Spiratella inflata elevata (Collins)

Plate 66, figures 5, 7, 9

Limacina elevata Collins, Johns Hopkins Univ., Studies in Geology, no. 11, p. 181, pl. 7, figs. 9–11, 1934 (Miocene, México).

Very small, asymmetrically planispiral, body whorl moderately inflated. Spire slightly depressed below level of body whorl, first whorl slightly projecting. Umbilicus very deep, narrow. Apertural part of body whorl broken back.

Height 0.5 mm, diameter 0.8 mm (figured specimen).

Type: USNM 645189.

Type locality: USGS 23737, Head of small stream flowing into Arroyo Tomás Martínez, about 3 kilometers northeast of Santa Rosa and about 28 kilometers northwest of Santa Lucrecia, Vera Cruz, México, deposits of middle Miocene age.

The lower part of the Gatun formation at locality 136a yielded three minute specimens of *Spiratella inflata elevata*. Whether this is a valid subspecies is questionable. Though the body whorl is less inflated than that of the prevailing form of the nominate subspecies, *S. inflata elevata* occurs with the nominate subspecies at the locality near Santa Rosa, in the Isthmus of Tehuantepec (Collins, 1934, p. 179, pl. 7, figs. 3–8). The nominate subspecies has been found also in Miocene deposits in the Dominican Republic (Pilsbry, 1922, p. 308, fig. 1). The inflation of the body whorl of the specimen from the Cercado formation of the Dominican Republic (USNM 483145), mentioned by Collins (1934, p. 180), is more or less intermediate. Whether intermediates are represented among the 40 specimens of *S. inflata elevata* from the type locality is indeterminable at the present time, as the collection is temporarily not in Washington.

Occurrence: Lower part of Gatun formation, locailty 136a. Middle Miocene deposits, México.

Family CAVOLINIDAE

Genus Vaginella Daudin

Daudin, Bull. Sciences, Soc. Philomatique Paris, no. 43, p. 145, 1800.

Type (monotype): *Vaginella depressa* Daudin, Miocene, western Europe.

Vaginella lophota Woodring, n. sp.

Plate 49, figures 10, 11

Of medium size, slender. Posterior part moderately, or exceptionally more strongly, inflated, anterior half progressively more strongly compressed toward aperture. Sides strongly keeled throughout their length. Apertural lips broken.

Height (not quite complete) 5.1 mm, width 2.3 mm, diameter 1.4 mm (type).

Type: USNM 646096.

Type locality: 54j (USGS 18833, Barro Colorado Island, southwestern part of island, stream crossing Conrad Trail at Conrad 2, about 365 meters above mouth, Canal Zone), Caimito formation.

This is the first Oligocene American species of *Vaginella*, which has an age range of Late Cretaceous to Miocene. It is characterized by the strong keel extending along the length of the shell and by the marked compression of the anterior half. Eight specimens were found in the moderately deep-water facies of the Caimito formation on Barro Coloado Island. Little shell material remains, except on the type and on a posterior fragment (locality 54l) that is more strongly inflated than the others.

V. chipolana Dall (Gardner, 1926–47, p. 257, pl. 37, figs. 1, 2, 1938; Collins, 1934, p. 214, pl. 13, figs. 16–19; Chipola formation, Florida) is larger, wider, more inflated, and the keel extends only part way up the shell. It is perhaps the same species as *V. depressa*, the type of the genus.

Occurrence: Caimito formation (late Oligocene), Barro Colorado Island, localities 54j, 54l.

Vaginella undulata (Gabb)

Balantium undulatum Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 200, 1873 (Miocene, Dominican Republic).

Vaganella undulata (Gabb) (error for *Vaginella*), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 309, fig. 2, 1922 (Miocene, Dominican Republic).

Vaginella undulata (Gabb), Collins, Johns Hopkins Univ. Studies in Geology, no. 11, p. 219, pl. 14, figs. 14, 15, 1934 (Miocene, Dominican Republic).

Vaginella caribbeana Collins, Idem, p. 220, pl. 14, figs. 16, 17, 1934 (Miocene, Canal Zone).

Of medium size, very slender, slightly concave, dorso-ventrally compressed. Ventral surface bearing low undulations, three on type of *Vaginella undulata* and at least five on type of *V. caribbeana*.

Height 6.5 mm, diameter 1.8 mm (type of *V. undulata*).

Type: Acad. Nat. Sci. Phila. 2892.

Type locality: Dominican Republic, presumably Cercado or Gurabo formation, Miocene.

Nothing can be added to Collins' description and illustration of the fragment that served as the type of *V. caribbeana* (USNM 645196), which is the only specimen from the Gatun formation. It has more undulations and somewhat stronger undulations than the type (the only specimen) of *V. undulata*. Those dif-

ferences surely are not of taxonomic significance. Collins suspected he was proposing an unnecessary name.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d. Presumably Cercado or Guabo formation (middle Miocene), Dominican Republic.

Genus Cavolina Abilgaard

Abilgaard, Skrivter af Naturhistorie-Selskabet, v. 1, p. 174, 175, 1791.

Type (monotype): *Cavolina natans* Abilgaard (= *Monoculus telemus* Linné), living, Atlantic and Pacific Oceans.

Subgenus Paleocavolina Woodring, n. subgen.

Type: *Cavolina* (*Paleocavolina*) *xenica* Woodring, n. sp. Caimito formation, Oligocene, Canal Zone.

Relatively large. Ventral side moderately inflated, smooth, little less than apertural half strongly bent. At least lateral margins rimmed. Apical and apertural margins defective. Dorsal side slightly inflated, end of apex missing. Remnants of marginal rim remaining. Narrow swollen band adjoining groove setting off marginal rim. Apical part bearing low, narrow ridges. Traces of similar sculpture on preserved patch of shell near swollen band close to apical margin.

The combination of rimmed margin, swollen band on the dorsal side near the margin, low, narrow ridges on the dorsal side, and long, strongly bent ventral side distinguishes *Paleocavolina* from the subgenera *Cavolina* s.s. and *Gamopleura* Bellardi (1873 (1872), p. 58; type (monotype): *Gamopleura taurinensis* (Sismonda) (*Hyalœa taurinensis* Sismonda), Miocene, Italy). The length of the apical spine is unknown. No trace of an interlocking projection and notch is apparent, but the lateral margins are not completely preserved.

Cavolina (Paleocavolina) xenica Woodring, n. sp.

Plate 49, figures 3, 4, 6, 9

Features of the monotypic subgenus.

Ventral side: height 5.5 mm, width 6.3 mm, diameter 3.5 mm (type). Dorsal side: height 6.4 mm, estimated restored width 6.5 mm, diameter 1.8 mm (paratype).

Type: USNM 646097; paratype, USNM 646098.

Type locality: 54j (USGS 18833, Barro Colorado Island, southwestern part of island, stream crossing Conrad Trail at Conrad 2, about 365 meters upstream from mouth, Canal Zone), Caimito formation.

Locality of paratype: 54h (USGS 18841, Barro Colorado Island, western part of island, mouth of first stream north of Zetek House, Canal Zone), Caimito formation.

Cavolina xenica is represented by a ventral side and a dorsal side collected in the moderately deep-water facies of the Caimito formation on Barro Colorado Island at localities 1.6 kilometers apart (54j and 54h respectively; Woodring, 1958, pl. 1). Patches of shell material are missing on both sides. It may seem to be rash to base a species and subgenus on defective material, but it is a distinctive species.

If *Cavolina cookei* Simonelli (1895, p. 19, figs. a-c; Malta) is of Aquitanian age, *C. xenica* is the oldest known *Cavolina*. The alleged late Oligocene species from Buton (Beets, 1942, p. 305–306, pl. 29, figs. 117–123; 1953, p. 251–252, pl. 1, figs. 5–7) are similar to Miocene and living species. Their age now is thought to be younger than Oligocene (Beets, 1953, p. 239).

Occurrence: Caimito formation (late Oligocene), Barro Colorado Island, localities 54h, 54j.

Subgenus Cavolina s.s.

Cavolina (Cavolina) triaspis Woodring, n. sp.

Plate 63, figures 16, 17

Small. Wide central part of ventral side strongly inflated and arched, flanked on each side by a low ridge shaped like an inverted V. Apertural margin defective. Dorsal side practically flat. Central part barely raised, flanked on each side by a low swelling. Apertural extremity, which presumably overhung ventral side, missing. Apical spine broken, its base narrow.

Height (not quite complete) 4.2 mm, width 4.5 mm, diameter 2.4 mm (type).

Type: USNM 646067.

Type locality: 177d (USGS 6036, Mount Hope, about 1/6 mile (270 meters) south of railroad station, Canal Zone), upper part of Gatun formation.

The type, from the upper part of the Gatun formation in the Mount Hope area, is the only specimen of *Cavolina triaspis*. It is the second American representative of a group of Miocene western European species typified by *C. bisulcata* (Kittl) (1886, p. 65, pl. 2, figs. 29–32; Polish Austria) and the very similar *C. audeninoi* Vinassi de Regny (Sacco, 1904, p. 13, pl. 4, figs. 2a–2c; Italy). *C. audeninoi trinitatis* Rutsch (1934, p. 312, pl. 8, figs. 6–8), from the middle Miocene part of the Brasso formation of Trinidad, was the first American form. The ventral side of the European species, as well as the Trinidad form, is almost evenly tipartate; that is, the swollen, arch-like central part is flanked on each side by a lower, swollen arch. Their dorsal side is more strongly sculptured than that of *C. triaspis*.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 177d.

Cavolina (Cavolina) cf. C. ventricosa (Guppy)

Plate 63, figures 11, 12

Small, both sides strongly inflated, dorsal side more strongly than ventral. Little shell material remaining on ventral side. Dorsal side bearing a low, central swelling of moderate width, set off by wide, shallow depression. Apertural part far overhanging ventral side. Posterior lateral margins upturned. Apical spine wide-based, bent toward dorsal side, tip missing.

Height 3.9 mm, width 4.3 mm, diameter 3.3 mm (figured specimen).

An early collection from the Mount Hope area contains another specimen of *Cavolina* s.s., evidently representing a new species. It is in poor condition. Though much of the dorsal side is preserved, it is badly cracked and bits of shell are missing.

The exceptionally strong inflation of the dorsal side is the most noteworthy feature of this species. In general features it resembles *C. ventricosa* (Woodring, 1928, p. 114, pl. 1, figs. 8, 9; Collins, 1934, p. 184, pl. 7, figs. 16–18; Bowden formation, Jamaica), but the dorsal inflation is greater; the central swelling is wider; and a pair of minor lateral swellings is absent.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 177.

Family ELLOBIIDAE

Subfamily ELLOBIINAE

Genus Ellobium Röding

Röding, Museum Boltenianum, p. 105, 1798.

Type (logotype, Winckworth, Malacolog.. Soc. London, v. 26, p. 139, 1945): *Ellobium midæ* Röding (=*Voluta aurismidæ* Gmelin = *Bulla aurismidæ* Linné), living, western Pacific Ocean.

Winckworth attributed the type designation to Gray (1847, p. 179), but that designation was not in suitable form for *Ellobium*. The type species is gigantic compared with the American species.

Ellobium aff. E. pellucens (Menke)

Plate 48, figure 24

Of medium size, moderately slender. No trace of sculpture apparent. Columella bearing two folds: a basal fold and one some distance above it.

Height 17.5 mm, diameter 8 mm (figured specimen).

The La Boca formation yielded the first American fossil representative of the salt-marsh pulmonate genus *Ellobium*. It is in poor condition: partly crushed and some shell is missing. In outline and lack of sculpture it closely resembles immature specimens of the living Caribbean species *E. pellucens* Menke (1828, p. 78). If it were known to be mature, it would be appropriate to consider it to be a small predecessor of the nominate form. The original aragonite is replaced by calcite, but if this fossil were related to the eastern Pacific *E. stagnalis* (d'Orbigny) (1835, p. 23), at least a trace of the fine, crimped sculpture of that species should be apparent.

Occurrence: La Boca formation (early Miocene), locality 116a.

Family HELMINTHOGLYPTIDAE

Subfamily XANTHONYCINAE

Genus Averellia Ancy

Ancy, [Letter to editor], Conchologists' Exchange, v. 1, p. 54, 1887. Substitute name for *Cœlospira* Ancy, 1886, not *Cœlospira* Hall, 1863.

Type (orthotype of *Cœlospira* Ancy, 1886): *Helix macneili* Crosse, living, Nicaragua and Costa Rica.

Subgenus Lecallia Woodring, n. subgen.

Type: *Averellia* (*Lecallia*) *stewarti* Woodring, n. sp., marine member of Bohio(?) formation, late Eocene or early Oligocene, Canal Zone.

Of medium size, flattened discoidal, periphery asymmetrically rounded. Umbilicus about a third of shell diameter. Whorls 4¼, slowly enlarging in diameter, upper surface slightly inflated. Growth lines exaggerated at intervals. Peristome missing.

Lecallia is inferred to be related to *Trichodiscina* von Martens (1890–1901, p. 133, 1892, substitute name for *Trichodiscus* Strebel and Pfeffer, 1880, not *Trichodiscus* Ehrenberg, 1830; type (logotype of *Trichodiscus* Strebel and Pfeffer, 1880): *Helix coactiliatus* Férrusac, living, northern México to Trinidad). *Trichodiscina* is currently assigned subgeneric rank under *Averellia*. The anatomy of the type species of *Averellia* is unknown. The upper surface of the shell is concave and the body whorl near the aperture is creased by two strong internal lamellæ. The jaw and radula of the type species of *Trichodiscina* have been described (Baker, 1922, p. 57, pl. 17, figs. 7, 9) and the genitalia of a closely related species, *A. cordovana* (Pfeiffer) (Baker, 1927, p. 242, pl. 20, figs. 53–57). *Lecallia* is larger than the species of *Trichodiscina* and the upper surface of its whorls is flatter.

Averellia (Lecallia) stewarti Woodring, n. sp.

Plate 48, figures 9, 14, 18

Features of the monotypic subgenus.

Height 6 mm, diameter 15.5 mm (type).

Type: USNM 646088.

Type locality: 41b (USGS 18839, East side of Palenquilla Point, head of cove north of triangulation station and southwest of Corozo Island, Canal Zone), marine member of Bohio(?) formation.

The collection from locality 41b includes the type of this land snail, associated with 40 marine species. Though parts of the shell, which is replaced by calcite, and the peristome are missing, it is in reasonably good condition and evidently was buried close to the mouth of the stream that carried it into the sea. The upper edge of the body whorl descends where it is broken off, indicating that not much more than the peristome is missing on that part of the whorl.

If the affinities of *Averellia stewarti* have been interpreted properly, it is the first fossil helminthoglyptid from the Caribbean region. In any event it is the oldest Central American land snail so far found. The species is named for R. H. Stewart, geologist of the Panama Canal Company.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 41b.

ADDITIONS AND CORRECTIONS TO FAMILIES COVERED IN PRECEDING CHAPTERS

Some 20 additional species of gastropods are now available, as a result of large collections from the Gatuncillo, La Boca, and Gatun formations, received after chapter B was prepared. A few of these species of special interest, better specimens of some already described, and some corrections for the preceding chapters are covered in the following pages. The pages cited in headings and citations refer to earlier chapters.

Family TURRITELLIDAE

Genus Turritella Lamarck

Turritella abrupta Spieker (p. 106)

Plate 63, figures 22, 24

Collections from the lower and middle parts of the Gatun formation contain larger and better specimens of *Turritella abrupta* than that shown on plate 23, figure 16. All, however, consist of only a few whorls. The largest (2½ whorls, height 56 mm) is estimated to have had a height of about 150 mm, not as large as the largest from Colombia and Venezuela.

This species is distributed along the south side of the Caribbean Sea, thence northward to the Tehuantepec area,, and along the Pacific coast from Chiriquí to Perí. The specimen from the Tehuantepec area, mentioned on page 107, has been found in the Johns Hopkins University collection, now in the U.S. National Museum.

Additional occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d, 138e. Middle part, eastern area, localities 139e, 139g. Agueguexquite formation (middle Miocene), Tehuantepec area, México.

Family VERMETIDAE

Genus Pataloconchus H. C. Lea (p. 161)

Petaloconchus sculpturatus H. C. Lea

Plate 63, figure 23

Petaloconchus sculpturatus H. C. Lea, Am. Philos. Soc. Trans., n. s., v. 9, p. 233, pl. 34, fig. 3, 1846 (Miocene, Virginia).

Petaloconchus domingensis Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 51, pl. 10, fig. 9, 1850 (Miocene, Dominican Republic).

Petaloconchus aff. *P. floridanus* Olsson and Harbison, Woodring, present report, p. 161, pl. 29, fig. 9, 1959.

Further sampling of the lower and middle parts of the Gatun formation show that the provisionally identified species of *Petaloconchus* is *P. sculpturatus*. Specimens that have the normal growth habit of *P. sculpturatus*, in the form of an open tapering cylinder, and at some localities specimens of irregular growth habit, were collected at localities 138c, 138e, and 139c. One of them is illustrated.

Two specimens from the original lot of *P. domingensis*, labelled by Sowerby and formerly in the Calvert collection, are now in the U.S. National Museum (560276).

Occurrence: Lower, middle, and possibly upper part of Gatun formation (middle Miocene). Lower part, localities 138c, 138e. Middle part, eastern area, locality 139c. For other Gatun localities see p. 162. Widely distributed in deposits of middle and late Miocene age from Virginia to Trinidad.

Family THIARIDAE

Subfamily THIARINAE

Genus Hemisinus Swainson (p. 157)

Subgenus?

Hemisinus amaras Woodring, n. sp.

Plate 63, figures 8, 13

Large, moderately inflated. Shoulder sharply carinate, sutural channel wide, shaped like a shallow, asymmetrical gutter. Early whorls missing. Lower half of body whorl sculptured with narrow, flat bands, becoming indistinct above level of aperture. Outer lip broken back, slightly sinuate at sutural channel, according to growth lines. Basal lip bearing a narrow, shall notch adjoining columellar lip.

Height (incomplete) 20.5 mm (estimated restored height 27 mm), diameter 12.5 mm (type).

Type: USNM 646071.

Type locality: 161d (USGS 8366, cuts west of Gatun Dam, station 3a, Canal Zone), middle part of Gatun formation.

The type—the only specimen—of this unique species of *Hemisinus* was overlooked in the preparation of chapter B. The combination of sharp carina, wide, gutter-shaped sutural channel, and absence of axial sculpture is unique. The basal notch is not as wide and deep as it appears to be, as the basal lip is slightly broken back. Though truncation of the spire is common in thiarids, the spire of this fossil was broken back as far as it now is after burial, possibly during collecting. Rock matrix is exposed at the broken spire.

H. truncatus (Gabb) (Pilsbry, 1922, p. 379, pl. 34, figs. 14–16) is the only Caribbean fossil or living species of comparable size and general outline. That species, however, is not carinate or is slightly carinate. It has a steeply sloping shelf instead of a gutter-shaped sutural channel, and almost, or entirely, microscopic spiral sculpture. It has been collected in the Dominican Republic only by Gabb and is the monotype of his *Ectracheliza* (Gabb, 1872 (1873), p. 271, misprinted 971)—a name of doubtful utility, as indicated by Pilsbry. *H. steerei* Conrad (1874, p. 32, pl. 1, fig. 14), a species in the remarkable fauna of the Pebas formation of late Miocene(?) age on the upper Amazon, has a narrower sutural channel and stronger spiral sculpture, according to Conrad's illustration. His type is missing.

Occurrence: Middle part of the Gatun formation (middle Miocene), western area, locality 161d.

Family CERITHIIDAE (p. 170)

Subfamily CAMPANILINAE

Genus Campanile Bayle

Bayle, *in* Fischer, Manuel de conchyliologie et de paléontologie conchyliologique, p. 680, 1884.

Type (logotype, Cossmann, Soc. Royale Malacologique Belgique Annales, v. 24, p. 25, 1889): *Cerithium giganteum* Lamarck, Eocene, western Europe.

Campanile is an Italian masculine noun. The generic name therefore takes that gender.

The tough matrix encasing the fossil from the La Boca formation, mentioned on page 170 as a large cerithid, has yielded to treatment not available when chapter B was prepared. It is not a cerithid, but is a large specimen (4 whorls, height 54 mm, diameter 29 mm) of *Turritella* cf. *T. collazica* (p. 98).

Recently acquired collections contain five specimens of *Campanile* from the Emperador limestone member of the La Boca formation and a mold of 1½ large whorls (height 52 mm, diameter 47 mm) from the La Boca proper. Though the mold presumably represents *Campanile*, it is listed as *Campanile?* sp., as its sculpture is unknown.

Campanile cf. C. herculeanus (Cooke)

Plate 51, figure 15

Very large for a mid-Tertiary cerithid, slender. Early whorls missing. Remaining whorls covered with calcareous crust or part of whorl consisting only of mold. Molds showing a sutural band and a band near lower edge of whorl. Both bands on encrusted whorls bearing tubercles, enlarged and distorted by crust. Tubercles on sutural band larger than those on lower band. Aperture missing, growth lines obscured by crust.

Height (incomplete, 5 whorls) 87.5 mm (estimated restored height 140 mm), diameter 54.5 mm (figured specimen). Height (incomplete 6 whorls) 104 mm (estimated restored height 150 mm), diameter 52 mm (largest specimen).

The affinities of this species are indeterminable on account of the uneven development of the calcareous crust enlarging and distorting the tubercles, and concealing any intervening minor spiral sculpture that may have been present. Nevertheless it is reasonably certain that the tubercles, especially those on the lower band, originally were stronger than those of *Campanile herculeanus* (Cooke) (1919, p. 116, pl. 1, fig. 7), which occurs in the Anguilla formation of the island of Anguilla, considered to be of the same age as the La Boca formation and its Emperador limestone member. The sculpture of *C. herculeanus* duplicates that of the smaller and more slender Oligocene French species *C. charpentieri* (Grateloup) (Boussac, 1912, pl. 1, figs. 3, 3a, 11). The other mid-Tertiary American species—*C. halensis* (Dall), *C. vaughani* (Dall) (1916, p. 512, pl. 87, figs. 9, 10; p. 513, pl. 87, fig. 8, respectively; late Oligocene, Georgia), *C. hernandœnsis* (Mansfield), *C. hernandoensis blackwaterensis* (Mansfield) (1937, p. 150, pl. 6, fig. 3, pl. 7, fig. 8; p. 151, pl. 6, figs. 1, 2, 4; late Oligocene, Florida), and *C. collazus* (Hubbard) (1920, p. 143, pl. 23, figs. 1, 2; late Oligocene, Puerto Rico)—have more subdued sculpture than *C. herculeanus*, and the Puerto Rican species differs also in whorl profile. Perhaps the Puerto Rican species is that for which Maury (1920, p. 55, pl. 8, figs. 1, 2) proposed the name *Campanile* (*Portoricia*) *laricum*, the monotype of *Portoricia*, based on molds. Until the molds can be correlated with specimens that show the sculpture, her name is a nomen dubium.

C. herculeanus and the Emperador species, whatever it may be, are relics of Tethyan origin, the last American species, younger than any in Europe.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), locality 117c.

Family CALYPTRAEIDAE

Genus Crucibulum Schumacher

Subgenus Dispotaea Say (p. 83)

Say, Acad. Nat. Sci. Phila. Jour., 1st ser., v. 4, p. 131, 1824.
Type (logotype, Harris, Bull. Am. Paleontology, v. 1, p. 64 [explanation of pl. 7 of reprint of Say's account], 1896): *Calyptræa grandis* Say, Miocene, Maryland [Virginia].

I am indebted to my colleague Druid Wilson for pointing out this type designation in an unlikely part of Harris' reprint. It puts *Dispotæa* on a better footing than the later designation cited on page 83 of the present account.

Family STROMBIDAE

Genus Orthaulax Gabb (p. 190)

Orthaulax gabbi Dall

Plate 49, figures 7, 12

Orthaulax gabbi Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 170, pl. 12, figs. 5, 5a, 5b, 1890 (Miocene, Florida). Cooke, U.S. Geol. Survey Prof. Paper 129–B, p. 29, pl. 3, figs. 5, 6a, 6b (Dall's illustrations), 7, pl. 4, fig. 1, 1921 (Miocene, Florida; Canal Zone records doubtful). Gardner, U.S. Geol. Survey Prof. Paper 142, p. 560, pl. 55, figs. 1–3 (Dall's illustrations), 1947 (Miocene, Florida). H. E. and E. H. Vokes, Tulane Studies Geology, v. 6, no. 2, p. 74, pls. 1–3, 1968 (Miocene, Florida).

Of medium size, strongly shouldered, shoulder ridged. Spire moderately high. Horizontal section at shoulder triangular.

Height (incomplete) 69 mm (estimated restored height 80 mm), maximum shoulder diameter 51 mm, minimum shoulder diameter 39.5 mm (figured specimen).

Type: Lectotype, herewith designated, USNM 112218.

Type locality: USGS 2212, 1 mile west of Baileys Ferry, Chipola River, Calhoun County, Florida, Chipola formation.

The collection from the La Boca formation at locality 101h, on the west side of Las Cascades Reach, includes a specimen identified as *Orthaulax gabbi*. It is almost entirely a natural cast, consisting of calcareous sandstone and irregularly disposed dense calcite, flecked with black mineral grains, like those in the calcareous sandstone. An axial section shows ghosts of the lower columellar part of a few whorls, but no other shell or callus outline.

A large sample of *O. gabbi*, recently described by H. E. and E. H. Vokes, was found to show a considerable range of variation in shell outline. Nevertheless fully mature shells and many of intermediate size, including the lectotype, have a ridged shoulder and a triangular horizontal section at the shoulder. Those features are well shown by a series of large specimens from Alum Bluff (USGS 2211), ranging in height, or estimated restored height, from 100 to 120 mm. The ridged shoulder is the most diagnostic feature of this species.

According to the catalog record, five specimens were in the type lot. The larger specimen illustrated by Dall is designated the lectotype. The smaller illustrated one is missing.

The fossils recorded as *O.* cf. *O. pugnax* and *O.* cf. *O. aquadillensis* on page 191 should have been recorded as *Orthaulax* sp., as their affinities are uncertain. They are so recorded in lists in the present chapter.

Occurrence: La Boca formation (early Miocene), locality 101h. Chipola formation (early Miocene), Florida.

Family COLUBRARIIDAE

Genus Colubraria Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 251, 1817.
Type (monotype): *Colubraria granulata* Schumacher (= *Murex maculosus* Gmelin = *Buccinum muricatum* Lightfoot), living, western Pacific Ocean.

Colubraria obscura (Reeve)

Plate 63, figures 20, 21

Triton obscurus Reeve, Conchologia iconica, vol. 2, *Triton*, species 63, pl. 16, fig. 63 and text, 1844 (living, East Indies).
Colubraria obscura (Reeve), Warmke and Abbott, Caribbean seashells, p. 116, pl. 21, fig. q, Livingston Publishing Co., 1961 (living, West Indies, western Pacific Ocean).
Epidromus testaceus Mörch, Catalogus conchyliorum * * * Comes de Yoldi, p. 107, Copenhagen, 1852 (living, West Indies).
Triton testaceus (Mörch), Morch, Malakozooligsche Blätter, v. 24, p. 25, 1877 (assigned to subgenus *Colubraria;* living, West Indies).
Colubraria lucasensis Strong and Hertlein, Calif. Acad. Sci. Proc., 4th ser., v. 22, no. 6, p. 173, pl. 35, fig. 17, 1937 (living, Baja Calif.). Emerson, Veliger, v. 8, p. 176, pl. 26, figs. 1–4, 1966 (living, Baja Calif. to Panamá).
Colubraria soverbii (Reeve), Campbell, Nautilus, v. 74, p. 140, pl. 10, figs. 5, 6, text fig. 4, 1961 (living, Gulf of California to Guaymas, México).

Large, inflated, whorls bulging. One varix on earliest preserved whorl, two irregularly arranged varices on other spire whorls, only terminal varix on body whorl. Early sculpture finely and evenly reticulate, axial and spiral threads of about equal strength, small nodes at intersections. At later stage axial threads stronger than spiral. On last few whorls both sets and accompanying nodes subdued. Interior of outer lip lirate. Base of parietal shield obscurely ridged. Narrow ridge near upper end of parietal wall. Siphonal canal short, bent backward, deeply emarginate.

Height (almost complete) 40.5 mm, diameter 15.5 mm (figured specimen).

Type: Presumably at British Museum (Natural History).

Type locality: Living, East Indies.

One specimen identified as *Colubraria obscura* was collected from sandstone of the Gatun formation, about half a meter below the base of coralliferous conglomerate, on the south side of Río Chargres, 175 meters below the spillway of Gatun Dam. The body whorl and part of the penult whorl are somewhat worn.

This is the first Tertiary record of a large species of *Colubraria* from the Caribbean region or southeastern United States, aside from the early Miocene Brazilian *C. parœnsis* Maury (1925a, p. 127, pl. 6, fig. 1), which, according to Maury's illustration, has strongly bulging whorls and strong spiral sculpture.

C. obscura is recognized as living in the Caribbean region and in the western Pacific Ocean—at least shells that are indistinguishable are found in both areas. On the same basis it also survived in the eastern Pacific Ocean, where it is represented by *C. lucasensis*. Though the type of *C. lucasensis* is small (height 27 mm), the shell from the Pacific coast of the Canal Zone illustrated by Emerson (figure 4) closely agrees with the Gatun fossil in size, outline, and sculpture.

Occurrence: Middle part of Gatun formation (middle Miocene), locality 160c. Living, Florida, Bermuda, Bahamas to Barbados; Gulf of California to Panamá; western Pacific Ocean.

Family MURICIDAE (p. 214)

Subfamily MURICINAE

Genus Pterynotus Swainson

Swainson, Zoological illustrations, 2d ser., v. 3, p. 100, 1833, subgenus without species.

Type (monotype, Swainson, Idem, p. 122, pl. 122, 1833): *Murex (Pteronotus) pinnatus* Swainson (= *Purpura alata* Röding), living, western Pacific Ocean.

Subgenus Subpterynotus Olsson and Harbison

Olsson and Harbison, Acad. Nat. Sci. Phila. Mon. 8, p. 246, 1953.

Type (orthotype): *Murex textilis* Gabb [*Murex (Pteronotus) textilis*], Miocene, Dominican Republic, Venezuela, Panamá, Florida; Pliocene, Florida.

Subpterynotus is distinguished from *Pterynotus* s.s. by its long, almost straight siphonal canal and its correspondingly almost straight, short end of the siphonal canal preceding the terminal canal. The cloth-like sculpture is stronger than that of the type species of *Pterynotus*, but is similar to the sculpture of other species, such as the western Pacific *P. pellucidus* (Reeve) and *P. tripterus* (Born) (Reeve, 1845, pl. 14, figs. 54, 55, respectively), and the eastern Pacific *Murex rhyssus* Dall, a junior homonym renamed *Pteropurpura vokesæ* Emerson (1964a, p. 5; illustrated as *Pteropurpura rhyssa*, Emerson, 1964, p. 153, pl. 20, fig. 1). The proper subfamily and generic assignment for *Pteropurpura vokesæ* will not be known until the radula is known. Its operculum has an apical nucleus like that of most muricine species, but its siphonal canal is closed, like that of the type species of *Pteropurpura*, an ocenebrine genus, although not all species of that genus have a closed canal.

Pterynotus (Subpterynotus) textilis (Gabb)

Plate 63, figures 18, 19

Murex (Pteronotus) textilis Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 202, 1873 (Miocene, Dominican Republic). Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 142, pl. 9, fig. 4, 1890 (Pliocene, Florida).

Murex textilis Gabb, Guppy, Geol. Soc. London Quart. Jour. v. 32, p. 522, pl. 29, fig. 1 (an inadequate illustration), 1876 (Miocene, Dominican Republic).

Murex (Pteropurpura) textilis Gabb, Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 243 (in discussion), 1892. Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 353, pl. 28, fig. 4, 1922 (Miocene, Dominican Republic).

Murex (Subpterynotus) textilis Gabb, Olsson and Harbison, Acad. Nat. Sci. Phila. Mon. 8, p. 247, pl. 36, figs. 7, 7a, 1953 (Pliocene, Florida). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 521, pl. 69, figs. 8, 10, 1965 (Miocene, Venezuela).

Murexiella (Subpterynotus) textilis (Gabb), E. H. Vokes, Tulane Studies Geology, v. 6, no. 3, p. 120, pl. 8, figs. 1–3, 1968 (Miocene, Dominican Republic, Florida; Pliocene, Florida).

Of medium size, trivaricate, a low, wide swelling midway between varices. Whorls strongly bulging, concave near suture. Varices thin, alined on last three whorls, edge bent backward, short projections on edge alined with primary spiral threads, still shorter projections alined with some secondary threads. Primary spiral threads high-standing, secondary, or secondary and tertiary, threads lower. Fine axial threads producing an effect of loosely woven cloth. On apertural face of varices axial threads looped upward (away from aperture) or horizontal in narrow channels corresponding to spiral threads, and looped downward (toward aperture) in channels or on flat surfaces corresponding to spaces between spiral threads, upward looping more conspicuous than downward. On back face of varices and between varices axial threads crimped, on some whorls subdued between varices. Lower part of body whorl, including siphonal canal, missing.

Height (incomplete) 24.5 mm (estimated restored height 40 mm), diameter 19.5 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3257.

Type locality: Dominican Republic, Miocene.

Though the siphonal canal of the only specimen, found in the lower part of the Gatun formation, is missing, the sculpture is unmistakable. The occurrence of this species in the Chipola formation, recorded by Vokes, extends its time range; that in Panamá expands the middle Miocene distribution; and late Miocene specimens from Florida, also recorded by Vokes, fill in a time gap. Eight shells of that age are in Druid Wilson's Acline collection of that age. On the Florida late Miocene and Pilocene shells the bands of downward loops on the apertural face of the varices are wider and therefore more conspicuous than the bands of upward loops. The sutural whorl-concavity is deeper on Pliocene specimens than on those of middle and late Miocene age. A progressive increase in size is shown by the available material: early Miocene, 15 mm; middle Miocene, 33 to an estimated 40 mm; late Miocene, estimated 48 mm; Pliocene, 56 to 67 mm.

This remarkable species left no descendants. It may be related to the Miocene Italian *Pterynotus latilabris* (Bellardi and Michelotti) (Bellardi, 1873, p. 88, pl. 4, fig. 11).

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c. Chipola formation (early Miocene), Florida. Cantaure formation (middle Miocene), Venezuela. Miocene (presumably Cercado or Gurabo formation), Dominican Republic. Deposits of late Miocene age, Florida. Caloosahatchee formation (Pliocene), Florida.

Subfamily TYPHINAE

Genus Typhis Montfort

Subgenus Talityphis Jousseaume (p. 221)

Typhis (Talityphis) eucteanus Woodring, n. sp.

Plate 63, figures 9, 10

Small, slender, spire high. Early whorls worn. Remaining whorls bearing four varices, ending on shoulder in blunt, hollow spines. Terminal varix lamellar, others fairly wide. Tubes closer to preceding varix than to succeeding varix, generally broken almost to base. Spiral sculpture faint or absent on spire whorls. Body whorl bearing six weak, widely spaced spiral threads, most conspicuous on flanks of terminal varix. Terminal varix expanded, its edge frilled by the spiral threads. Siphonal canal short, tip missing.

Height (practically complete) 19 mm, diameter 9.7 mm (type). Height (practically complete) 23.3 mm, diameter (incomplete) 11 mm (largest specimen).

Type: USNM 646083.

Type locality: 138f (USGS 23663, south side of Transmisthmian Highway, hillside excavation at Colchoneriá Yero, about 450 meters southwest of Cativa, Panamá, lower part of Gatun formation.

This small, slender species was found in the lower part of the Gatun formation. Three were collected at the type locality and three others, available through the kindness of H. E. and E. H. Vokes, are in the Tulane collection from a nearby locality.

Typhis eucteanus is smaller and more slender than *T. alatus* Sowerby (1850, p. 48, pl. 10, fig. 4; height 31.8 mm, diameter 9 mm), collected only by Heneken in the Dominican Republic, and the varices, other than the terminal varix, of the Gatun species, are less lamellar. It is of the same size as *T. pterinus* Gardner (1926–47, p. 528, pl. 53, fig. 14, 1947; Shoal River formation, Fla.), but is more slender and the varices of that species are like those of *T. alatus*. On the contrary the varices of *T. puertoricensis* Warmke (1964), a small species living in Puerto Rican waters, are high and wide.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138f.

Family NASSARIIDAE

Genus Psilarius Woodring

Woodring, Nautilus, v. 77, no. 4, p. 143, Apr. 14, 1964. Substitute name for *Leptarius* Woodring, p. 272 of present account, Feb. 27, 1964, not *Leptarius* Gill, 1863.

Attention is drawn to the substitute name for the junior homonym *Leptarius*.

Family OLIVIDAE

Subfamily OLIVINAE

Genus Oliva Bruguière

Subgenus Strephonella Dall (p. 278)

Oliva (Strephonella) colpotus Woodring, n. name

Oliva plicata Guppy, *in* Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 308, pl. 30, fig. 12, 1896 (Miocene, Jamaica). Not *Oliva plicata* Fischer von Waldheim, Muséum-Demidoff, v. 3, p. 161, Moscow, 1807.

Oliva dimidiata Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 165, 1917 (Miocene, Dominican Republic). Not *Oliva dimidiata* Sowerby, *in* Darwin, The geology of the voyage of the *Beagle*, pt. 3, Geological observations on South America, p. 263, London, 1846.

Both *Oliva plicata* Guppy, the name used on page 278 of the present account, and its subjective synonym *Oliva dimidiata* Pilsbry and Johnson are junior homonyms.

Family?

Genus Glyptostyla Dall

Glyptostyla panamensis Dall (p. 289)

Plate 48, figure 23

After publication of chapter C, A. A. Olsson exposed by careful work the columella of two specimens of *Glyptostyla panamensis*. They show that the folds

are not like volutid folds, they are seated on a pad. The wide basal fold is followed upward by a gap and then by four or five closely spaced narrower, low folds. The effect of a wide basal fold and a wider upper fold on the type, as shown on plate 39, figure 21, is due to damaging of the pad when the specimen was prepared for the drawing published by Dall. The result is that Olsson's *Peruficus*, instead of being a synonym of *Glyptostyla*, as concluded on page 289, is a valid genus and doubtless is to be allocated to a different family.

Olsson, who had examined and photographed the lectotype of *Strepsidura striata* Newton (1922, p. 33, pl. 3, figs, 24, 25 (*S. multistriata* in explanation of plate); Eames, 1957, p. 48, pl. 7, fig. 3), an Eocene species from Nigeria, pointed out that it is very closely related to *Glyptostyla panamensis*. The remarkable columellar features are practically identifical, except that on *Strepsidura spirata* the gap above the basal fold is partly filled by a low fold. The Nigerian species has a conspicuous siphonal fasciole limited by a thread and its axial sculpture is weak. The end of the siphonal canal is broken on all the specimens of *Glyptostyla panamensis*. Much of the columellar side remains on the type, but the siphonal fasciole is worn. The fasciole is shown to best advantage on an immature specimen (locality 40d, height 24.6 mm). The limiting thread is weaker than that of the Nigerian species. It should be pointed out that the outer lip of both species is flaring. *Strepsidura spirata* is the type of *Strepsiduropsis* (Eames, 1957, p. 48), proposed as a subgenus of *Strepsidura*. The Nigerian fossil is considered to be a species of *Glyptostyla*. Whether the differences between it and *G. panamensis* are of specific or subgeneric rank is a matter of judgment. The family status of the genus is uncertain.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), localities 40, 40a, 40c, 40d.

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4, 6. *Acteocina* cf. *A. bullata* (Kiener) (p. 417).
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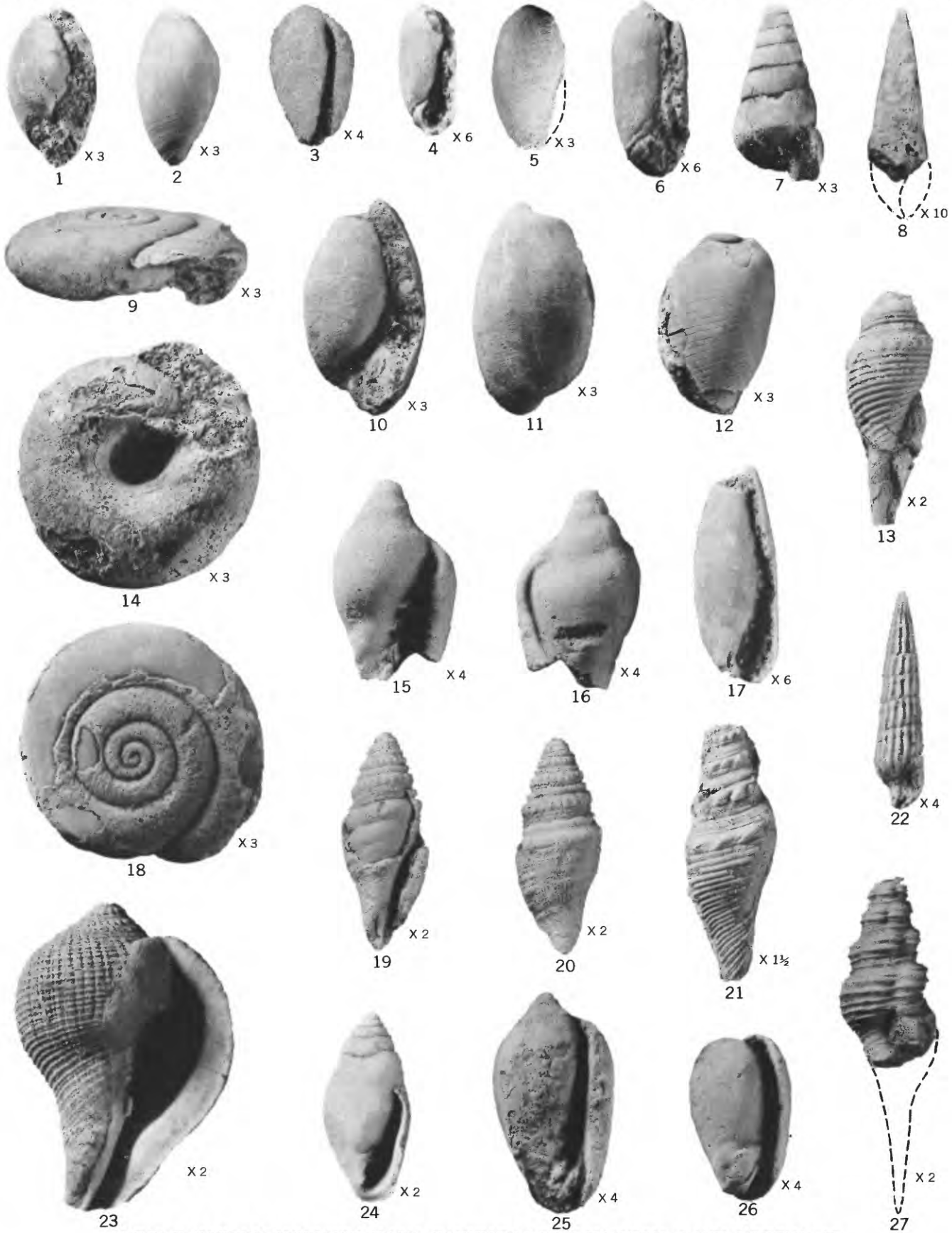


MIDDLE EOCENE MOLLUSK FROM GATUNCILLO FORMATION, LATE EOCENE OR EARLY OLIGOCENE MOLLUSKS FROM MARINE MEMBER OF BOHIO(?) FORMATION, LATE OLIGOCENE MOLLUSKS FROM BOHIO AND CAIMITO FORMATIONS, AND EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION

368-278 O - 70 - 11

PLATE 49

FIGURE 1. *Eulima nobilis* Guppy (p. 326).
Height 5.9 mm, diameter 1.7 mm. Locality 147b. Middle part of Gatun formation. USNM 646072.

2. *Eulima sarissiformis* (Pilsbry and Johnson) (p. 327).
Height (incomplete) 11.5 mm, diameter 2.7 mm. Locality 138c. Lower part of Gatun formation. USNM 646074.

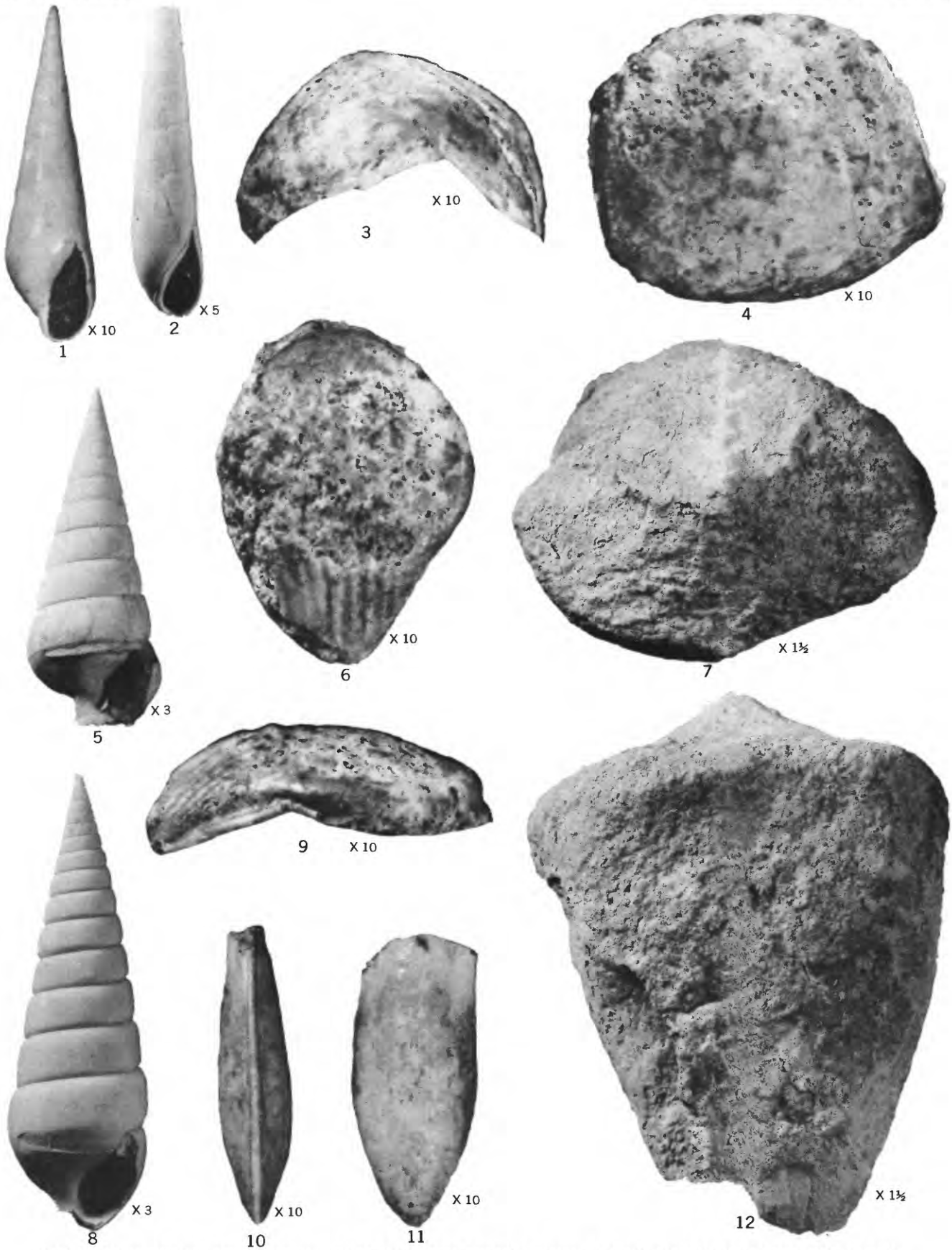
3, 4, 6, 9. *Cavolina* (*Paleocavolina*) *xenica* Woodring, n. sp. (p. 428).
3, 4. Type, ventral side. Height 5.5 mm, width 6.3 mm, diameter 3.5 mm. Locality 54j, Caimito formation. USNM 646097.
3. Right side.
4. Exterior.
6, 9. Paratype, dorsal side. Height 6.4 mm, estimated restored width 6.5 mm, diameter 1.8 mm. Locality 54h. Caimito formation. USNM 646098.
6. Exterior.
9. Right side.

5. *Niso* (*Niso*) *mesata* Woodring, n. sp. (p. 329).
Paratype. Height (not quite complete) 21.1 mm, diameter (not quite complete) 8 mm. Locality 142. Middle part of Gatun formation. USNM 646080.

7, 12. *Orthaulax gabbi* Dall (p. 432).
Height (incomplete) 69 mm, maximum shoulder diameter 51 mm, minimum shoulder diameter 39.5 mm. Locality 101h. La Boca formation. USGS 646101.

8. *Balcis* (*Balcis*) *cetia* Woodring, n. sp. (p. 328).
Type. Height (not quite complete) 28.3 mm, diameter 8.7 mm. Locality 138f. Lower part of Gatun formation. USNM 646078.

10, 11. *Vaginella lophota* Woodring, n. sp. (p. 427).
Type. Height (not quite complete) 5.1 mm, width 2.3 mm, diameter 1.4 mm. Locality 54j, Caimito formation. USNM 646096.



LATE OLIGOCENE MOLLUSKS FROM CAIMITO FORMATION, EARLY MIOCENE MOLLUSK FROM LA BOCA FORMATION, AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 50

FIGURES 1, 2, 5–8. *Floribella aldrichi* (Dall) (p. 421).

1, 2. Height (incomplete) 33.5 mm, diameter (incomplete) 31 mm. Locality 115a. La Boca formation. USNM 646099.

5–8. Topotypes. McClelland farm, Chipola River, Calhoun County, Fla. Chipola formation.

5, 7. Height (incomplete) 61 mm, diameter (incomplete) 64 mm. USNM 645998.

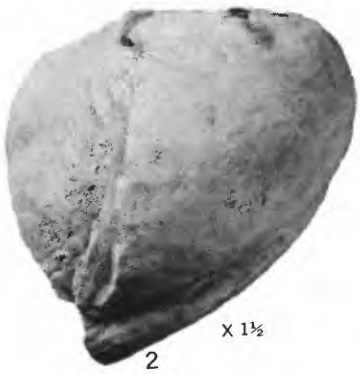
6, 8. Height (incomplete) 43 mm, diameter (practically complete) 51.5 mm. USNM 645999.

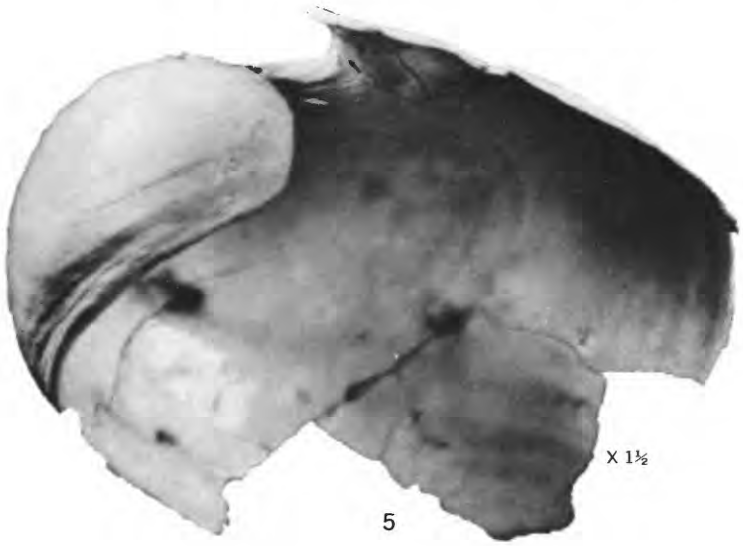
3. *Terebra* (*Oreoterebra*) *dicheres* Woodring, n. sp. (p. 404).

Type. Height (incomplete) 35 mm, diameter 11.5 mm. Locality 115a. La Boca formation. USNM 645870.

4. *Strioterebrum* cf. *S. celethra* (Maury) (p. 409).

Height (incomplete) 25.8 mm, diameter 9 mm. Locality 115b. La Boca formation. USNM 645871.





EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION AND CHIPOLA FORMATION OF FLORIDA

PLATE 51

FIGURES 1, 2. *Balcis* (*Balcis*) *jacululum* (Maury) (p. 327).
Height (not quite complete) 3.3 mm, diameter 1.1 mm. Locality 48b. Middle part of Gatun formation. USNM 646075.

3. *Niso* (*Niso*) *mesata* Woodring, n. sp. (p. 329).
Type. Height (incomplete) 14 mm, diameter (incomplete) 6.4 mm. Locality 138c. Lower part of Gatun formation. USNM 646079.

4–6. *Volvarina leander* (Brown and Pilsbry) (p. 331).
4. Height 11.4 mm, diameter 5.2 mm. Locality 177b. Upper part of Gatun formation, eastern area. USNM 645708.
5. Height 9 mm, diameter 4.4 mm. Locality 155c. Middle part of Gatun formation. USNM 645707.
6. Height 8 mm, diameter 3.7 mm. Locality 147b. Middle part of Gatun formation. USNM 645706.

7. *Persicula* (*Rabicea*) *couviana stenygra* Woodring, n. subsp. (p. 333).
Type. Height 10 mm, diameter 6.8 mm. Locality 138c. Lower part of Gatun formation. USNM 645711.

8, 9. *Cancellaria* (*Cancellaria*) *tapeina* Woodring, n. sp. (p. 335).
Type. Height (almost complete) 34.7 mm, diameter 20.5 mm. Locality 182a. Upper part of Gatun formation, western area. USNM 645714.

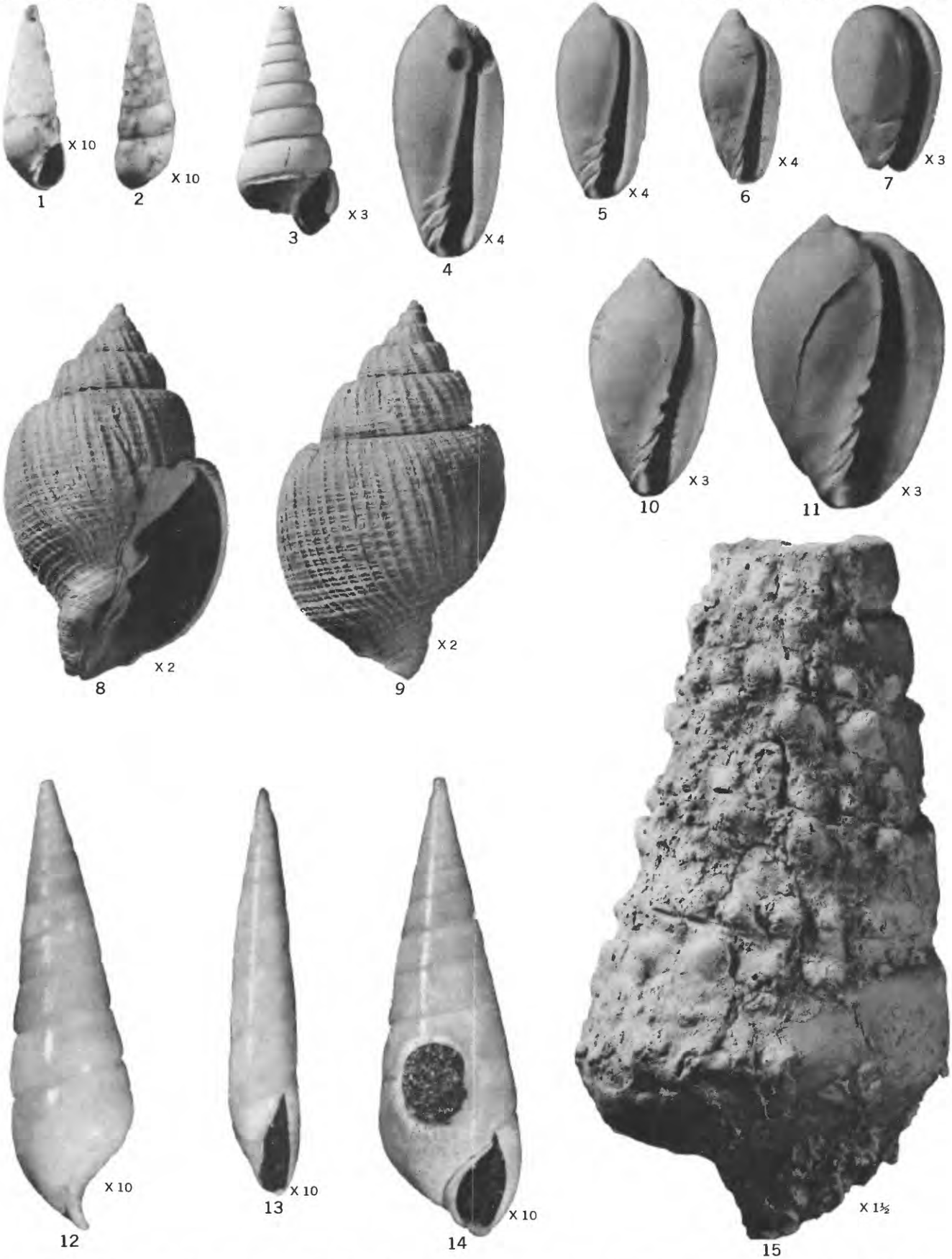
10, 11. *Prunum* (*Microspira*) *gatunense* (Brown and Pilsbry) (p. 332).
10. Height 14.5 mm, diameter 8 mm. Locality 138c. Lower part of Gatun formation. USNM 645710.
11. Height 17.8 mm, diameter 12 mm. Locality 139c. Middle part of Gatun formation. USNM 645709.

12. *Balcis* (*Balcis*) *aulaca* Woodring, n. sp. (p. 328).
Type. Height (not quite complete) 7.8 mm, diameter (not quite complete) 2.2 mm. Locality 138. Lower part of Gatun formation. USNM 646077.

13. *Eulima acuta* Sowerby (p. 327).
Height 7.3 mm, diameter 1.2 mm. Locality 159d. Middle part of Gatun formation. USNM 646073.

14. *Balcis* (*Balcis*) *lipara* Woodring, n. sp. (p. 328).
Type. Height (not quite complete) 8.3 mm, diameter 2.5 mm. Locality 138. Lower part of Gatun formation. USNM 646076.

15. *Campanile* cf. *C. herculeanus* (Cooke) (p. 431).
Height (incomplete) 87.5 mm, diameter 54.5 mm. Locality 117c. Emperador limestone member of La Boca formation. USNM 646102.



EARLY MIOCENE MOLLUSK FROM EMPERADOR LIMESTONE MEMBER OF LA BOCA FORMATION AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 52

FIGURES 1, 2. *Cancellaria* (*Cancellaria*) *anomoia* Woodring, n. sp. (p. 334).
Type. Height 19.1 mm, diameter 11.7 mm. Locality 138c. Lower part of Gatun formation. USNM 645712.

3, 4. *Cancellaria* (*Cancellaria*) aff. *C. macneili* Mansfield (p. 335).
Height 19 mm, diameter 12 mm. Locality 137. Lower part of Gatun formation. USNM 645713.

5, 6. *Cancellaria* (*Cancellaria*) *apimela* Woodring, n. sp. (p. 337).
Type. Height 22.6 mm, diameter 13 mm. Locality 182a. Upper part of Gatun formation, western area. USNM 645720.

7, 8. *Cancellaria* (*Cancellaria*) *epistomifera lipara* Woodring, n. subsp. (p. 337).
Type. Height 28 mm, diameter 17.5 mm. Locality 183. Upper part of Gatun formation, western area. USNM 645719.

9, 10. *Cancellaria* (*Pyruclia*) *cibarcola cibarcola* Anderson (p. 338).
Immature specimen showing early sculpture. Height 24 mm, diameter 15.9 mm. Locality 138c. Lower part of Gatun formation. USNM 645723.

11–18. *Cancellaria* (*Cancellaria*) *epistomifera dariena* Toula (p. 335).
Lower part of Gatun formation.

11, 12. Strongly turreted specimen. Height 31.5 mm, diameter 20 mm. Locality 136a. USNM 645718.

13, 14. Distinctly turreted specimen. Height 27.7 mm, diameter 17.6 mm. Locality 138c. USNM 645717.

15, 16. Slender specimen. Height 31 mm, diameter 16.5 mm. Locality 138c. USNM 645716.

17, 18. Inflated specimen. Height 34 mm, diameter 21.5 mm. Locality 138c. USNM 645715.

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 53

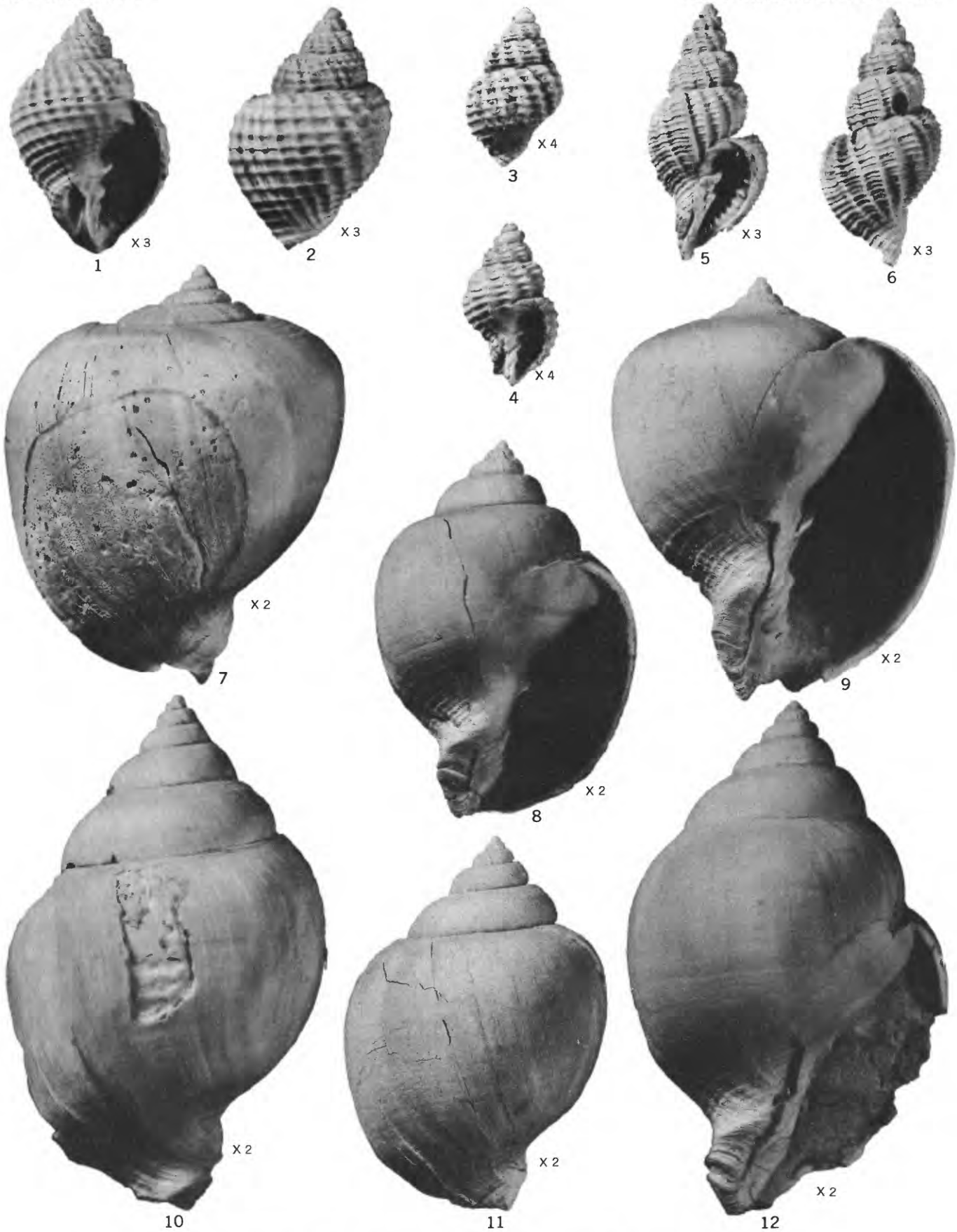
FIGURE 1, 2. *Cancellaria acalypta* Woodring, n. sp. (p. 341).
Type. Height 15.6 mm, diameter 10.2 mm. Locality 136a. Lower part of Gatun formation. USNM 645730.

3, 4. *Cancellaria nancellaria* Woodring, n. sp. (p. 341).
Type. Height 7.6 mm, diameter 4.5 mm. Locality 147b. Middle part of Gatun formation. USNM 645731.

5, 6. *Cancellaria* (*Narona*) *barystoma* Woodring, n. sp. (p. 342).
Type. Height 16.3 mm, diameter 7.8 mm. Locality 138d. Lower part of Gatun formation. USNM 645732.

7, 9. *Cancellaria* (*Pyruclia*) *diadela* Woodring, n. sp. (p. 338).
Type. Height (practically complete) 39.5 mm, diameter 33 mm. Locality 182. Upper part of Gatun formation, western area. USNM 645724.

8, 10–12. *Cancellaria* (*Pyruclia*) *cibarcola cibarcola* Anderson (p. 338).
Locality 138c. Lower part of Gatun formation.
8, 11. Height (practically complete) 35.7 mm, diameter (incomplete) 25 mm. USNM 645722.
10, 12. Exceptionally large, high-spired specimen. Height (practically complete) 49.2 mm, diameter (incomplete) 30 mm. USNM 645721.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 54

FIGURE 1, 2. *Cancellaria* (*Euclia*) *dinota* Woodring, n. sp. (p. 340).

Type. Height (practically complete) 29.9 mm, diameter 18 mm. Locality 138c. Lower part of Gatun formation. USNM 645728.

3, 4, 7, 8, 11, 12. *Cancellaria* (*Euclia*) *codazzii* Anderson (p. 339).

Lower part of Gatun formation.

3, 4. Slightly angulated, slightly spinose specimen. Height (practically complete) 33 mm, diameter 20.7 mm. Locality 138c. USNM 645725.

7, 8. Moderately angulated, moderately spinose specimen. Height (practically complete) 35.6 mm, diameter 24 mm. Locality 138c. USNM 645726.

11, 12. Strongly angulated, strongly spinose specimen. Height (practically complete) 32 mm, diameter 21.5 mm. Locality 138e. USNM 645727.

5, 6, 9, 10. *Cancellaria* (*Charcolleria*) *terryi* Olsson (p. 343).

5, 6. Height 42.3 mm, diameter 19 mm. Locality 138c. Lower part of Gatun formation. USNM 645734.

9, 10. Height (incomplete) 53.5 mm, diameter 24 mm. Locality 155. Middle part of Gatun formation. USNM 645733.

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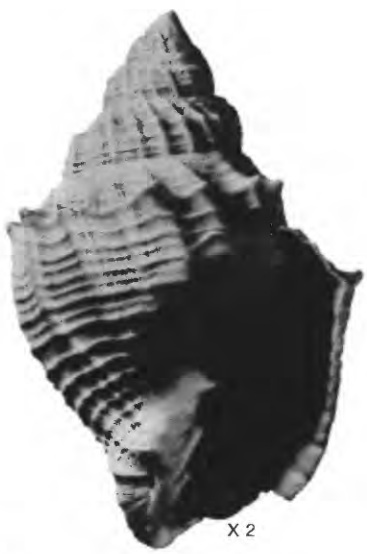

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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 55

FIGURE 1, 2. *Conus imitator imitator* Brown and Pilsbry (p. 354).

1. Height 45.4 mm, diameter 22 mm. Locality 177d. Upper part of Gatun formation, eastern area. USNM 645749.

2. Height 33 mm, diameter 16 mm. Locality 138c. Lower part of Gatun formation. USNM 645750.

3. *Conus acolus* Woodring, n. sp. (p. 349).

Type. Height 35 mm, diameter 20.8 mm. Locality 136a. Lower part of Gatun formation. USNM 645741.

4. *Conus recognitus* Guppy (p. 346).

Height (almost complete) 39 mm, diameter (body whorl broken back) 20.8 mm. Locality 182. Upper part of Gatun formation, western area. USNM 645736.

5, 6. *Conus aemulator aemulator* Brown and Pilsbry (p. 351).

Type. Height 22.7 mm, diameter 12.8 mm. Gatun Locks excavation. Middle part of Gatun formation. Acad. Nat. Sci. Phila. 1961. Photograph by A. A. Olsson.

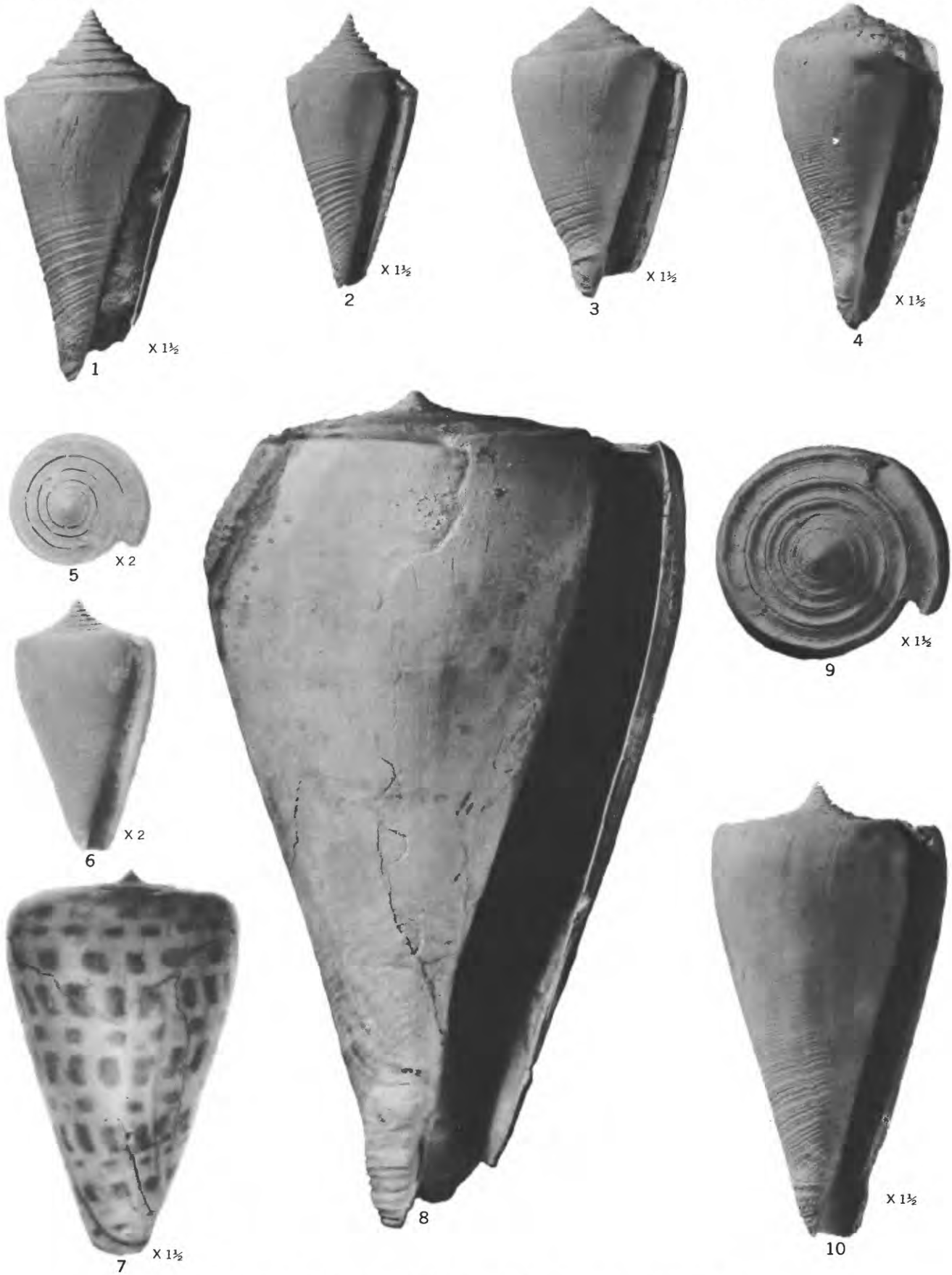
7. *Conus spurius* Gmelin (p. 348).

Height 45.8 mm, diameter 28.5 mm. Locality 155. Middle part of Gatun formation. USNM 645738. Photograph by A. A. Olsson.

8–10. *Conus molis* Brown and Pilsbry (p. 350).

8. Slightly reduced. Height 160 mm, diameter 90 mm. Locality 185.Upper part of Gatun formation, western area. USNM 645742.

9, 10. Immature specimen. Height 54.5 mm, diameter 27.7 mm. Locality 155b Middle part of Gatun formation, eastern area. USNM 645743.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 56

FIGURE 1, 2. *Aphera islacolonis* (Maury) (p. 344).
Height 16 mm, diameter 10 mm. Locality 138f. Middle part of Gatun formation. USNM 645735.

3, 7, 9. *Conus consobrinus consobrinus* Sowerby (p. 352).
3, 7. Height 47.7 mm, diameter 30.3 mm. Locality 138c. Lower part of Gatun formation. USNM 645745.
9. Height 61.7 mm, diameter 30.3 mm. Locality 161b. Middle part of Gatun formation. USNM 645746.

4, 8. *Conus aemulator aemulator* Brown and Pilsbry (p. 351).
Height 45 mm, diameter 28 mm. Locality 155a. Middle part of Gatun formation. USNM 645744.

5, 6. *Cancellaria (Euclia) dinota* Woodring, n. sp. (p. 340).
Exceptionally large specimen. Height 34.9 mm, diameter 21 mm. Locality 138d. Lower part of Gatun formation. USNM 645729.

10, 11. *Conus bravoi* Spieker (p. 348).
Lower part of Gatun formation.
10. Height 59.4 mm, diameter 36.6 mm. Locality 138c. USNM 645739.
11. Height (incomplete) 64 mm, diameter 44 mm. Locality 137a. USNM 645740.

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 57

FIGURES 1, 7. *Conus taphrus* Woodring, n. sp. (p. 354).
Type. Height (almost complete) 28.2 mm, diameter 15 mm. Locality 161d. Middle part of Gatun formation. USNM 645748.

2. *Conus musaensis* Olsson (p. 347).
Height 20.6 mm, diameter 10 mm. Locality 170. Middle part of Gatun formation. USNM 645737.

3, 4. *Conus multiliratus multiliratus* Böse (p. 356).
Height (almost complete) 27.2 mm, diameter 14.4 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 645751.

5, 6. *Conus tortuosostriatus* Toula (p. 359).
Locality 175. Upper part of Gatun formation, eastern area.
5. Slender specimen. Height (not quite complete) 26.3 mm, diameter 11.7 mm. USNM 645756.
6. Inflated specimen. Height (incomplete) 28.2 mm, diameter 15.7 mm. USNM 645755.

8. *Pleurofusia acra* Woodring, n. sp. (p. 367).
Type. Height (practically complete) 22.4 mm, diameter 7.5 mm. Locality 155c. Middle part of Gatun formation. USNM 645764.

9, 10. *Cochlespira* (*Ancistrosyrinx*) *cedonulli* (Reeve) (p. 371).
Height (incomplete) 19.3 mm, diameter (spines broken) 10.2 mm. Locality 177b. Upper part of Gatun formation. USNM 645769.

11, 18, 22. *Gemmula vaningeni* (Brown and Pilsbry) (p. 361).
Locality 175. Upper part of Gatun formation, eastern area.
11, 18. Malformed specimen. Height (incomplete) 25.9 mm, diameter 10 mm. USNM 645758.
22. Height (not quite complete) 38.8 mm, diameter (incomplete) 12.3 mm. USNM 645757.

12, 23, 24. *Pleuroliria* (*Polystira*) *tenagos* (Gardner) (p. 364).
12. Profile modified by peripheral carina. Height (incomplete) 42.3 mm, diameter 16.6 mm. Locality 138c. Lower part of Gatun formation. USNM 645760.
23. Profile slightly modified by peripheral carina. Height 58.8 mm, diameter 16.6 mm. Locality 173. Upper part of Gatun formation, eastern area. USNM 645762.
24. Profile somewhat modified by peripheral carina. Height 51.4 mm, diameter 14.4 mm. Locality 157. Middle part of Gatun formation. USNM 645761.

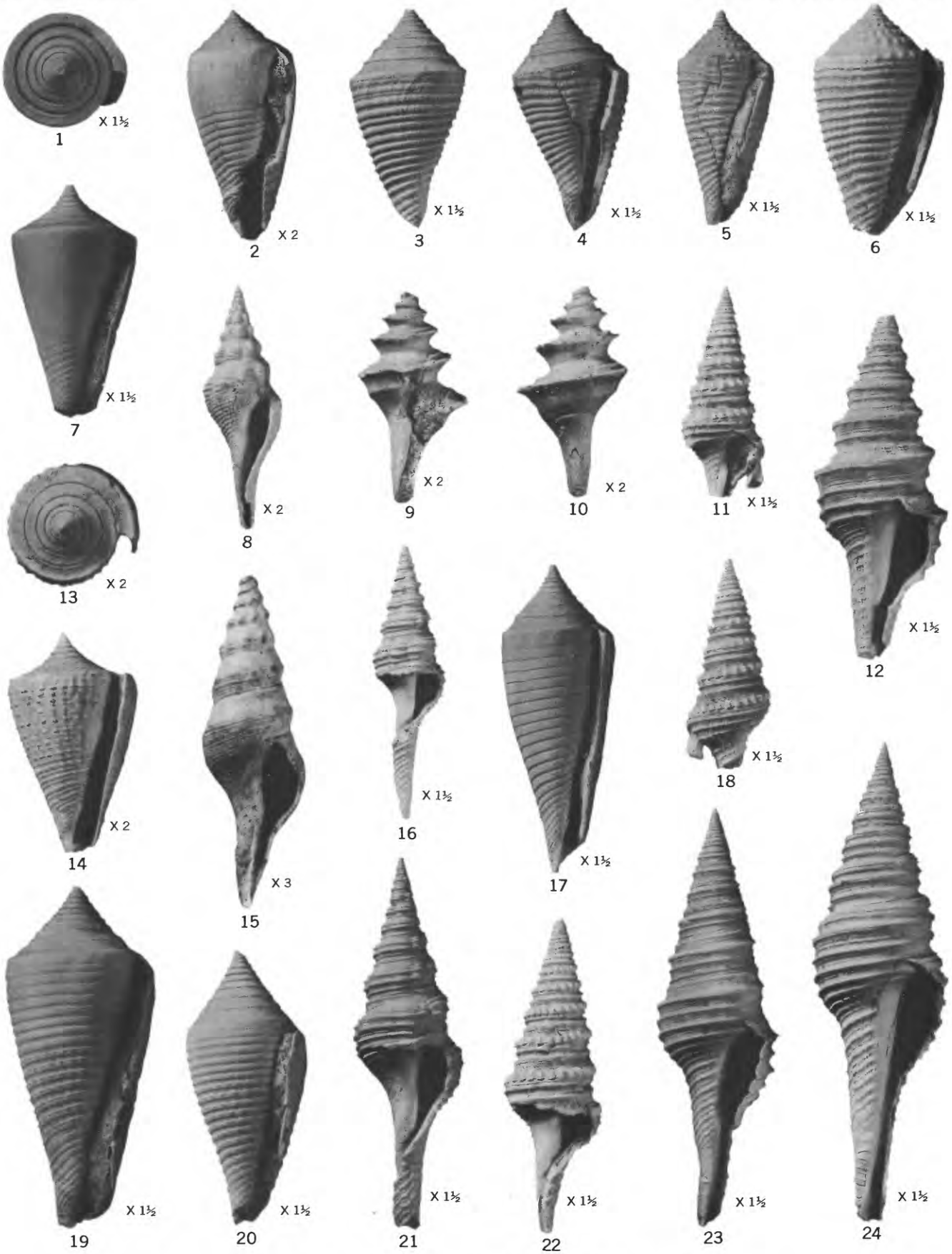
13, 14. *Conus symmetricus* Sowerby (p. 353).
Height 20.4 mm, diameter 11.8 mm. Locality 155a. Middle part of Gatun formation. USNM 645747.

15. *Leucosyrinx xenica* Woodring, n. sp. (p. 370).
Type. Height 15.4 mm, diameter 4.9 mm. Locality 185. Upper part of Gatun formation, western area. USNM 645768.

16, 21. *Pleurofusia* (*Cruziturricula*) *fusinus fusinus* (Brown and Pilsbry) (p. 369).
Locality 138c. Lower part of Gatun formation.
16. Height (not quite complete) 33.5 mm, diameter (incomplete) 9 mm. USNM 645766.
21. Height (incomplete) 45.7 mm, diameter (incomplete) 13.5 mm. USNM 645765.

17. *Conus burckhardti harrisi* Olsson (p. 358).
Height 37.7 mm, diameter 13.5 mm. Locality 138a. Lower part of Gatun formation. USNM 645754.

19, 20. *Conus burckhardti burckhardti* Böse (p. 357).
Locality 155. Middle part of Gatun formation.
19. Height (practically complete) 42.3 mm, diameter 17.7 mm. USNM 645752.
20. Height (practically complete) 33.7 mm, diameter 14.8 mm. USNM 645753.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 58

FIGURES 1, 22. *Crassispira* (*Hindsiclava*) *consors consors* (Sowerby) (p. 378).

1. Height (not quite complete) 32 mm, diameter 9.2 mm. Locality 155a. Middle part of Gatun formation. USNM 645779.

22. Height (not quite complete) 42.9 mm, diameter 12 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 645778.

2, 3. *Crassispira* (*Crassispirella*) *tyloessa* Woodring, n. sp. (p. 381).

Type. Height 13.4 mm, diameter 5.2 mm. Locality 139c. Middle part of Gatun formation. USNM 645783.

4, 5. *Crassispira* (*Crassispirella*) *cymation* Woodring, n. sp. (p. 381).

Locality 161c. Middle part of Gatun formation.

4. Paratype. Height (incomplete) 7.5 mm, diameter 4 mm. USNM 645782.

5. Type. Height (not quite complete) 8 mm, diameter (incomplete) 3.3 mm. USNM 645781.

6, 7. *Clathrodrillia* aff. *C. saavedrai* Woodring, n. sp. (p. 383).

Height 10.4 mm, diameter 3.5 mm. Locality 161c. Middle part of Gatun formation. USNM 645791.

8, 20, 21, 23-25. *Clathrodrillia gatunensis* (Toula) (p. 381).

8. Height (almost complete) 34 mm, diameter 13.5 mm. Locality 161a. Middle part of Gatun formation. USNM 645786.

20, 21. Height (almost complete) 33.6 mm, diameter 8.8 mm. Locality 155c. Middle part of Gatun formation. USNM 645788.

23. Height (almost complete) 40.5 mm, diameter 12.5 mm. Locality 159b. Middle part of Gatun formation. USNM 645787.

24, 25. Height (almost complete) 52.4 mm, diameter 17.5 mm. Locality 138c. Lower part of Gatun formation. USNM 645785.

9–12. *Carinodrillia* (*Carinodrillia*) *zooki* (Brown and Pilsbry) (p. 375).

9, 10. Height 21.2 mm, diameter 6.8 mm. Locality 138a. Lower part of Gatun formation. USNM 645774.

11, 12. Height 19.8 mm, diameter 6 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 645773.

13, 14. *Carinodrillia* (*Carinodrillia*) cf. *C. elocata* (Pilsbry and Johnson) (p. 376).

Height (almost complete) 26.8 mm, diameter 9.8 mm. Locality 139c. Middle part of Gatun formation. USNM 645776.

15, 16. *Clathrodrillia* cf. *C. islalindae* (Maury) (p. 384).

Height (not quite complete) 15.8 mm, diameter 5.5 mm. Locality 138f. Lower part of Gatun formation. USNM 645793.

17, 18. *Drillia* (*Neodrillia*) *riogurabonis eurysoma* Gardner (p. 374).

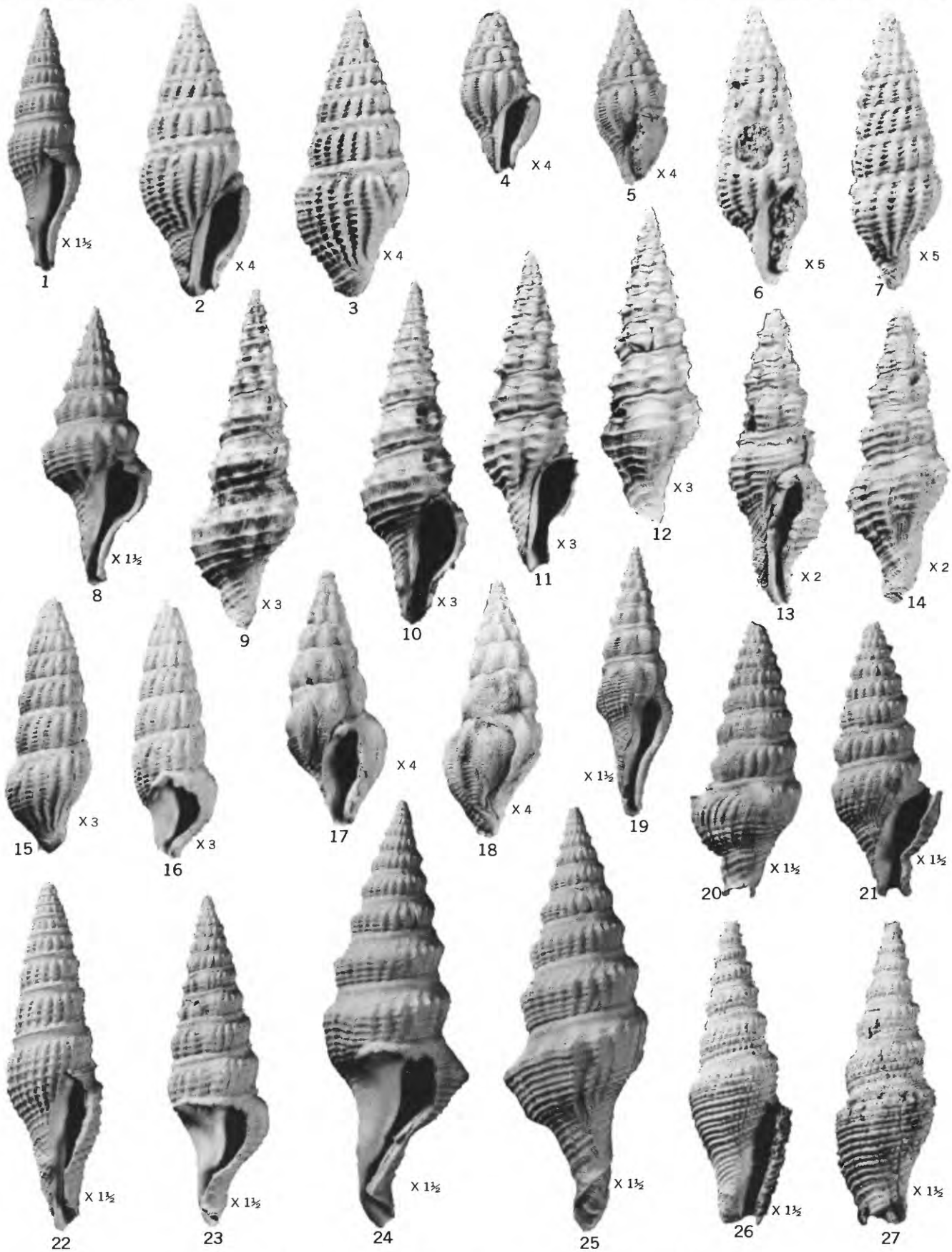
Height (practically complete) 11.8 mm, diameter 4.6 mm. Locality 138c. Lower part of Gatun formation. USNM 645771.

19. *Crassispira* (*Crassispira*) *henekeni leptalea* Woodring, n. subsp. (p. 377).

Type. Height (practically complete) 30.6 mm, diameter 10.5 mm. Locality 147h. Middle part of Gatun formation. USNM 645777.

26, 27. *Scobinella morierei* (Cossmann) (p. 372).

Height (almost complete) 37 mm, diameter (incomplete) 12.5 mm. Locality 138a. Lower part of Gatun formation. USNM 645770.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 59

FIGURE 1, 2. *Agladrillia* (*Agladrillia*) *phengoides* Woodring, n. sp. (p. 386).
Type. Height 6.8 mm, diameter 2.2 mm. Locality 147b. Middle part of Gatun formation. USNM 645799.

3, 4. *Agladrillia* (*Agladrillia*) *characta* Woodring, n. sp. (p. 385).
Type. Height 12.8 mm, diameter 4.3 mm. Locality 147g. Middle part of Gatun formation. USNM 645794.

5, 6. *Clathrodrillia* aff. *C. lelandi* (Olsson) (p. 384).
Height (incomplete) 21.8 mm, diameter 7.5 mm. Locality 136a. Lower part of Gatun formation. USNM 645792.

7–9. *Microdrillia trina* Mansfield (p. 389).
Middle part of Gatun formation.

7. Flat-sided specimen. Height 6.3 mm, diameter 1.9 mm. Locality 147g. USNM 645809.

8. Subequal peripheral and lower spiral threads. Height 5.6 mm, diameter 2 mm. Locality 147b. USNM 645807.

9. Peripheral spiral thread stronger than lower threads. Locality 147b. USNM 645808.

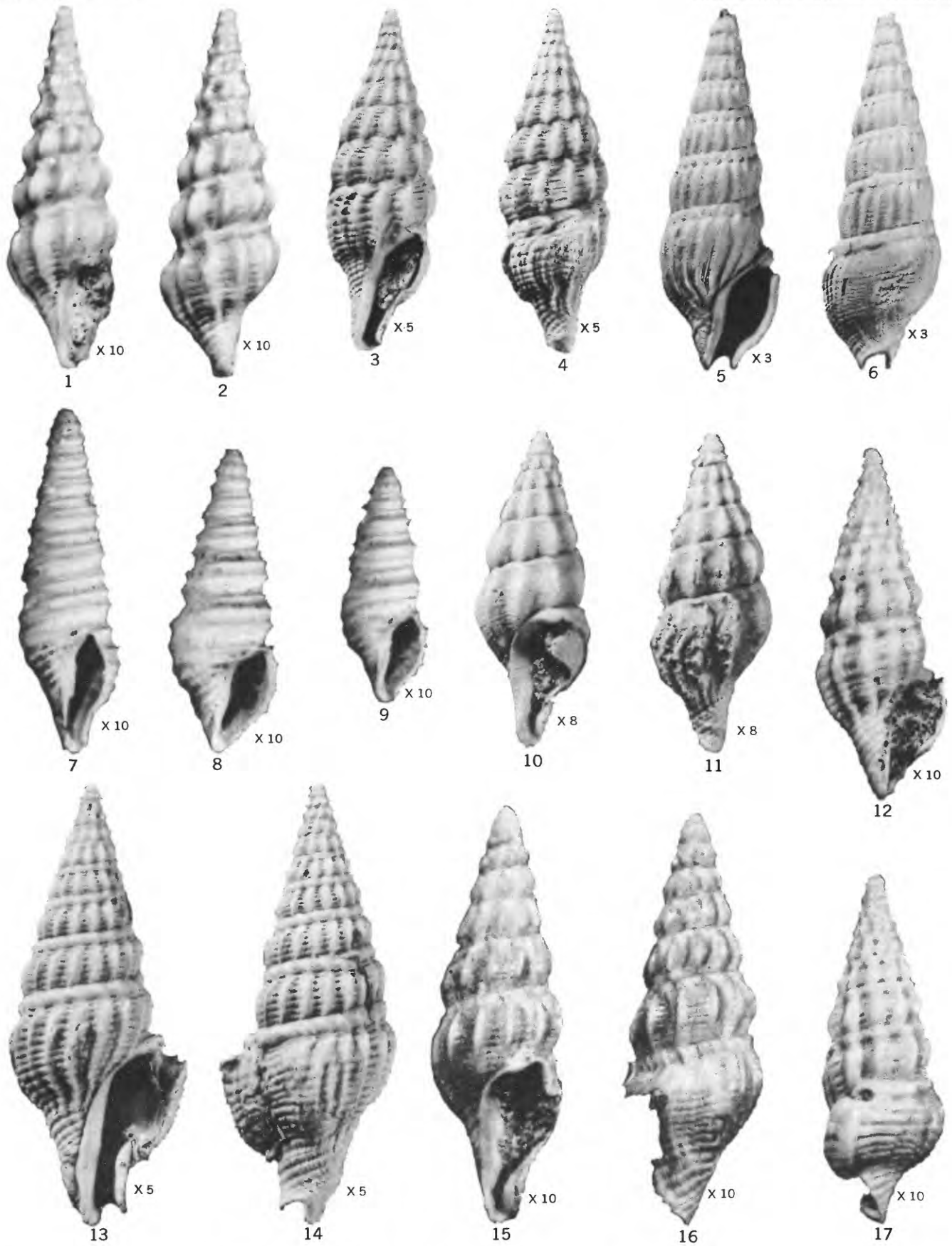
10, 11, 15, 16. *Agladrillia* (*Agladrillia*) *enneacyma enneacyma* (Brown and Pilsbry) (p. 385). Locality 147b. Middle part of Gatun formation.

10, 11. Inflated specimen. Height 7.2 mm, diameter 2.8 mm. USNM 645797.

15, 16. Slender specimen. Height 7.7 mm, diameter 2.5 mm. USNM 645796.

12, 17. *Agladrillia* (*Agladrillia*) *acaria ectypha* Woodring n. subsp. (p. 387).
Type. Height 6.5 mm, diameter 2.3 mm. Locality 138. Middle part of Gatun formation. USNM 645801.

13, 14. *Clathrodrillia saavedrai* Woodring, n. sp. (p. 383).
Type. Height 16.5 mm, diameter 6.2 mm. Locality 147b. Middle part of Gatun formation. USNM 645790.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 60

FIGURE 1. *Glyphostoma* (*Rhiglyphostoma*) *allodapum* Woodring, n. sp. (p. 402).
Type. Height (incomplete) 7 mm, diameter 3.3 mm. Locality 138d. Lower part of Gatun formation. USNM 645835.

2, 3. *Euclathurella* (*Euclathurella*) *vendryesiana* (Dall) (p. 396).
Type of *Pleurotoma* (*Genota*) *gertrudis* Toula. Gatun Locks excavation. Middle parts of Gatun formation. Technische Hochschule, Vienna.

4. *Lepicythara heptagona* (Gabb) (p. 390).
Height 11.5 mm, diameter 5.7 mm. Locality 157. Middle part of Gatun formation. USNM 645811.

5. *Kurtziella* (*Kurtziella*) *pagella* Woodring, n. sp. (p. 393).
Type. Height 4 mm, diameter 1.8 mm. Locality 147b. Middle part of Gatun formation. USNM 645816.

6. *Kurtziella* (*Kurtziella*) *stenotella* Woodring, n. sp. (p. 393).
Type. Height 4.5 mm, diameter 1.9 mm. Locality 147b. Middle part of Gatun formation. USNM 645818.

7. *Glyphostoma* (*Euglyphostoma*) *olssoni* Woodring, n. sp. (p. 401).
Type. Height 13.6 mm, diameter 5.7 mm. Locality 176. Upper part of Gatun formation. USNM 645834.

8. *Kurtziella* (*Cryoturris*) sp. (p. 394).
Height 2.5 mm, diameter 1.2 mm. Locality 138d. Lower part of Gatun formation. USNM 645821.

9, 20. *Dolostoma anorhepes* Woodring, n. sp (p. 398).
9. Immature specimen. Height 5 mm, diameter 1.9 mm. Locality 147b. Middle part of Gatun formation. USNM 645823.
20. Type. Height (almost complete) 15.5 mm, diameter 6 mm. Locality 138. Lower part of Gatun formation. USNM 645822.

10. *Nannodiella rintriada* (Mansfield) (p. 395).
Height 4.5 mm, diameter 1.9 mm. Locality 147b. Middle part of Gatun formation. USNM 645827.

11, 18, 19. *Agladrillia* (*Eumetadrillia*) *isthmica* (Brown and Pilsbry) (p. 387).
Lower part of Gatun formation.
11. Height 13.9 mm, diameter 5.6 mm. Locality 138d. USNM 645804.
18, 19. Height 19.9 mm, diameter (incomplete) 6.8 mm. Locality 138c. USNM 645803.

12. *Cytharella?* cf. *C. compsacosta* (Gardner) (p. 392).
Height (not quite complete) 4.2 mm, diameter 1.7 mm. Locality 138c. Lower part of Gatun formation. USNM 645815.

13. *Ithycythara defuniak* Gardner (p. 391).
Height 4 mm, diameter 1.5 mm. Locality 147b. Middle part of Gatun formation. USNM 645812.

14. *Ithycythara* cf. *I. elongata* (Gabb) (p. 392).
Height (not quite complete) 6.2 mm, diameter 2.2 mm. Locality 138c. Lower part of Gatun formation. USNM 645814.

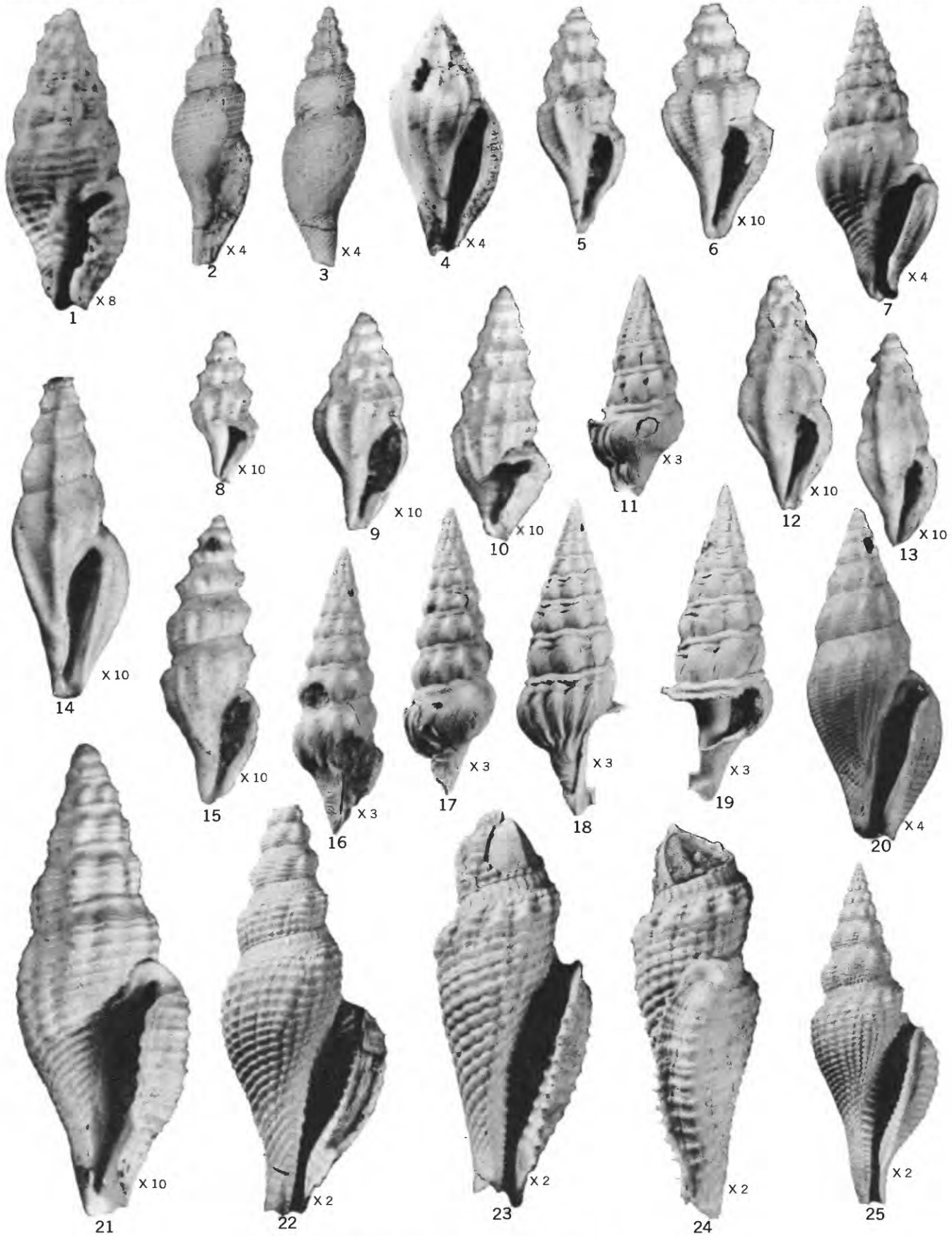
15. *Kurtziella* (*Cryoturris*) *habra* Woodring, n. sp. (p. 394).
Type. Height 5.2 mm, diameter 1.9 mm. Locality 138a. Lower part of Gatun formation. USNM 645820.

16, 17. *Agladrillia* (*Eumetadrillia*) *acidna* Woodring, n. sp. (p. 388).
Type. Height 18 mm, diameter 5.9 mm. Locality 172. Upper part of Gatun formation, eastern area. USNM 645806.

21. *Euclathurella* (*Miraclathurella*) *eucharis* Woodring, n. sp. (p. 397).
Type. Height 9 mm, diameter 3.6 mm. Locality 138c. Lower part of Gatun formation. USNM 645825.

22, 25. *Glyphostoma* (*Glyphostoma*) *dentiferum* Gabb (p. 399).
Middle part of Gatun formation.
22. Height (incomplete) 38.2 mm, diameter 15.2 mm. Locality 155a. USNM 645830.
25. Immature specimen. Height 32.2 mm, diameter 12.2 mm. Locality 157. USNM 645831.

23, 24. *Glyphostoma* (*Glyphostoma*) *pyrgota* Woodring, n. sp. (p. 400).
Type. Height (incomplete) 37.3 mm, diameter 15 mm. Locality 157. Middle part of Gatun formation. USNM 645833



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 61

FIGURE 1, 14. *Terebra* (*Paraterebra*) aff. *T. taurina* (Lightfoot) (p. 406).

1. Height (incomplete) 48 mm, diameter 15.5 mm. Locality 179. Upper part of Gatun formation, western area. USNM 645844.

14. Finely sculptured specimen. Height (incomplete) 43 mm, diameter 16.5 mm. Locality 155. Middle part of Gatun formation. USNM 645843.

2. *Daphnella pagera* Woodring, n. sp. (p. 403).

Type. Height (almost complete) 12.3 mm, diameter 4.7 mm. Locality 173a. Upper part of Gatun formation, eastern area. USNM 135580.

3, 7, 8, 9. *Terebra* (*Oreoterebra*) *subsulcifera subsulcifera* Brown and Pilsbry (p. 404).

Middle part of Gatun formation.

3. Coarsely sculptured specimen. Height (incomplete) 39.8 mm, diameter 14 mm. Locality 139c. USNM 645839.

7. Height (incomplete) 51 mm, diameter 14.5 mm. Locality 155b. USNM 645838.

8, 9. Height (almost complete) 68.5 mm, diameter 12.8 mm. Locality 155. USNM 645837.

4. *Dolostoma dinota* Woodring, n. sp. (p. 398).

Type. Height (practically complete) 12.9 mm, diameter 5.3 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 645829.

5. *Terebra* (*Oreoterebra*) *subsulcifera cembra* Olsson (p. 405).

Height (almost complete) 48 mm, diameter 10.8 mm. Locality 136. Lower part of Gatun formation. USNM 645840.

6. *Strioterebrum* aff. *S. raptum* (Gardner) (p. 414).

Height (almost complete) 10 mm, diameter 3.5 mm. Locality 138c. Lower part of Gatun formation. USNM 646048.

10, 11, 15, 16. *Terebra* (*Panaterebra*) *cucurrupiensis* Oinomikado (p. 407).

10. Height (almost complete) 66.4 mm, diameter 19.5 mm. Locality 138c. Lower part of Gatun formation. USNM 645847.

11. Slender specimen. Height (almost complete) 65.5 mm, diameter 15.5 mm. Locality 139e. Middle part of Gatun formation. USNM 645848.

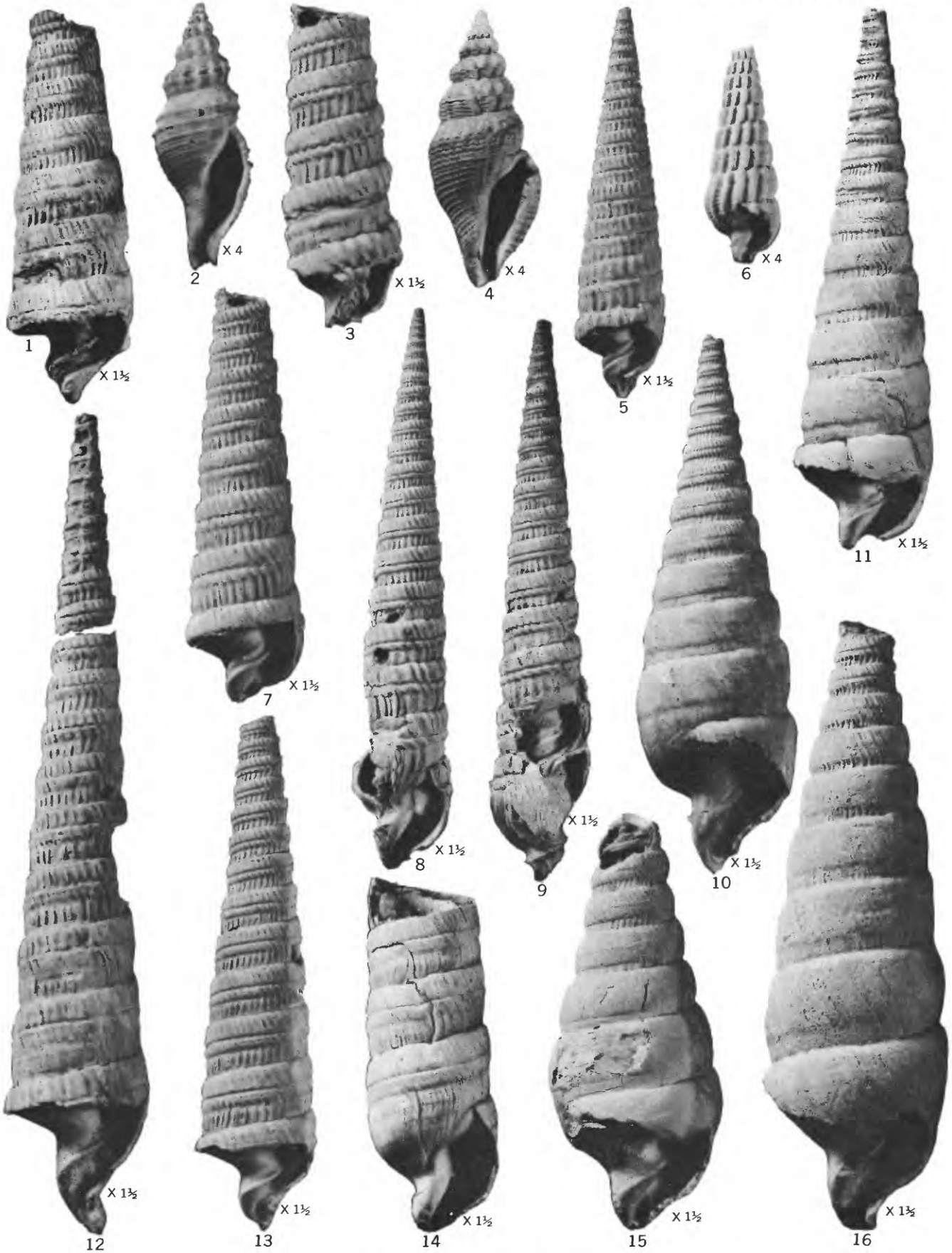
15. Strongly inflated specimen. Height (incomplete) 51.8 mm, diameter 21.5 mm. Locality 138f. Lower part of Gatun formation. USNM 645845.

16. Height (incomplete) 75.5 mm, diameter 22 mm. Locality 138c. Lower part of Gatun formation. USNM 645846.

12, 13. *Terebra* (*Oreoterebra*) *isaacpetiti* Maury (p. 405).

12. Height (almost complete) 99.5 mm, diameter 17.5 mm. Locality 182. Upper part of Gatun formation, western area. USNM 645842.

13. Height (incomplete) 63.5 mm, diameter 14.7 mm. Locality 139c. Middle part of Gatun formation. USNM 645841.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 62

FIGURE 1, 2. *Acteocina elachista* Woodring, n. sp. (p. 418).
Type. Height 2.3 mm, diameter 1.2 mm. Locality 147b. Middle part of Gatun formation. USNM 646052.

3, 4. *Acteocina rusa* Gardner (p. 418).
Height 2.8 mm, diameter 1.3 mm. Locality 139b. Middle part of Gatun formation. USNM 646053.

5. *Sulcoretusa sulcata lipara* (Woodring) (p. 424).
Height 2.7 mm, basal diameter 1.3 mm. Locality 147b. Middle part of Gatun formation. USNM 646061.

6. *Retusa (Cylichnina) quercinensis biforis* Pilsbry and Johnson (p. 423).
Height 2.8 mm, diameter 1.5 mm. Locality 147g. Middle part of Gatun formation. USNM 646060.

7, 9. *Acteocina bullata* (Kiener), small form (p. 417).
Height 4.9 mm, diameter 2.2 mm. Locality 139b. Middle part of Gatun formation. USNM 646051.

8, 16. *Atys (Weinkauffia) cadus* Woodring, n. sp. (p. 423).
Type. Height 2.1 mm, diameter 1.4 mm. Locality 139b. Middle part of Gatun formation. USNM 646058.

10. *Atys (Aliculastrum) eurys* Woodring, n. sp. (p. 422).
Type. Height 7.3 mm, diameter 3.6 mm. Locality 159d. Middle part of Gatun formation. USNM 646057.

11. *Acteon (Acteon) punctostriatus* (C. B. Adams) (p. 415).
Height 3.7 mm, diameter 2 mm. Locality 138c. Lower part of Gatun formation. USNM 646049.

12. *Ringicula (Ringiculella) semistriata* d'Orbigny (p. 416).
Height 3 mm, diameter 2 mm. Locality 159d. Middle part of Gatun formation. USNM 646050.

13. *Cyclichnella atacata stigara* Woodring, n. subsp. (p. 419).
Type. Height 3.2 mm, diameter 1.8 mm. Locality 147b. Middle part of Gatun formation. USNM 646054.

14. *Roxania chipolana* (Dall) (p. 419).
Height 3.5 mm, diameter 2.2 mm. Locality 147b. Middle part of Gatun formation. USNM 646055.

15. *Volvulella (Volvulella) phoinicoides* (Gardner) (p. 426).
Height 3.3 mm, diameter 1.1 mm. Locality 138c. Lower part of Gatun formation. USNM 646065.

17. *Volvulella (Volvulella) cylindrica parallela* (Pilsbry and Johnson) (p. 426).
Height 4.7 mm, diameter 1.6 mm. Locality 159d. Middle part of Gatun formation. USNM 646064.

18. *Bulla umbilicata* Röding, small form (p. 421).
Height 8.5 mm, diameter 5.2 mm. Locality 161c. Middle part of Gatun formation. USNM 646056.

19, 20. *Volvulella (Volvulella) oxytata* (Bush) (p. 425).
Locality 138c. Lower part of Gatun formation.
19. Moderately slender specimen; apical part of outer lip abnormal. Height 3.6 mm, diameter 1.4 mm. USNM 646063.
20. Slender specimen. Height 3.4 mm, diameter 1.2 mm. USNM 646062.

21, 27. *Crassispira (Hindsiclava) pyrgoma* Woodring, n. sp. (p. 380).
Locality 208. Chagres sandstone.
21. Paratype. Height (incomplete) 26.3 mm, diameter 9.6 mm. USNM 645866.
27. Type. Height (incomplete) 35.5 mm, diameter 10.5 mm. USNM 645867.

22, 35. *Strioterebrum oresignum hadrum* Woodring, n. subsp. (p. 413).
Locality 136. Lower part of Gatun formation.
22. Paratype. Height (incomplete) 24.2 mm, diameter 8.2 mm. USNM 646046.
35. Type. Height (incomplete) 46.4 mm, diameter 12.8 mm. USNM 646045.

23, 24. *Strioterebrum gausapatum* (Brown and Pilsbry) (p. 411).
Middle part of Gatun formation.
23. Height (incomplete) 33.6 mm, diameter 7.5 mm. Locality 155b. USNM 646040.
24. Topotype. Height (almost complete) 27.3 mm, diameter 6.7 mm. Locality 159d. USNM 646041.

25, 31, 32, 36. *Strioterebrum spiriferum* (Dall) (p. 409).
25. Lectotype, an immature shell. Height (almost complete) 30.1 mm, diameter 7.8 mm. Mount Hope, Canal Zone. Upper part of Gatun formation, eastern area. USNM 113654.
31. Height (almost complete) 61.7 mm, diameter 13 mm. Locality 138d. Lower part of Gatun formation. USNM 645850.
32. Topotype of *Terebra gatunensis* Toula. Height (incomplete) 58.5 mm, diameter 14.5 mm. Locality 159. Middle part of Gatun formation, eastern area. USNM 645849.
36. Height (incomplete) 44.5 mm, diameter 12 mm. Locality 138e. Lower part of Gatun formation. USNM 645851.

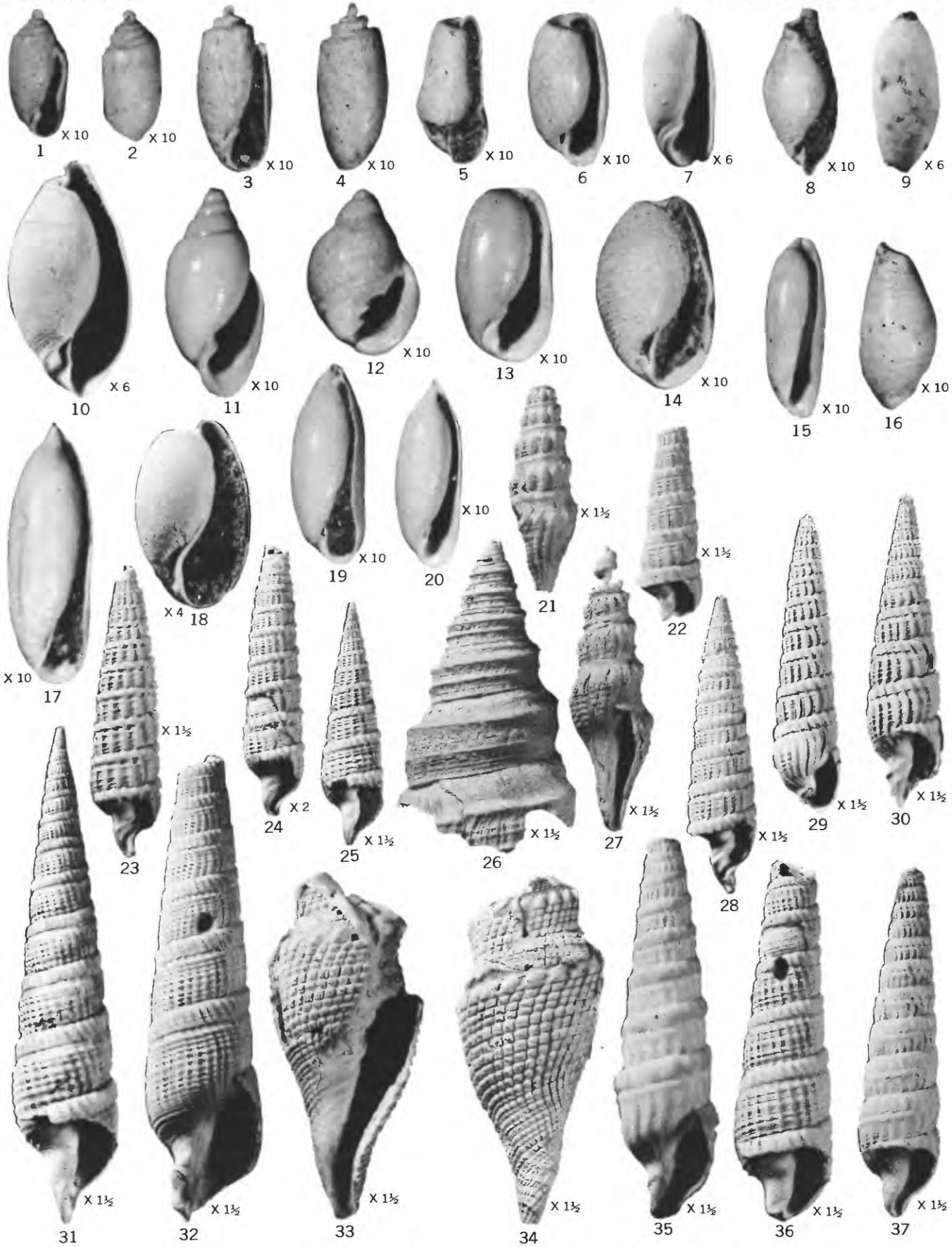
26. *Pleuroliria (Polystira) ecuadoriana* (Olsson) (p. 365).
Height (incomplete) 39.5 mm, diameter (incomplete) 22.5 mm. Locality 208. Chagres sandstone. USNM 645867.

28. *Strioterebrum indocayapum* Olsson (p. 412).
Height (almost complete) 36.8 mm, diameter 8.7 mm. Locality 138c. Lower part of Gatun formation. USNM 646042.

29, 30. *Strioterebrum wolfgangi* (Toula) (p. 411).
Upper part of Gatun formation, eastern area.
29. Slender specimen. Height (incomplete) 37 mm, diameter 8.2 mm. Locality 175. USNM 646039.
30. Moderately slender specimen. Height (almost complete) 38.8 mm., diameter 9.5 mm. Locality 177b. USNM 646038.

33, 34. *Scobinella ecuadoriana* Olsson (p. 373).
Height (incomplete) 43.4 mm, diameter 18.5 mm. Locality 208. Chagres sandstone. USNM 645863.

37. *Strioterebrum oresignum oresignum* Olsson (p. 413).
Height (incomplete) 43.5 mm, diameter 10.2 mm. Locality 139c. Middle part of Gatun formation. USNM 646044.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND
LATE MIOCENE MOLLUSKS FROM CHAGRES SANDSTONE

PLATE 63

FIGURE 1, 2. *Clathrodrillia?* sp. (p. 384).
Height (incomplete) 25.9 mm, diameter 9.7 mm. Locality 208. Chagres sandstone. USNM 645868.

3, 4. *Strioterebrum monidum* (Woodring) (p. 414).
Height (almost complete) 23.5 mm, diameter 5.8 mm. Locality 138c. Lower part of Gatun formation. USNM 646047.

5. *Carinodrillia* (*Carinodrillia*) sp. (p. 376).
Height (almost complete) 27.6 mm, diameter 10.3 mm. Locality 208. Chagres sandstone. USNM 645864.

6, 7. *Darbya?* (*Buridrillia?*) sp. (p. 377).
Height (incomplete) 15 mm, diameter 6 mm. Locality 208. Chagres sandstone. USNM 645865.

8, 13. *Hemisinus amaras* Woodring, n. sp. (p. 430).
Type. Height (incomplete) 20.5 mm, diameter 12.5 mm. Locality 161d. Middle part of Gatun formation. USNM 646071.

9, 10. *Typhis* (*Talityphis*) *eucteanus* Woodring, n. sp. (p. 434).
Type. Height (practically complete) 19 mm, diameter 9.7 mm. Locality 138f. Lower part of Gatun formation. USNM 646083.

11, 12. *Cavolina* (*Cavolina*) cf. *C. ventricosa* (Guppy) (p. 429).
Height 3.9 mm, width 4.3 mm, diameter 3.3 mm. Locality 177. Upper part of Gatun formation, eastern area. USNM 113855.
11. Ventral side.
12. Dorsal side.

14, 15. *Trigonostoma* n. sp. (p. 345).
Height (almost complete) 20.2 mm, diameter 14.7 mm. Locality 208. Chagres sandstone. USNM 645861.

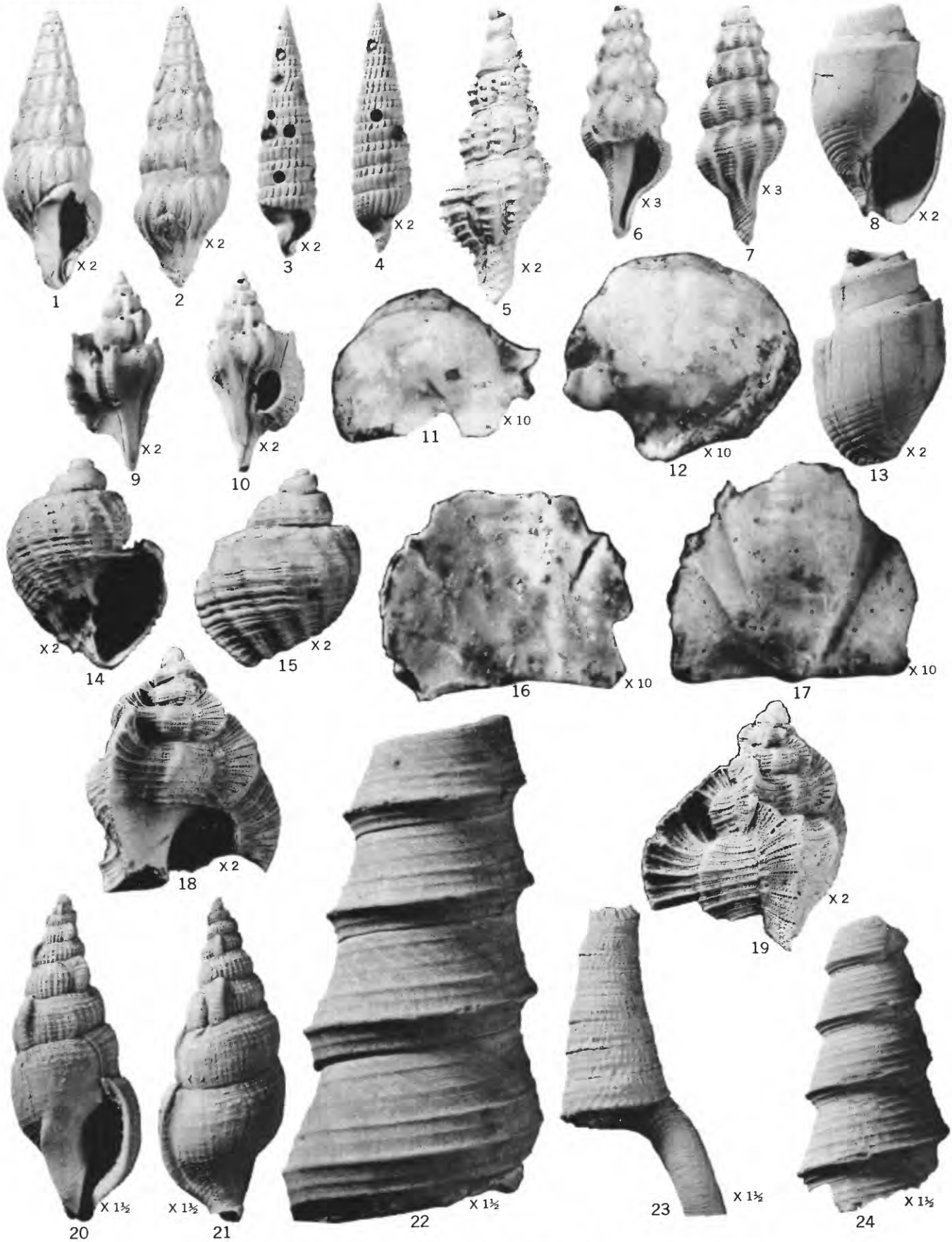
16, 17. *Cavolina* (*Cavolina*) *triaspis* Woodring, n. sp. (p. 428).
Type. Height (not quite complete) 4.2 mm, width 4.5 mm. Locality 177d. Upper part of Gatun formation, eastern area. USNM 646067.
16. Dorsal side.
17. Ventral side.

18, 19. *Pterynotus* (*Subpterynotus*) *textilis* (Gabb) (p. 433).
Height (incomplete) 24.5 mm, diameter 19.5 mm. Locality 138c. Lower part of Gatun formation. USNM 646082.

20, 21. *Colubraria obscura* (Reeve) (p. 432).
Height (almost complete) 40.5 mm, diameter 15.5 mm. Locality 160c. Middle part of Gatun formation. USNM 646081.

22, 24. *Turritella abrupta* Spieker (p. 430).
Locality 138e. Lower part of Gatun formation.
22. Height (incomplete) 68 mm, diameter 31 mm. USNM 646068.
24. Height (incomplete) 37 mm, diameter 19 mm. USNM 646069.

23. *Petaloconchus sculpturatus* H. C. Lea (p. 430).
Height of cylinder 28 mm, diameter 14 mm. Locality 139c. Middle part of Gatun formation. USNM 646070.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND
LATE MIOCENE MOLLUSKS FROM CHAGRES SANDSTONE

PLATE 64

[All figures × 56]

FIGURE 1. *Agladrillia* (*Agladrillia*) *characta* Woodring, n. sp. (p. 385).
Locality 147b. Middle part of Gatun formation. USNM 645795.

2. *Drillia* (*Neodrillia*) *riogurabonis eurysoma* Gardner (p. 374).
Locality 139b. Middle part of Gatun formation. USNM 645772.

3. *Agladrillia* (*Agladrillia*) *phengoides* Woodring, n. sp. (p. 386).
Locality 147b. Middle part of Gatun formation. USNM 645800.

4. *Agladrillia* (*Agladrillia*) *enneacyma enneacyma* (Brown and Pilsbry (p. 385).
Locality 147b. Middle part of Gatun formation. USNM 645798.

5. *Microdrillia trina* Mansfield (p. 389).
Locality 147b. Middle part of Gatun formation. USNM 645810.

6. *Kurtziella* (*Kurtziella*) *pagella* Woodring, n. sp. (p. 393).
Locality 147b. Middle part of Gatun formation. USNM 645817.

7. *Nannodiella rintriada* (Mansfield) (p. 395).
Locality 147b. Middle part of Gatun formation. USNM 645828.

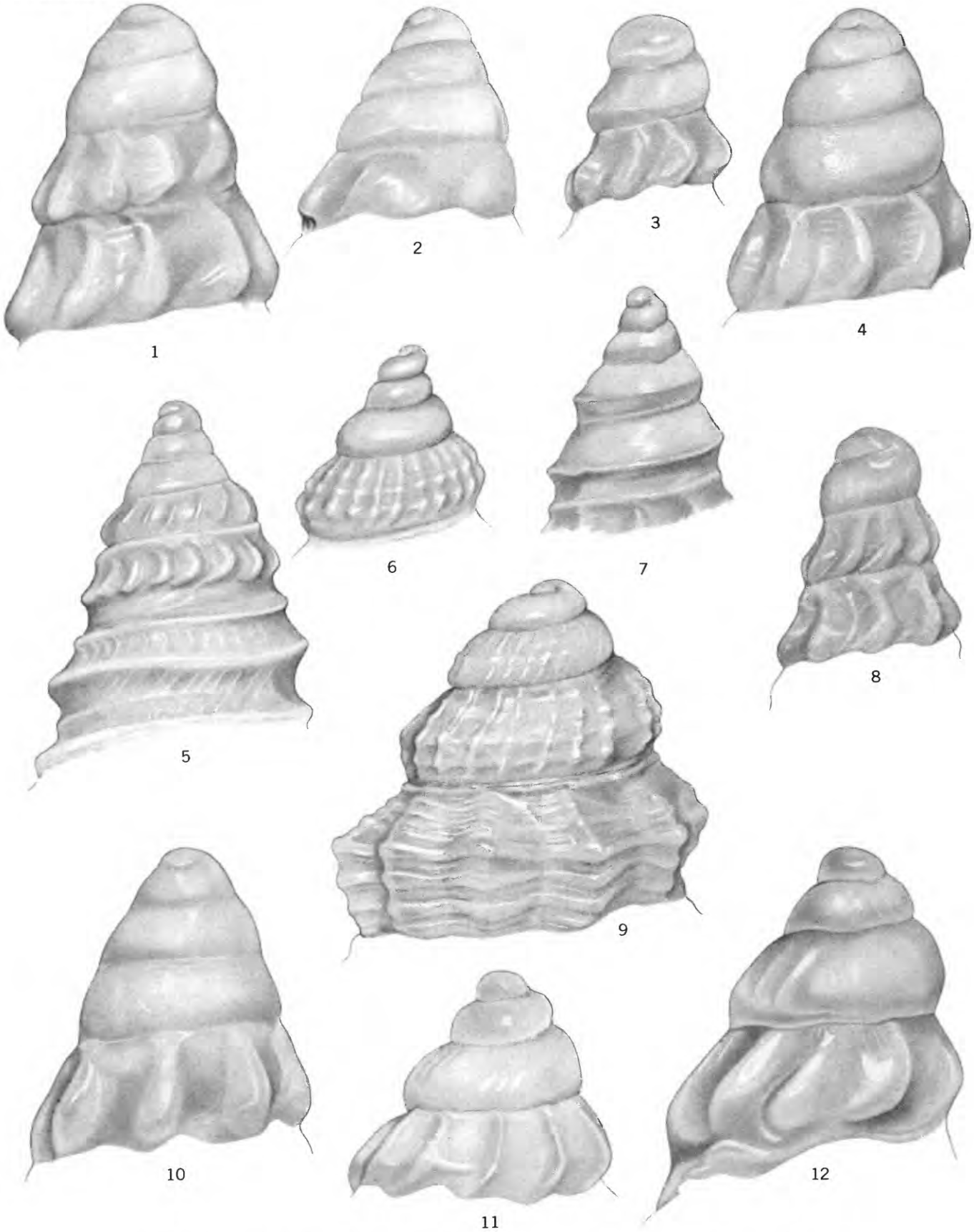
8. *Agladrillia* (*Agladrillia*) *acaria ectypha* Woodring, n. subsp. (p. 387).
Locality 138. Lower part of Gatun formation. USNM 645802.

9. *Kurtziella* (*Kurtziella*) *stenotella* Woodring, n. sp. (p. 393).
Locality 147b. Middle part of Gatun formation. USNM 645819.

10. *Agladrillia* (*Eumetadrillia*) *isthmica* (Brown and Pilsbry) (p. 387).
Locality 138. Lower part of Gatun formation. USNM 645805.

11. *Lepicythara heptagona* (Gabb) (p. 390).
Locality 157. Middle part of Gatun formation. USNM 645811.

12. *Ithycythara defuniak* Gardner (p. 391).
Locality 138c. Lower part of Gatun formation. USNM 645813.



PROTOCONCHS OF MIDDLE MIOCENE TURRIDS FROM GATUN FORMATION

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PLATE 65

[All figures × 56]

FIGURE 1. *Gemmula vaningeni* (Brown and Pilsbry) (p. 361).
Locality 147b. Middle part of Gatun formation. USNM 645759.

2. *Pleuroliria* (*Polystira*) *tenagos* (Gardner) (p. 364).
Locality 147b. Middle part of Gatun formation. USNM 645763.

3. *Pleurofusia acra* Woodring, n. sp. (p. 367).
Type. Locality 155c. Middle part of Gatun formation. USNM 645764.

4. *Pleurofusia* (*Cruziturricula*) *fusinus fusinus* (Brown and Pilsbry) (p. 369).
Locality 146. Middle part of Gatun formation. USNM 645767.

5. *Crassispira* (*Crassispira*) *henekeni leptalea* Woodring, n. subsp. (p. 377).
Type. Locality 147h. Middle part of Gatun formation. USNM 645777.

6. *Crassispira* (*Hindsiclava*) *consors consors* (Sowerby) (p. 378).
Locality 138c. Lower part of Gatun formation. USNM 645780.

7. *Clathrodrillia gatunensis* (Toula) (p. 381).
Locality 138c. Lower part of Gatun formation. USNM 645789.

8. *Clathrodrillia saavedrai* Woodring, n. sp. (p. 383).
Type. Locality 147b. Middle part of Gatun formation. USNM 645790.

9. *Carinodrillia* (*Carinodrillia*) *zooki* (Brown and Pilsbry) (p. 375).
Locality 147g. Middle part of Gatun formation. USNM 645775.

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PROTOCONCHS OF MIDDLE MIOCENE TURRIDS FROM GATUN FORMATION

PLATE 66

[All figures × 56]

FIGURE 1. *Strioterebrum wolfgangi* (Toula) (p. 411).
Locality 174. Upper part of Gatun formation, eastern area. USNM 135599.

2. *Dolostoma anorhepes* Woodring, n. sp. (p. 398).
Locality 147b. Middle part of Gatun formation. USNM 645824.

3. *Glyphostoma* (*Glyphostoma*) *dentiferum* Gabb (p. 399).
Locality 138c. Lower part of Gatun formation. USNM 645852.

4. *Strioterebrum spiriferum* (Dall) (p. 409).
Locality 138c. Lower part of Gatun formation. USNM 645852.

5, 7, 9. *Spiratella inflata elevata* (Collins) (p. 427).
Locality 136a. Lower part of Gatun formation. USNM 646066.

6. *Glyphostoma* (*Rhiglyphostoma*) *allodapum* Woodring, n. sp. (p. 402).
Paratype. Locality 138d. Lower part of Gatun formation. USNM 645836.

8. *Euclathurella* (*Miraclathurella*) *eucharis* Woodring, n. sp. (p. 397).
Locality 147b. Middle part of Gatun formation. USNM 645826.

10. *Strioterebrum indocayapum* Olsson (p. 412).
Locality 147b. Middle part of Gatun formation. USNM 646043.

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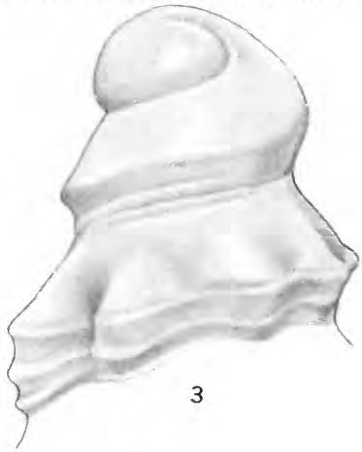

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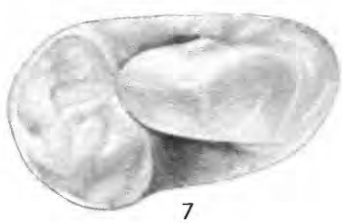

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PROTOCONCHS OF MIDDLE MIOCENE TURRIDS AND TEREBRIDS, AND PTEROPOD FROM GATUN FORMATION

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