

Geology and Paleontology of Canal Zone and Adjoining Parts of Panama

DESCRIPTION OF TERTIARY MOLLUSKS
(GASTROPODS: COLUMBELLIDAE TO VOLUTIDAE)

GEOLOGICAL SURVEY PROFESSIONAL PAPER 306-C



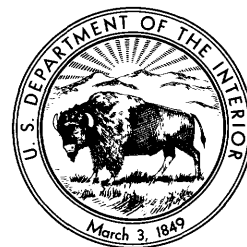
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By W. P. WOODRING

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*A contribution to the history of
the Panamá land bridge*



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CONTENTS

	Page		Page
Abstract.....	241	Description of Tertiary mollusks—continued from chap-	
Introduction.....	241	ter B.....	246
Additions to localities at which fossils were collected.....	242	Gastropods—continued from chapter B.....	246
Faunal summaries of species.....	242	Family Columbelloidae.....	246
Eocene series.....	242	Family Buccinidae.....	256
Gatuncillo formation.....	242	Family Nassariidae.....	269
Eocene or Oligocene series.....	243	Family Melongenidae.....	273
Marine member of Bohio(?) formation.....	243	Family Fasciolaridae.....	274
Oligocene series.....	243	Family Fusinidae.....	275
Bohio formation.....	243	Family Olividae.....	276
Caimito formation, Gatun Lake area.....	243	Family Mitridae.....	282
Lower part of Caimito formation, Madden basin.....	243	Family Xancidae.....	285
Miocene series.....	243	Family Volutidae.....	287
Culebra formation.....	243	References cited.....	290
La Boca formation.....	244	Index.....	293
Gatun formation.....	245		
Pliocene series.....	246		
Chagres sandstone.....	246		

ILLUSTRATIONS

[Plates follow index]

- PLATE 39. Middle Eocene mollusks from Gatuncillo formation, late Eocene or early Oligocene mollusks from marine member of Bohio(?) formation, late Oligocene mollusks from Bohio formation, early Miocene mollusk from Culebra formation, and middle Miocene mollusks from Gatun formation.
- 40-43, 45. Middle and late Miocene mollusks from Gatun formation.
- 44, 46. Middle Miocene mollusks from Gatun formation.
47. Middle Miocene mollusks from Gatun formation and early Pliocene mollusks from Chagres sandstone.

TABLE

TABLE 1. Mollusks from Gatun formation (Columbellidae to Volutidae).....	In pocket
	III

GEOLOGY AND PALEONTOLOGY OF CANAL ZONE AND ADJOINING PARTS OF PANAMA

DESCRIPTION OF TERTIARY MOLLUSKS (GASTROPODS: COLUMBELLIDAE TO VOLUTIDAE)

By W. P. WOODRING

ABSTRACT

The description of the mollusks in the Tertiary formations of the Canal Zone and adjoining parts of Panamá—ranging in age from middle and late Eocene to early Pliocene—is continued from chapter B. Ninety-four species and subspecies in 10 families of gastropods are covered in the present chapter. Eighty-four are formally described and the remaining 10 are briefly described or only mentioned.

The fossils from the Gatuncillo formation—all from strata considered of middle Eocene age—include an early species of the genus *Xancus*, *X. cf. X. peruvianus*, and *Otenilyria ctenista*, the type of a new volutid genus known also in deposits of middle and late Eocene age in northwestern Europe.

The late Eocene or early Oligocene marine member of the Bohio(?) formation yielded *Glyptostyla panamensis*, the type of a volutid genus that occurs in late Eocene deposits in Perú and Colombia, and in late Eocene or early Oligocene in Perú and the Canal Zone. All the specimens of *G. panamensis* were collected at Vamos Vamos, which is now under the waters of Gatun Lake.

Mitrella epacta, a columbellid related to early Miocene forms of southeastern United States, was found in marine strata of late Oligocene age in the upper part of the Bohio formation of Barro Colorado Island. The earliest species of *Antillophos* and the earliest species of *Oliva* and *Olivella* now known in the Caribbean region occur in the Caimito formation of the Gatun Lake area, also of late Oligocene age. These fossils are so poorly preserved that they are named only generically.

Recent core drilling in the northwestern part of the Gaillard Cut area shows that the strata of that region formerly assigned to the Culebra formation are to be transferred to the La Boca formation. These strata include the Emperador limestone member. The La Boca and also the Pedro Miguel agglomerate are given formation rank instead of member rank in the Panamá formation. In Chapter A, both the Culebra and the La Boca were assigned to the early half of the lower Miocene.

Strombina cf. *S. quirosana*, which occurs in the Culebra formation, is of interest as the earliest species of *Strombina* now known in the Caribbean region. Two Culebra buccinids, *Cymatophos*? cf. *C. reatchi* and *Antillophos*? cf. *A. candeigatunensis*, suggest close alliance with larger Gatun forms. *Northia*? cf. *N. northiae*, from the Culebra, may be the earliest representative of a genus that now is monotypic and endemic in eastern Pacific waters. The type material of *Nassarius praeambiguus* was found in the La Boca formation. The La Boca specimens, like many of the other La Boca mollusks, are poorly preserved.

Three-fourths of the 84 species and subspecies described in

the present chapter occur in the middle to late Miocene Gatun formation. The Gatun fossils are notable for the diversity of columbellid and buccinid genera. The columbellids include an *Antillophos*-like genus (*Strombinophos*) and a *Strioterebrum*-like genus (*Strombinella*). The buccinids include four *Phos*-like groups: *Cymatophos*, *Calophos*, *Antillophos*, and its subgenus *Rhipophos*. With the exception of *Cymatophos* and *Antillophos* proper, the genera and subgenus mentioned are not known to be living. The buccinid *Nicema* and the nassarid *Nanarius* (subgenus of *Nassarius*) and *Leptarius* are also not known to be living. *Sincola* (subgenus of *Strombina*), *Cymatophos*, and *Strephonella* (subgenus of *Oliva*), like many other genera and subgenera in the Gatun formation, survive in eastern Pacific waters but not in the Caribbean Sea. On the contrary, *Xancus* survives in the Caribbean Sea, but has become extinct in the eastern Pacific Ocean since Miocene time.

Two *Phos*-like genera are found in the Chagres sandstone, of early Pliocene age: *Cymatophos*? *aculus* and *Amarophos bothrus*. If *Cymatophos*? *aculus* is a species of *Cymatophos*, it is the last known species of the genus in the present Caribbean region. The genus *Amarophos* occurs also in strata of early Miocene age in Columbia and Costa Rica and late Miocene in Costa Rica. It is not known to be living.

INTRODUCTION

This is the third chapter dealing with the mollusks found in the Tertiary formations of the Canal Zone and adjoining parts of Panamá. Ninety-four species and subspecies in 10 families of gastropods are covered in the present chapter. Eighty-four of these forms are formally described and the remaining 10 are briefly described or merely mentioned. The 296 forms covered in the three chapters so far issued are estimated to be a little less than half of the total number in the collections at hand.

The following new genera and subgenera are proposed:

Amarophos, Buccinidae.

Type: *Amarophos bothrus* Woodring, n.sp., Chagres sandstone, Pliocene, p. 267. Gender masculine.

Calophos, Buccinidae.

Type: *Calophos ectyphus* Woodring, n.sp., Gatun formation, Miocene, p. 262. Gender masculine.

Otenilyria, Volutidae, Lyrinae.

Type: *Otenilyria ctenista* Woodring, n.sp., Gatuncillo formation, Eocene, p. 288. Gender feminine.

Leptarius, Nassariidae.

Type: *Leptarius leptus* Woodring, n.sp., Gatun formation, Miocene, p. 272. Gender masculine.

Nanarius, subgenus of *Nassarius*, Nassariidae.

Type: *Uzita paraprasta* Gardner, Miocene, Florida and Canal Zone, p. 271. Gender masculine.

Nicema, Buccinidae.

Type: *Nicema amara* Woodring, n. sp., Gatun formation, Miocene, p. 268. Gender neuter.

Pallacera, Nassariidae.

Type: *Nassa myristicata* Hinds, Recent, eastern Pacific Ocean, Nicaragua to Panamá, p. 269. Gender feminine.

Rhipophos, subgenus of *Antillophos*, Buccinidae.

Type: *Phos metuloides* Dall, Gatun formation, Miocene, p. 266. Gender masculine.

ADDITIONS TO LOCALITIES AT WHICH FOSSILS WERE COLLECTED

New localities at which fossils were collected are as follows:

Additions to localities at which fossils were collected

No. used in this report	USGS Cenozoic No.	Description of locality
		Culebra formation
116a	20956	East bank of Panama Canal at Canal station 1870 near Paraiso, Canal Zone; 700 feet (213 meters) southeast of locality 116. Small-pebble conglomerate and conglomeratic sandstone. R. H. Stewart and Anselmo Mena, 1957.
		Lower part of Gatun formation
138c	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. R. H. Stewart and Anselmo Mena, 1957-59.
138d	22016	Same locality as 138c. W. P. Woodring, 1960.
138e	22391	Spoil from refinery-site dredging operations on east side of Payardi Island, Panamá; latitude 9°23' N., plus 2,000 to 2,600 feet (600 to 800 meters), longitude 79°49' W. to 79°49' plus 500 feet (150 meters). Dredge operating to depth of 27 feet (8 meters) below sea level. Lower part of Gatun formation underlying 15 to 20 feet (4 to 6 meters) of Pleistocene coralliferous deposits. R. H. Stewart, 1960.

Additions to localities at which fossils were collected—Continued

No. used in this report	USGS Cenozoic No.	Description of locality
		Middle part of Gatun formation, eastern area
139a	21844	East side of road leading from Transisthmian Highway to refinery site on Payardi Island, Panamá; 730 meters northeast of locality 138. David R. Stewart, 1959.
139b	22017	East side of road leading from Transisthmian Highway to refinery site on Payardi Island, Panamá; about 100 meters southwest of refinery gate. R. H. Stewart and Anselmo Mena, 1959.
139c	22018	Same locality as 139b. W. P. Woodring, 1960.
139d	22390	Same locality as 139b. R. H. Stewart, 1960.
139e	22019	Refinery site on Payardi Island, Panamá; top of hill at edge of hills northeast of refinery gate. R. H. Stewart and Anselmo Mena, 1959.
139f	22020	Same locality as 139c. W. P. Woodring, 1960.
139g	22417	Road leading from Transisthmian Highway to Cemento Atlántico site at Samba Bonita, Panamá; latitude 9°22' N., longitude 79°50' W., plus 3,600 feet (1,095 meters), about 1.1 kilometers west-northwest of Cativa. R. H. Stewart, 1960.

FAUNAL SUMMARIES OF SPECIES

As in chapter B, the faunal tables list relative frequency, 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

EOCENE SERIES

GATUNCILLO FORMATION

The families covered in the present chapter include four species of silicified fossils collected in the Río Casaya area. Two of the four are named. *Xancus* cf. *X. peruvianus* is an early species of a genus that occurs in the Eocene of Colombia and Perú, but did not reach southeastern United States until Oligocene time. *Otenilyria ctenista* is the type of a new volutid genus found also in deposits of middle and late Eocene age in northwestern Europe.

Mollusks from Gatuncillo formation at locality 38 in Río Casaya area (Columbellidae to Volutidae)

[R, rare]

Columbellid?, genus?	R
Olivid, genus?	R
<i>Xancus</i> cf. <i>X. peruvianus</i> Olsson	R
<i>Otenilyria ctenista</i> Woodring, n. sp.	R

EOCENE OR OLIGOCENE SERIES

MARINE MEMBER OF BOHIO(?) FORMATION

Glyptostyla panamensis is the only named species from the marine member of the Bohio(?) formation. It is the type of the volutid genus *Glyptostyla* (Olson's *Peruficus*), an early Tertiary genus so far known in late Eocene deposits in Colombia and Perú and in late Eocene or early Oligocene in Perú and the Canal Zone. All the specimens of *Glyptostyla panamensis* were collected at the now submerged Vamos Vamos locality. An unnamed species of *Mitrella* is related to larger middle Eocene to middle Miocene species of southeastern United States.

Mollusks from marine member of Bohio(?) formation (Columbellidae to Volutidae)

[R, rare; C, common]

	Localities						
	Vamos Vamos				Palenquilla Point		Trinidad Island
	40	40a	40c	40d	41a	41b	42
<i>Mitrella</i> sp.		R			R	C	C
<i>Tritiaria?</i> sp.		R				R	
Buccinid?, genus?							
Buccinid? or nassariid?, genus?				R			
Olivid, genus?				R	R		R
<i>Glyptostyla panamensis</i> Dall.	R	R	R	C			

OLIGOCENE SERIES

BOHIO FORMATION

Marine strata of late Oligocene age in the upper part of the Bohio formation on Barro Colorado Island yielded four species, only one of which, *Mitrella epacta*, is named. *Mitrella epacta* is related to early Miocene forms found in southeastern United States.

Mollusks from upper part of Bohio formation on Barro Colorado Island (Columbellidae to Mitridae)

[R, rare; F, few]

	Localities	
	42d	42g
<i>Mitrella epacta</i> Woodring, n. sp.	R	
<i>Antillophos?</i> sp.	R	
Olivid, genus?	F	R
<i>Mitra</i> (<i>Tiara</i>) sp.	R	

CAIMITO FORMATION, GATUN LAKE AREA

The Caimito formation of the Gatun Lake area, which is of late Oligocene age, yielded seven species. All are so poorly preserved or so incomplete that none is named. One of the species, listed as *Antillophos* sp.,

is of special interest, however, as it extends the range of the genus back to late Oligocene time. The earliest species heretofore known are of early Miocene age. The unidentified species of *Oliva* and *Olivella* are also the earliest in the Caribbean region.

Mollusks from Caimito formation of Gatun Lake area (Buccinidae to Olividae)

[R, rare; F, few]

	Localities						
	Barro Colorado Island			Pato Horqueto Island		Panama Railroad	
	54g	54h	54j	55a	55b	56	57a
<i>Antillophos</i> (<i>Antillophos</i>) sp.						F	
<i>Antillophos?</i> (<i>Antillophos?</i>) sp.	R	R	F				
<i>Latirus?</i> sp.					R		
<i>Oliva</i> (<i>Oliva</i>) sp.					R	R	
<i>Ancilla?</i> sp.			R				
<i>Olivella</i> sp.				F			
Olivid, genus?							R

LOWER PART OF CAIMITO FORMATION, MADDEN BASIN

Two unnamed species—*Fusinus?* sp. and *Xancus* sp.—were found at locality 71 in a limestone in the lower part of the Caimito formation of Madden basin, the late Oligocene part of the formation in that area.

MIOCENE SERIES

CULEBRA FORMATION

Core hole GH10, drilled in 1959 at Contractors Hill, on the west side of the canal at the continental divide, penetrated a thickness of 104 meters of the Culebra formation without reaching the base of the formation.

Collections from the Culebra formation include 13 species in the families covered in the present chapter. Five are given provisional names and the rest are identified only generically. *Strombina* cf. *S. quirosana* is of interest as the earliest species of *Strombina* now known in the Caribbean region. *Cymatophos?* cf. *C. veatchi* suggests the larger species *C. veatchi* of the Gatun formation. *Antillophos?* cf. *A. candei gatunensis* likewise suggests a larger Gatun form. If the fossil described as *Northia?* cf. *N. northiae* is indeed a species of *Northia*, it is the earliest species of the genus. At the present time *Northia* is monotypic and endemic in eastern Pacific waters.

The largest collection of Culebra mollusks now available—a total of some 90 species—was forwarded by R. H. Stewart in 1957. These fossils were collected from small-pebble conglomerate and conglomeratic sandstone in a small slide on the east bank of the canal at canal station 1870 immediately northwest of Paraiso. The locality is entered in the list on page 242 as locality 116a.

Mollusks from Culebra formation (Columbellidae to Xancidae)

[R, rare; F, few]

	Localities													
	102	104a	104b	106	108c	110	110a	111a	112	112a	114	115	115a	116a
<i>Strombina</i> cf. <i>S. quirosana</i> H. K. Hodson											R			
<i>Metula</i> sp.						R F				R	R	R	R	
<i>Cymatophos</i> ? cf. <i>C. veatchi</i> (Olsson)									R		R		R	
<i>Antillophos</i> ? (<i>Antillophos</i> ?) sp., small											R			
<i>Antillophos</i> ? (<i>Antillophos</i> ?) cf. <i>A. candei gatunensis</i> (Toula)	R			R				F	R		R			
<i>Northia</i> ? cf. <i>N. northiae</i> (Gray)													R	
<i>Melongena</i> sp.					R	R	R							
<i>Pasciolaria</i> sp.														R
<i>Fusinus</i> ? sp.								R						
<i>Olivella</i> sp.											F	R		F
<i>Agaronia</i> sp.														F
<i>Mitra</i> (<i>Tiara</i>) sp.									?R				?R	R
<i>Xancus</i> cf. <i>X. rex</i> Pilsbry and Johnson		R	R											R

LA BOCA FORMATION

The present widening of Gaillard Cut involves an extensive program of core drilling. After the drilling along the Empire Reach (the reach immediately northwest of locality 102 of plate 2) got under way, R. H. Stewart, geologist of the Panama Canal, soon realized that the geology of the northwestern part of the Gaillard Cut area had been misinterpreted. Through the kindness of Lt. Col. R. D. Brown, Jr., Engineering and Construction Director of the Panama Canal Company, and Mr. Stewart, I had an opportunity, during the winter of 1959-60, to examine and sample the cores from the Empire Reach and other core holes.

As concluded by Mr. Stewart, in the Gaillard Cut area northwest of locality 102, the strata formerly referred to the Culebra formation are part of the unit heretofore designated the La Boca marine member of the Panamá formation. The Emperador limestone, formerly treated as a member of the Culebra formation, is in the La Boca. That is, coralliferous limestone does not occur in both Culebra and La Boca, (see Chapter A, p. 34-35 and 40-41); it occurs only in La Boca. In view of these relations, the La Boca is here given formation rank, instead of member rank in the Panamá formation, and the Emperador limestone is a member of the La Boca. The Pedro Miguel agglomerate, formerly a member of the Panamá formation, is also here given formation rank. The changes in stratigraphic terminology are shown in the following table.

Fossil localities 98 to 101, inclusive, listed on page 121, are to be transferred to the La Boca formation. Localities 123 and 129, representing coralliferous limestone at the base of the La Boca, as described on pages 40-41, are to be assigned to the Emperador limestone member.

Carbonaceous debris is more abundant in the Culebra formation than in the La Boca. Calcareous sandstone of the Culebra contains *Miogypsina*, and a few

Stratigraphic terminology of formations overlying Las Cascadas agglomerate in Gaillard Cut area

Former terminology		Present terminology
Panamá formation	Panamá formation proper	Panamá formation
	Pedro Miguel agglomerate member	Pedro Miguel agglomerate
	La Boca marine member	La Boca formation, including Emperador limestone member
Cucaracha formation		Cucaracha formation
Culebra formation, including Emperador limestone member		Culebra formation

miliolids may be found in fine-grained rocks of the Culebra. Calcareous siltstone is more abundant in the La Boca than in the Culebra. In the La Boca, it locally contains abundant Foraminifera, including planktonic species and *Siphogenerina*, and *Lepidocyclina* is fairly common. The La Boca overlaps on to the Las Cascadas agglomerate. The Bas Obispo formation of plate 2 in the area immediately northwest of locality 102 should be changed to Las Cascadas.

Though the strata, including the Emperador limestone member, transferred to the La Boca formation, are younger than formerly supposed, the difference in age is not great. It has already been pointed out (p. 42) that the La Boca is not much younger than the Culebra. Both are assigned to the early half of early Miocene time. The transfer leaves in the Culebra formation species that have brackish-water affinities, notably *Neritina* sp., *Littorina* aff. *L. angulifera*, *Potamides suprasulcatus*, and *Terebralia dentilabris*?

The La Boca fossils include seven species in the families under consideration in this chapter. The inappropriately named *Nassarius praeambiguus* is the only one that is described. The La Boca specimens of

that species, like many of the other La Boca mollusks, are poorly preserved. The description is based chiefly on Gatun fossils that are considered conspecific.

Mollusks from La Boca formation (Columbellidae to Volutidae)

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

	Localities					
	99a	99b	99d	100	100a	101
<i>Mitrella?</i> sp.	-----	R	-----	-----	R	-----
<i>Nassarius</i> (<i>Uzita?</i>) <i>praeambiguus</i> (Brown and Pilsbry)	-----	C	-----	C	C	R
<i>Melongenina</i> sp.	R	R	C	-----	-----	-----
<i>Fusinus?</i> sp.	-----	R	-----	-----	-----	-----
<i>Oliva</i> (<i>Oliva</i>) sp.	-----	F	R	C	-----	F
<i>Olivella?</i> sp.	-----	-----	R	-----	-----	-----
<i>Lyria?</i> sp.	-----	-----	-----	-----	-----	-----

In core holes in the Empire Reach the Emperador limestone member has a thickness of 5.8 to 38 meters. The maximum is almost the same as the outcrop thickness of 35 meters on Río Masambí in the same area (p. 40). The limestone rests directly on the Las Cascadas agglomerate or is separated from it by a varying thickness of siltstone or sandstone, or both. In core hole ERW 34, a thickness of 12½ meters was penetrated below the limestone without reaching the top of the Las Cascadas. It still is uncertain whether the patches of reef limestone are at the same horizon wherever they are found. The varying thickness of La Boca strata between the limestone and the Las Cascadas may be due to deposition of the La Boca on an irregular surface.

In 1960 Mr. Stewart found, at the foot of the hills west of Borinquín Highway, two adjoining excavations in coralliferous limestone. The excavations doubtless represent the quarry "one-third mile west-northwest of Empire" (USGS 6016, locality 118 of present report), which may be regarded as the type locality of the Emperador limestone member. The excavations are located approximately where locality 117 is plotted on plate 2. They have been covered recently with spoil from the widening of the Empire Reach. Locality 117 (USGS 6014, "limestone on street near railroad at Empire") presumably is to be shifted to the east side of Borinquín Highway about 900 meters northwest of where it is plotted on plate 2. At the corrected location bulldozing of a knoll adjoining the highway exposed coralliferous limestone. The highway is the former alignment of the Panama Railroad.

No species from the Emperador limestone member are represented among the fossils examined during the preparation of the present chapter.

GATUN FORMATION

The Gatun formation furnished the bulk of the fossils described in the present chapter: 63 species and

subspecies, three-fourths of the total number. Through the interest of R. H. Stewart, ten new collections are available from road construction and dredging operations for a refinery on Payardi Island, on the Caribbean coast 2½ kilometers east of the Canal Zone boundary. The new localities, representing the lower and middle parts of the Gatun formation, are listed on page 242. Mr. Stewart's collection from locality 138c is the largest at hand from the lower part of the Gatun.

The Gatun fossils are listed in table 1. They include two unusual columbellid genera: *Strombino-phos*, which is *Antillophos*-like, and *Strombinella*, which resembles *Strioterebrum*. They also include four *Phos*-like buccinid genera and subgenera: *Cymatophos*, *Calophos*, *Antillophos*, and its subgenus *Rhipophos*. With the exception of *Cymatophos* and *Antillophos* proper, the columbellid and buccinid genera mentioned are not known to be living. The buccinid genus *Nicema* and the nassarids *Nanarius* (subgenus of *Nassarius*) and *Leptarius* also are not known to be living.

Sincola (subgenus of *Strombina*), *Cymatophos*, and *Strephonella* (subgenus of *Oliva*) are to be grouped with the genera and subgenera that now survive in eastern Pacific waters, but not in the Caribbean Sea. The doubtfully identified *Northia?*, as well as *Hanetia* and *Metula*, may be in the same group. *Strombina* in the restricted sense was formerly thought to be extinct in the Caribbean Sea, but is now known to be living there. *Xancus* is one of the few genera that formerly lived in eastern Pacific and western Atlantic waters, and now survive in the Caribbean Sea but not in the eastern Pacific Ocean. Three such genera or subgenera have so far been considered in the present report: *Muracypraea* (subgenus of *Cypraea*), *Sconsia*, and *Xancus*.

Enaeta ecnomia is more closely related to *E. barnesii*, a Recent eastern Pacific species, than to Recent Caribbean species. *Antillophos candei gatunensis* has close living allies in the western Atlantic Ocean (*A. candei candei*) and the eastern Pacific Ocean (*A. veraguensis*). Likewise, *Mitra limonensis* is related to Recent western Atlantic and eastern Pacific forms: *M. swainsonii antillensis* and *M. swainsonii swainsonii*, respectively. The only recognized allies of the Gatun forms of *Nanarius*, a diminutive subgenus of *Nassarius*, are found in the middle Miocene Shoal River formation of Florida.

Cymatophos veatchi veatchi is abundant in the lower part of the Gatun—extraordinarily abundant at locality 138c—and rare in the middle part. The lineage of that species is unknown in the middle Miocene upper part of the formation in the eastern area, but reap-

pears in the upper Miocene upper part in the western area in the form of *C. veatchi erymnus*. *Calophos ectyphus* is also abundant in the lower part and rare in the middle part. *Nicema amara* and *Enaeta ecnomia* were found only in the lower part, *Strombinella olssoni* and *Leptarius leptus* in the middle part in the western area, and *Antillophos mexicanus* and *Voluta alfaroi eurytera* in the upper part in the western area. *Voluta alfaroi eurytera* occurs also in the Chagres sandstone.

PLIOCENE SERIES

CHAGRES SANDSTONE

Five species, two of which are *Phos*-like, occur in the Chagres sandstone. If *Cymatophos? acolus* is a representative of *Cymatophos*, it is the last known species of the genus in the present Caribbean region. *Amarophos bothrus* is the type of an apparently extinct genus found also in lower Miocene deposits in Columbia and Costa Rica and in upper Miocene in Costa Rica.

Mollusks from Chagres sandstone (Buccinidae to Fasciolaridae)

[R, rare; C, common]

	Localities	
	197	208
<i>Hanetia dalli</i> (Brown and Pilsbry), subsp.	-----	R
<i>Cymatophos? acolus</i> Woodring, n. sp.	?R	C
<i>Amarophos bothrus</i> Woodring, n. sp.	-----	C
<i>Latirus (Polygona) anapetes</i> Woodring, n. sp.	-----	R
<i>Voluta alfaroi eurytera</i> Woodring, n. subsp.	-----	R

DESCRIPTION OF TERTIARY MOLLUSKS—CONTINUED FROM CHAPTER B

GASTROPODS—CONTINUED FROM CHAPTER B

Family COLUMBELLIDAE

The Gatun formation has yielded six genera and 15 species of columbellids, but in the other fossiliferous formations the representation of the family is meager. A great array of columbellids is found in the Miocene deposits of the Caribbean region, especially in the middle Miocene, including *Conus*-like (*Parametaria*), *Antillophos*-like (*Strombinophos*), *Vexillum*-like (*Metulella*), *Hastula*-like (*Mazatlanina*) and *Strioterebrum*-like (*Strombinella*) genera, as well as more conventional genera. *Mazatlanina* is so far unrecorded, but occurs in late Miocene strata at Puerto Limón, Costa Rica, where it is represented by the Recent Caribbean species *M. aciculata*. *Strombinophos* and *Strombinella* are found in the Gatun formation.

Genus *Mitrella* Risso

Risso, Histoire naturelle des principales productions de l'Europe méridionale, t. 4, p. 247, 1826.

Type (logotype, Cox, Neogene and Quaternary Mollusca from the Zanzibar Protectorate, p. 28, 1927): *Mitrella flaminea* Risso (= *Murex scriptus* Linné), Recent, eastern Atlantic Ocean and Mediterranean Sea.

Cox attributed the type designation to Cossmann (1901, p. 235), who, however, designated *Murex scriptus* without mentioning any of the species assigned to the genus by Risso. Strictly speaking the designation should be in the reverse of the form used by Cox, as was done a year later (Woodring, 1928, p. 273). This is, of course, a trivial legalistic matter.

Small smooth columbellids that have a moderately to strongly constricted pillar occur in deposits as old as Eocene in Europe and America. They seem to be properly referred to *Mitrella*. The species described in the present report, however, are considerably smaller than the type species. Not only is the protoconch considerably smaller, it is also less cylindrical and has a much smaller apex. As in other species, the protoconch is not clearly set off from the remainder of the shell.

Poorly preserved columbellids, listed as *Mitrella?* sp., occur in the La Boca formation.

Subgenus?

Mitrella species

Plate 39, figure 1

Very small, slender to slightly inflated, about 7-whorled, including protoconch, which is conical and enlarges from a minute apex. Early whorls slightly bulging, late whorls flat, or almost flat. Early part of body whorl rounded or faintly angulated at level of posterior end of outer lip. Pillar short, moderately constricted from remainder of shell. Pillar sculptured with four to six spiral bands, remainder of shell smooth. Outer lip preceded by a weak varix, faintly notched, interior not exposed. Inner lip apparently not denticulate.

Height 2.7 mm, diameter 1.2 mm (figured specimen). Height 3.5 mm, diameter 1.5 mm (largest specimen).

This minute columbellid was found in the marine member of the Bohio(?) formation: 10 specimens at Trinidad Island and one at the submerged Vamos Vamos locality. The preservation is so poor that the species, evidently new, is not named.

The unnamed columbellid is even smaller than the small Claiborne (middle Eocene) species *M. parva* (Lea) (Palmer, 1937, p. 277, pl. 37, figs. 2, 3, pl. 84, fig. 7) and the early part of the body whorl of the Canal Zone form is more rounded at the level of the

posterior end of the outer lip. The columellar lip of *M. parva* bears minute denticles. The apparent absence of denticles on the fossils from the Canal Zone may be a matter of faulty preservation. Weak denticles are present on the type of *Mitrella*, but their presence or absence is probably of no taxonomic value at a level higher than specific rank. No comparable species of late Eocene age has so far been found in southeastern United States. The same group of small slender species, however, is continued by an unidentified species in the Oligocene Vicksburg group and by columbellids in the late early Miocene Chipola formation and the middle Miocene Oak Grove sand member of the Shoal River formation that have been named *M. mikra* Gardner (1926-47, p. 503, pl. 52, fig. 20, 1947), *M. oryzoides* Gardner (idem, p. 504, pl. 52, fig. 19), *M. nanna* Gardner (idem, p. 505, pl. 52, fig. 22) and *M. sima* Gardner (idem, p. 505, pl. 52, fig. 10). (These small, slender smooth Miocene columbellids have been overnamed.) The Oligocene and Miocene forms are larger than the Canal Zone species. Like *M. parva*, they have denticles on the inner lip.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), Gatun Lake area, localities 40a, 42.

***Mitrella limonensis* (Gabb)**

Plate 39, figure 2

Strombina limonensis Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., vol. 8, p. 356, pl. 46, fig. 40, 1881 (Pliocene, Costa Rica).

Very small or small, inflated, pupoid, 6- or 7-whorled, including protoconch, which is conical and enlarges from a minute apex. Early whorls distinctly bulging, late whorls slightly bulging. Pillar short, moderately constricted from remainder of shell. Pillar sculptured with six or seven spiral bands, remainder of shell smooth. Outer lip preceded by a strong, wide varix, distinctly notched, interior denticulate. Columellar lip faintly denticulate, at least in large form.

Height 2.6 mm, diameter 1.4 mm (figured specimen, small form). Height 4.8 mm, diameter 2.5 mm (large form).

Type: Acad. Nat. Sci. Phila. 3398.

Type locality: Puerto Limón Peninsula, Costa Rica, Pliocene.

Two forms of *Mitrella limonensis* are recognized in the Canal Zone: the figured diminutive form and a large form almost twice as large as the diminutive form. Six localities, representing the middle part of the Gatun formation, yielded the diminutive form. The largest number of specimens (18) were collected at locality 147b. Three specimens of the large form

are associated with the diminutive form at that locality and four others were found in the upper part of the Gatun formation in the eastern area. The type and other specimens from the type locality are intermediate in size between the two forms.

The inflated, pupoid outline and distinctly varicose, distinctly notched outer lip distinguish *M. limonensis* from other small species of *Mitrella*, such as the unnamed species from the marine member of the Bohio(?) formation, *M. debooyi* (Maury) (1917, p. 100, pl. 21, fig. 6; Cercado formation, Dominican Republic), and *M. pedana* Gardner (1926-47, p. 501, pl. 52, fig. 9, 1947; Chipola formation, Florida).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139b, 146, 147b, 147f, 147g, 155c. Upper part, eastern area, locality 173a. Pliocene, Puerto Limón Peninsula, Costa Rica.

***Mitrella epacta* Woodring, n. sp.**

Plate 39, figures 3, 4

Of medium size, moderately inflated, about 10-whorled, including protoconch, which is conical and enlarges from a small apex. Early part of body whorl rounded at level of posterior end of outer lip. Pillar moderately short, moderately constricted from remainder of shell. Pillar sculptured with six or seven spiral bands, remainder of shell smooth. Outer lip preceded by a weak, wide varix, faintly notched, interior denticulate. Columellar lip weakly denticulate.

Height (incomplete) 7.2 mm, diameter 3.1 mm (type). Height 5.7 mm, diameter 2.4 mm (paratype).

Type: USNM 643624; paratype, USNM 643625.

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), upper part of Bohio formation.

The upper part of the Bohio formation of Barro Colorado Island yielded two specimens of *Mitrella epacta*. The early whorls of the type are missing and its outer lip is somewhat damaged, producing the effect of a pronounced posterior notch.

M. epacta is larger than *M. acanthodes* (Dall) (1915, p. 73, pl. 4, fig. 4), an early lower Miocene species from the Tampa limestone of Florida, and its early post-protoconch whorls are not slightly turreted like those of the Florida species. The Bohio species is more similar to the late early Miocene *M. oxia* Gardner (1926-47, p. 507, pl. 52, fig. 18, 1944; Chipola formation, Florida), but has less rapid enlarging whorls and a less constricted pillar.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d.

Subgenus Columbellopsis Bucquoy, Dautzenberg and Dollfus

Bucquoy, Dautzenberg and Dollfus, *Mollusques marins du Rousillon*, t. 1, p. 77, 1882.

Type (orthotype): *Columbella minor* Scacchi, Recent, Mediterranean Sea.

Columbellopsis is used for slender species of *Mitrella* that have a strongly constricted pillar. The following species, like the preceding species of *Mitrella*, has a more conical protoconch, enlarging from a smaller apex, than that of the type species.

***Mitrella* (*Columbellopsis*) aff. *M. fenestrata* (C. B. Adams)**

Plate 39, figure 5

Of medium size, moderately slender, $7\frac{1}{2}$ -whorled, including protoconch, which is conical, enlarges from a small apex and has bulging whorls. Post-protoconch whorls practically flat. Early part of body whorl faintly angulated at level of posterior end of outer lip. Pillar moderately short, strongly constricted from remainder of shell. Pillar sculptured with eight or nine spiral bands, remainder of shell smooth. Outer lip defective on only adult shell.

Height 6.2 mm, diameter 2.7 (figured specimen).

This species is represented by an adult shell, the outer lip of which is broken back, and three immature shells, all from the lower part of the Gatun formation. A very slender, fragmentary, immature shell of two whorls (early whorls missing) found in the middle part of the Gatun in the western area is doubtfully identified as the same species.

Mitrella aff. *M. fenestrata* evidently is closely related to the Recent Caribbean species *M. fenestrata*. The apex of the protoconch of the fossils, however, is smaller and their post-protoconch whorls enlarge more rapidly. The Gatun species is more similar to the late lower Miocene *M. asema* Gardner (1926-47, p. 509, pl. 52, fig. 6, 1947; Chipola formation, Florida) than to any of the other numerous species of the genus from the Miocene of Florida that have been named, but is smaller, at least on the basis of the inadequate Gatun material. The protoconch of *M. asema* has a small tip, like that of *M. cf. M. fenestrata*.

M. fenestrata (Clench and Turner, 1950, p. 280, pl. 41, fig. 2; Abbott, 1958, p. 70, pl. 3, fig. n) long was known as *Astyris fusiformis* (d'Orbigny). d'Orbigny's *Colombella fusiformis* (a typographic error for *Columbella*) (1841-47(?), vol. 2, p. 136, pl. 21, figs. 25-27, 1847(?), however, is a homonym of the same name used at earlier dates for three other species, Anton's (1839, p. 88) being the earliest. C. B. Adams' *Columbella fenestrata* seems to be the earliest available name for this species, which occurs in the Pliocene Caloosahatchee marl of Florida (Dall, 1890-1903, p. 138, 1890,

Astyris fusiformis; Olsson and Harbison, 1953, p. 237, pl. 38, figs. 2, 2a, *Anachis* (*Alia*) cf. *A. fenestrata*).

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

Genus *Anachis* H. and A. Adams

H. and A. Adams, *The genera of Recent Mollusca*, v. 1, p. 184, 1853.

Type (logotype, Tate, Woodward's *A manual of the Mollusca*, 2d ed., app., p. 13, 1870): *Columbella scalarina* Sowerby, Recent, Mazatlán, México, to Panamá.

Subgenus *Costoanachis* Sacco

Sacco, *I molluschi dei terreni terziarii del Piemonte e della Liguria*, pt. 6, p. 57, 1890.

Type (logotype, Pace, *Malac. Soc. London Proc.*, v. 5, p. 43, 1902): *Columbella* (*Anachis*) *turrita* Sacco, Miocene, Italy.

Pace's statement under *Costoanachis* on page 43 is not a type designation, but his general statement on page 41 converts it into a type designation.

The type of *Anachis* is a large, heavily sculptured species. Small, slender, delicately sculptured species are grouped under the subgenus *Costoanachis*.

***Anachis* (*Costoanachis*) *mira mira* (Dall)**

Plate 39, figures 13-18

Strombina mira Dall, in Guppy and Dall, *U.S. Nat. Mus. Proc.*, v. 19, p. 312, pl. 29, fig. 7, 1896 (Miocene, Canal Zone). Brown and Pilsbry, *Acad. Nat. Sci. Phila.*, v. 63, p. 352, 1911 (Miocene, Canal Zone: Dall's record).

Columbella (*Atilia*) *gracilis* Toulou, *K. k. Geol. Reichsanstalt Jahrb.*, Band 61, p. 501, pl. 31, fig. 15, 1911 (Miocene Canal Zone). Not *Columbella gracilis* C. B. Adams, 1852.

Of medium size, slender to moderately inflated, 8- or 9-whorled, thin-shelled or somewhat thick-shelled. Protoconch consisting of about $3\frac{1}{2}$ whorls, rapidly enlarging from a small apex, not clearly set off from post-protoconch whorls. Axial sculpture variable, fairly strong to absent, or practically absent. Axial ribs closely spaced, appearing on second to fourth post-protoconch whorl, generally disappearing on late whorls, or almost to entirely absent on entire shell. Sutural cord absent or weak. Pillar sculptured with spiral threads that fade out posteriorly, but may extend to level of posterior end of outer lip or beyond. Suture channeled on specimens that have a spiral groove at level of posterior end of outer lip. Faint microscopic spiral lineation visible on body whorl and late spire whorls of some specimens. Mature body whorl moderately to strongly varicose near outer lip. Interior of outer lip denticulate. Columellar lip finely denticulate.

Height 9.3 mm, diameter 4 mm (type, an inflated specimen). Height 6.4 mm, diameter 2.4 mm (figured small, slender specimen).

Type: USNM 113713.

Type locality: 177 (Monkey Hill [Mount Hope], near Gatun, Canal Zone), upper part of Gatun formation.

Anachis mira is a very variable species—variable in outline and thickness of shell, and especially variable in axial sculpture. It is widely distributed in the Gatun formation, but is abundant only at the type locality. Specimens that show a range in axial sculpture from fairly strong to absent, or practically absent, are identified as *A. mira mira*, and those that have strong axial sculpture as *A. mira fugax*. There is, however, no marked discontinuity so far as sculpture is concerned. Both occur in the three parts of the formation, but *A. mira mira* has a restricted distribution in the lower part and *A. mira fugax* was not found in the upper part in the western area. The two forms are associated at five localities (138d, 139b, 147b, 175, 177).

A. mira mira embraces both the most slender and the most inflated specimens. Plate 39, figures 13–16 illustrate the range of variation in outline. Dall chose as the type the most inflated shell in a lot of 21 specimens. It practically lacks axial sculpture, though a few weak ribs are visible on part of the penult whorl and some ghosts of ribs are visible on the later part of the body whorl, which bears a weak sutural cord. The type and other specimens that practically lack, or entirely lack, axial sculpture are not convincing as specimens of a species of *Anachis*, but they grade into specimens that have fairly strong axial sculpture on part of the shell. Fairly strong axial ribs on intermediate whorls are shown on plate 39, figures 17, 18.

The type of Toulou's *Columbella gracilis* (height 7.6 mm, diameter 2.5 mm) is slender and has axial ribs on the last 1¼ whorls.

The lot from which the type of *A. mira* was selected has the largest number of specimens (21). This weakly sculptured *Anachis* occurs also in middle Miocene deposits on Río Banana in southeastern Costa Rica (USGS 5882e, 5882f, 5882m).

Occurrence: Lower, middle and upper parts of Gatun formation (middle and late Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139b, 139c, 147b, 155, 155c. Upper part, eastern area, localities 173, 175, 177, 177b, 177c; western area, locality 185. Middle Miocene, Costa Rica.

Anachis (Costoanachis) *mira fugax* Brown and Pilsbry

Plate 40, figures 1–4, 9, 10

Anachis fugax Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 351, pl. 25, fig. 5, 1911 (Miocene, Canal Zone).

Phos semilineatum Toulou, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 501, pl. 31, fig. 16, 1911 (Miocene, Canal Zone).

Not as slender as the most slender specimens of *A. mira mira*, more strongly sculptured axially, body whorl generally bearing a more or less distinct sutural cord, noded by the axial ribs. Axial ribs closely spaced on early whorls, closely or widely spaced on late whorls, 13 to 20 ribs on sculptured penult whorl. Ribs appearing at beginning of first post-protoconch whorl, or generally at later stage on first or second whorl; persisting to varix near outer lip, or disappearing on body or penult whorl, or disappearing on antepenult whorl and reappearing on penult and body whorls. Spiral sculpture generally not extending as far as level of posterior end of outer lip and, therefore, suture generally not channeled.

Height 12 mm, diameter 5 mm (largest specimen). Height 11.6 mm, diameter 4.5 (largest figured specimen).

Type: Acad. Nat. Sci. Phila. 1717.

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

Widely spaced ribs on late whorls accompanied by a distinct sutural cord are illustrated on plate 40, figures 9, 10; closely spaced ribs on late whorls accompanied by a weak sutural cord on plate 40, figures 3, 4; and the disappearance and reappearance of closely spaced ribs accompanied by a weak sutural cord on plate 40, figures 1, 2. Despite the variability, *A. mira fugax* in general is characterized by strong axial sculpture. Taken by themselves, specimens that have widely spaced axial ribs on late whorls and a distinct sutural cord show little resemblance to specimens of *A. mira mira* that lack, or practically lack, axial sculpture and lack a sutural cord; in fact, they suggest different genera. Nevertheless, the features of protoconch and aperture are the same and the sculptural features are gradational. No representative of *A. mira fugax* is as slender as the very slender form of *A. mira mira* and no representative of *A. mira mira* has a distinct sutural cord. Extension of the spiral sculpture to the level of the posterior end of the outer lip, and therefore a channeled suture, are more common in *A. mira mira*.

The type of Toulou's *Phos semilineatum* (height 9.6 mm, diameter 4.2 mm) has closely spaced ribs and a faint sutural cord on the body whorl.

A. mira fugax was found at 19 localities. The 15 specimens from locality 147b (11 immature) is the largest number in any lot.

A. stevensoni Marks (1951, p. 112, pl. 7, fig. 6), from the lower Miocene Subibaja formation of Ecuador, is the earliest described columbellid closely related to *A.*

mira fugax. The Ecuadoran species is smaller, has a bulbous-tipped protoconch of fewer whorls, and is not known to include specimens that have a sutural cord. The middle Miocene Jamaican *A. aulata* Woodring (1928, p. 277, pl. 16, fig. 17), like *A. stevensoni*, is smaller than *A. mira fugax* and has a bulbous-tipped 1½-whorled protoconch. The ribs on the body whorl of the Jamaican species are more closely spaced and more nearly vertical than on the typical form of *A. mira fugax*. The type of *A. aulata*, but no other specimens, has a double sutural cord.

Many species of columbellids of the genus *Anachis*, including species of *Costoanachis*, live in the Panamic region. *A. rehderi* Hertlein and Strong (1940-51, p. 83, pl. 2, fig. 14, 1951) is more similar to *A. mira fugax* than any known species living in Caribbean waters. Like many specimens of *A. mira fugax*, *A. rehderi* has a sutural cord, but is somewhat smaller and, so far as known, does not include forms that are inflated and have widely spaced ribs on the body whorl.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 137, 138, 138a, 138c, 138d. Middle part, eastern area, localities 139b, 140, 146, 147b, 147g; western area, localities 161, 161a, 161b, 161c. Upper part, eastern area, localities 163, 175, 177, 177c.

Anachis (Costoanachis) stibara Woodring, n. sp.

Plate 40, figures 28, 29

Fairly large, slender, estimated to be about 8-whorled. Protoconch and earliest sculptured whorls not preserved. Axial sculpture consisting of strong, narrow ribs, widely spaced on intermediate and late whorls, nine or ten on penult whorl, subdued or disappearing on body whorl. Suture bordered by a strong, narrow cord. Pillar sculptured with spiral threads that fade out posteriorly. Outer lip varicose, interior strongly denticulate. Columellar lip weakly denticulate.

Height (not quite complete) 14.6 mm, diameter 5.7 mm (type).

Type: USNM 643634.

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.

The strong, widely spaced axial ribs and strong sutural cord are characteristic features of *Anachis stibara*. It is represented, however, by only four specimens, all imperfect and all from the type locality. In apertural view the spire whorls of the type are corroded. Faint traces of very narrow brownish or grayish, axial color bands are visible on the type.

At the type locality *A. stibara* is associated with *A.*

mira fugax, but it is unlikely that it is a large strongly sculptured form of *A. mira fugax*, even though that columbellid is variable.

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

Anachis (Costoanachis) species

A third species of *Anachis* in the Gatun formation is represented by a minute, immature, rapidly enlarging shell (height 3.6 mm, diameter 1.5 mm) from the lower part of the formation. The protoconch is conical and consists of 3½ whorls. The three post-protoconch whorls are sculptured with closely spaced axial ribs (15 on body whorl) and closely spaced spiral threads lying between the ribs. The posteriormost spiral thread is wider than the others, forming an indistinct sutural cord.

A similar undescribed species from the Cercado formation of the Dominican Republic (USGS 8525) lacks the sutural cord and its spiral sculpture consists of narrow cords separated by fine striae. It reaches a height of 7.8 mm and a diameter of 3.2 mm.

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

Genus *Zanassarina* Pilsbry and Lowe

Pilsbry and Lowe, Acad. Nat. Sci. Phila. Proc., v. 84, p. 75, 1932.

Type (orthotype): *Nassarina poecila* Pilsbry and Lowe, Recent, Pacific coast of Nicaragua.

Zanassarina was proposed as a subgenus of *Nassarina* Dall (1889, p. 181; type (orthotype): *N. bushii* Dall, Recent, Cape Hatteras to Florida and Gulf of Mexico), which Dall assigned to the Buccinidae. Though *Nassarina* later was transferred to the Columbellidae (Woodring, 1928, p. 279), the transfer was ill advised. Dall grouped columbellids, including a species of *Zanassarina* (*Mangilia? glypta* Bush), under *Nassarina*, but *N. bushii* (Dall, 1889, p. 182, pl. 15, fig. 12) itself is not convincing as a columbellid. That species has an inflated 1½-whorled protoconch, lacks a notch on the outer lip, and its columellar lip is not molded against the parietal wall. It probably is related to *Engina*, a buccinid. Verification of the affinities of both *Nassarina* and *Zanassarina* on the basis of anatomical features is needed.

Zanassarina is an eastern Pacific and a western Atlantic genus and extends back to the Miocene. *Nassarina*, on the contrary, seems to be monotypic.

Zanassarina habra Woodring, n. sp.

Plate 39, figures 9, 10

Small, slender, 8-whorled. Protoconch large for size of shell, conical, enlarging from a minute apex, 3½-

whorled. Sculpture reticulate. Axial ribs widely spaced, 10 or 11 on late whorls. Spiral threads narrower and more closely spaced than axial ribs, and overriding them. Three or four spiral threads on penult whorl (depending on position of suture of body whorl), seven or eight on body whorl, not including a weak sutural thread that generally appears on late spire whorls and becomes stronger on body whorl. Pillar sculptured with closely spaced spiral threads. Body whorl slightly varicose near outer lip. Edge of outer lip imperfect, interior denticulate. Columellar lip faintly denticulate.

Height 5 mm, diameter 1.9 mm (type). Height 5.6 mm, diameter 2.2 mm (largest specimen).

Type: USNM 643635.

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

This small, strongly sculptured columbellid was found in the middle part of the Gatun formation. The 14 specimens from the type locality and the two additional specimens show little variation, except in the strength of the sutural cord on late whorls. The thin edge of the outer lip is not preserved on any specimen and therefore the shallow notch of *Zanassarina* is not apparent.

Z. habra is closely related to *Z. glypta* (Bush) (1885, p. 461, pl. 45, figs. 5, 5a), the only Recent species of the genus along the southeastern coast of the United States, but has a larger protoconch and narrower, more delicately sculptured axial ribs. The protoconch whorls of *Z. glypta* are not angulated, as shown in Bush's figure 5a. A somewhat smaller unidentified Miocene species from Jamaica (Woodring, 1928, p. 280, pl. 16, fig. 20) is more crudely sculptured than *Z. habra*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 146, 147b, 147f.

Zanassarina species

An unidentified species of *Zanassarina* (height, not quite complete, 5 mm, diameter, 2.2 mm), evidently a new species, is represented by a poorly preserved specimen from the upper part of the Gatun formation in the western area. The last protoconch whorl is preserved, but the others are missing. The post-protoconch whorls bulge slightly. The axial ribs are closely spaced and the spiral threads are strongly swollen on the ribs. A sutural spiral thread appears at an early stage on the second post-protoconch whorl and is strong on the last two whorls.

The slightly bulging whorls, closely spaced axial ribs, swollen spiral threads, and strong sutural thread are notable features of this species.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 185.

Genus *Strombinophos* Pilsbry and Olsson

Pilsbry and Olsson, Acad. Nat. Sci. Phila. Proc., v. 93, p. 35, 1941.

Type (orthotype): *Strombinophos loripanus* Pilsbry and Olsson, Pliocene, Ecuador.

The *Antillophos*-like genus *Strombinophos* occurs in the middle Miocene part of the Gatun formation, in deposits of middle Miocene age in Panamá, Costa Rica and Florida, and in the Pliocene of Florida and Ecuador. *Engoniophos vadosus* Gardner (1926-47, p. 464, pl. 50, fig. 18, 1944; Shoal River formation, Florida) is a species of *Strombinophos*. The genus is not known to be living.

Strombinophos mimicus Woodring, n. sp.

Plate 39, figure 20; plate 40, figures 26, 27

Of medium size, slender, 9-whorled. Protoconch large, conical, 3-whorled. Earliest sculpture consisting of narrow, arcuate axial threads, gradually transformed into axial ribs on first post-protoconch whorl, and spiral threads gradually added. Sculpture reticulate, formed by axial ribs and overriding spiral threads. Axial ribs narrow, 12 to 17 on penult whorl. Primary spiral threads closely spaced, five or six on penult whorl, not including one to three bordering suture. A secondary thread present between some primary spirals, absent between others. Suture bordered by a spiral almost as strong as primary threads, or by one to three comparable to secondary threads. Body whorl, generally later half, bearing one or two varix-like thickenings. Outer lip not notched, its interior bearing heavy elongate denticles, prolonged as ridges far within aperture. Columellar lip bearing slender elongate denticles.

Height 16 mm, diameter 6 mm (type). Height 14.9 mm, diameter 5.9 mm.

Type: USNM 643636.

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

The edge of the outer lip is somewhat damaged on all the specimens. Growth lines close to the edge, however, show no indication of a notch. A varix-like thickening may be fairly close to the outer lip or some distance from it. The early arcuate axial threads are worn on the type, but are well shown on the other figured specimen (pl. 39, fig. 20).

Strombinophos mimicus is similar to *S. maxwelli* Olsson and Harbison (1953, p. 238, pl. 33, fig. 11; Plio-

cene, Florida), but has stronger and more numerous axial ribs. Though *S. mimicus* occurs at 12 localities in the lower and middle parts of the Gatun formation, it is not abundant. Nine specimens—the largest number in any lot—were found at the type locality by means of long-continued collecting.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 138, 138a, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 147b, 147g, 155c.

Strombinophos cf. *S. estrellensis* (Olsson)

The middle part of the Gatun formation in the western area at locality 161c yielded five defective specimens of *Strombinophos* that are more inflated than *S. mimicus* and are sculptured with fewer and wider axial ribs. The penult whorl bears 8 to 11 ribs. In the number and width of ribs this form is similar to the middle Miocene Costa Rican *S. estrellensis* (Olsson) (1922, p. 120, pl. 9, figs. 17, 18). That species, however, reaches a larger size (21.5 mm as compared with 15.5 mm), is more slender, and its spiral threads are weaker in the spaces between the ribs.

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

Genus *Strombina* Mörch

Möreh, Catalogus conchyliorum * * * Comes de Yoldi, pt. 1, p. 85, 1852.

Type (logotype, Cossmann, Essais de paléoconchologie comparée, pt. 4, p. 241, 1901: selected as type of *Strombocolumbus*, proposed as a substitute name for *Strombina*): *Columbella lanceolata* Sowerby, Recent, Ecuador and Galapagos Islands.

Strombina is an American genus that has an age range of early Miocene to Recent. It was widely distributed in both western Atlantic and eastern Pacific tropical waters during Miocene time and then reached southeastern United States. Pliocene distribution was more restricted: Ecuador, the Pacific coast of Panamá, Venezuela, Trinidad, and Florida. Some 20 species are now found in eastern Pacific waters but only one in the Caribbean Sea.

As a matter of fact, *Strombina* was formerly supposed to be extinct in the Caribbean Sea. In 1950, however, R. W. Foster dredged specimens off Scarborough, Tobago, at a depth of 36 fathoms. This Caribbean species is identified as *S. pumilio* (Reeve) (1859, species 147, pl. 24), although axial ribs are suppressed or absent on spire whorls of the specimen deposited in the U.S. National Museum. Reeve illustrated his species only in dorsal view and in mirror image. Another specimen in the collections of the U.S. National Museum was collected along the coast of Jamaica by

C. B. Adams and was cataloged as "*Strombina coromandeliana* C. B. Adams not Lamarck." This specimen has low axial ribs on spire whorls. Reeve cited Cumaná, Venezuela, as the locality for his species. Neither his record nor the Jamaican specimen have been taken seriously.

S. pumilio occurs also in fossiliferous strata in the Cabo Blanco and Cumaná areas in Venezuela. The fossiliferous strata in both areas are now considered of Pliocene age. Those in the Cabo Blanco area, now designated the Mare formation (Rivero, *in* Schwarck Anglade, 1956, p. 107; Weisbord, 1957, p. 18–20), have been erroneously referred to the middle Miocene (Woodring, *in* Kehrler, 1939, p. 1,853). The fossil *Strombina* of the Cabo Blanco area was listed at an early date by Lorié (1889, p. 137) as *Columbella recurva* Sowerby. Rutsch (1934, p. 68) commented on the occurrence of the genus there in very young, probably Pleistocene, deposits. Three specimens from Cumaná in the Guppy collection (USNM 115516) are labelled "*Columbella gradata* Guppy var. *crassa*": a nude name. *S. pumilio* is indeed closely related to the Miocene Jamaican *S. gradata* (Guppy) (Woodring, 1928, p. 283, pl. 17, figs. 3, 4). All except the earliest post-protococonch whorls of *S. pumilio*, however, are more distinctly shouldered than those of *S. gradata* and are spirally sculptured.

Some 40 species of *Strombina* from the Tertiary deposits of tropical America have been named. Though several groups are represented among both the fossil and living species, recognition of subgenera has not gone far.

Subgenus?

Strombina cf. *S. quirosana* H. K. Hodson

A poorly preserved, small, slender, smooth (aside from spiral sculpture on the pillar) columbellid (height 2.6 mm, diameter 1.1 mm) from the Culebra formation is of interest as representing the earliest species of *Strombina* now known in the Caribbean region. It is more slender than the late early Miocene Venezuelan *S. quirosana* (Hodson and Hodson, 1931, p. 27, pl. 10, figs. 12, 13).

Occurrence: Culebra formation (early Miocene), locality 114.

Subgenus *Strombina* s. s.

Strombina (*Strombina*) *lessepsiana* Brown and Pilsbry

Plate 40, figures 22, 23, 30, 31

Strombina lessepsiana Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 352, pl. 25, figs. 11, 12, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 126, pl. 10, figs. 13, 20, 1922 (Miocene, Canal Zone and Costa Rica).

Columbella (*Strombina*) *gatunensis* Toulou, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 501, pl. 30, fig. 8, 1911 (Miocene, Canal Zone).

Of medium size to large, slender, smoothly tapering or somewhat turreted, horizontal cross section of body whorl strongly triangular. Protoconch large, $2\frac{1}{2}$ -whorled. Narrow sutural channel on early post-protoconch whorls formed by spiral groove just above suture. Faint axial ribs visible on first to third post-protoconch whorls on a few specimens. Narrow axial ribs appearing on posterior part of fourth or fifth post-protoconch whorl, or suppressed until a later stage, as late as body whorl. Ribs continuing on body whorl to dorsal hump, or suppressed except on dorsal hump; almost invariably suppressed between dorsal hump and outer lip. Ribbed whorls and dorsal hump slightly shouldered, forming a somewhat turreted outline. Ribbed part of whorls bearing weak to very faint spiral sculpture. Pillar strongly sculptured spirally, as in most species of the genus. Outer lip slightly ascending toward suture.

Height 32.7 mm, diameter 12 mm (figured specimen from lower part of Gatun formation). Height 27 mm, diameter 10 mm (figured specimen from middle part of Gatun formation).

Type: Acad. Nat. Sci. Phila. 1718.

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

Strombina lessepsiana is the most abundant and most widespread columbellid in the Gatun formation. It is found throughout the formation. In general, the fossils from successively younger parts of the formation are progressively smaller. All of 42 specimens from the upper part of the formation in the eastern area at locality 177b are small, the largest having a height of 23 mm and a diameter of 9 mm. The smallest of all were collected at locality 183, in the upper part in the western area. The largest of 20 from that locality measures about 18 mm by 7 mm, but it may not be quite mature.

About 100 specimens were collected in the lower part of the Gatun at locality 138c. Though that number is the result of long-continued collecting, 46 specimens were found later in a single visit at the same place (locality 138d).

Both axial and spiral sculpture are variable. Most of the preserved early post-protoconch whorls are too worn to show whether the first to third whorls bear faint axial ribs. Such ribs are most distinct on shells from localities 177b and 183, already mentioned. Relatively strong axial sculpture on intermediate and late whorls is accompanied by a somewhat turreted outline (pl. 40, fig. 30, 31). On a few specimens axial ribs

disappear on intermediate or late whorls and then reappear. Even the strongest spiral sculpture is weak. Both the type of *S. lessepsiana* and the type of Toulou's *S. gatunensis* (height 26.6 mm, diameter 9.8 mm) are weakly sculptured. About a third of the specimens from the lower part of the Gatun and a few from the middle part bear microscopic, irregularly arranged, crudely spiral striae.

S. lessepsiana is a representative of a group of triangular species sculptured with narrow axial ribs. Species of this group occur in Miocene deposits—middle Miocene wherever the dating is known—in Florida, the Dominican Republic, Costa Rica, Panamá, southwestern Colombia, and Ecuador. *S. prisma* Pilsbry and Johnson (Brown and Pilsbry, 1911, p. 352, footnote, pl. 25, figs. 9, 10; Dominican Republic) and *S. waltonia* Gardner (1926-47, p. 513, pl. 52, figs. 26-27, 1947; Florida) are perhaps the most closely allied species. Both lack a channeled suture and *S. prisma* is more inflated than *S. lessepsiana*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136, 136a, 137, 137a, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139c, 139f, 155, 155a, 155b, 157; western area, localities 161, 161a, 161b. Upper part, eastern area, localities 171, 172, 173, 176a, 177, 177b, (small form); western area, locality 183 (small form). Middle Miocene, Costa Rica, small form.

Strombina (*Strombina*) *ochyra* Woodring, n. sp.

Plate 39, figures 11, 12

Moderately large, rapidly enlarging in diameter, somewhat turreted, horizontal cross section of body whorl practically circular to distinctly triangular. Protoconch not preserved. Narrow to moderately wide axial ribs appearing on antepenult or penult whorl and on body whorl extending to dorsal hump or, in its absence, to position of dorsal hump. Ribs disappearing on anterior part of spire whorls and at corresponding level on body whorl. Spiral sculpture fairly strong on posterior part of late spire whorls and on corresponding part of body whorl. Outer lip strongly ascending toward suture.

Height (incomplete, 5 whorls) 19 mm, diameter 9 mm (type).

Type: USNM 643640.

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.

Five specimens, all found in the middle part of the Gatun formation at and near the Gatun Third Locks excavation, are referred to *Strombina ochyra*. They are not as slender as *S. lessepsiana* and their outer lip is more strongly ascending. In general they are also less triangular and have heavier axial ribs and stronger spiral sculpture. Nevertheless in those three features even these five specimens practically intergrade with *S. lessepsiana*. The specimen that has the strongest triangular outline (locality 155a) also has the narrowest ribs. The type has a slight dorsal hump and a faint hump preceding the dorsal hump. The specimen from locality 155 and the more slender of two from locality 155c are practically circular. Though these two practically circular fossils are most unlike *S. lessepsiana* in outline, they show the microscopic irregular striae mentioned under that species.

S. ochyra is larger than *S. costaricensis* Olsson (1922, p. 128, pl. 10, figs. 8, 16, 17; middle Miocene, Costa Rica) and has weaker spiral sculpture.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155, 155a, 155c, 157.

Strombina (Strombina?) pleurica Woodring, n. sp.

Plate 40, figures 5, 6

Of medium size, rapidly enlarging in diameter, horizontal cross section of body whorl circular. Protoconch conical, 2½-whorled. Weak axial ribs appearing on later part of first post-protoconch whorl, continuing on second, then disappearing, reappearing in subdued form on later part of penult whorl, and continuing with greater strength on body whorl. Ribs extending from suture to suture on spire whorls and beyond periphery on body whorl. Spiral sculpture weak on later part of penult whorl and on posterior part of body whorl, stronger below periphery on body whorl, merging into strong sculpture of pillar. Outer lip slightly ascending. Posterior part of parietal wall bearing a strong oblique ridge, comparable to elongate denticles on interior of outer lip.

Height 14 mm, diameter 6.4 mm (type).

Type: USNM 643641.

Type locality: 138d (USGS 22016, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of USGS 16909, same locality as USGS 21956), lower part of Gatun formation.

This *Amphissa*-like *Strombina* is characterized by its circular cross section and relatively strong axial and spiral sculpture on the body whorl. It is larger than *S. bassi* Maury (1917, p. 96, pl. 15, fig. 17; Gurabo formation, Dominican Republic) and has less

uniform axial sculpture. The type, found in the lower part of the Gatun formation, in association with *S. lessepsiana* and *S. cf. S. lissa*, is the only specimen. It may not be fully mature.

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

Strombina (Strombina?) cf. S. lissa Gardner

Of medium size, rapidly enlarging in diameter, horizontal cross section of body whorl circular or almost circular. Dorsal hump absent or weak, hump preceding dorsal hump absent. Protoconch conical, about 2½-whorled, not clearly set off from remainder of shell. Spire whorls and body whorl devoid of sculpture, except weak spiral sculpture on pillar. Outer lip moderately ascending toward suture. Posterior part of parietal wall heavily callused.

Height 15 mm, diameter 6.9 mm (largest specimen). Height 11.2 mm, diameter 5.8 mm.

This species apparently is smooth, aside from weak spiral sculpture on the pillar. It is represented by six specimens from the lower part of the Gatun formation. All are somewhat worn and incomplete or otherwise damaged. The four specimens from locality 136 are smaller and more slender than the two from locality 138e, and show narrow brownish zigzag bands.

S. cf. S. lissa has a more heavily margined aperture than *S. lissa* (Gardner, 1926-47, p. 514, pl. 52, figs. 14, 15, 1947), a species from the Shoal River formation of Florida. It is unlikely that these smooth Miocene forms are closely related to the Recent *S. pavonina* (Hinds) (Keen, 1958, p. 396, fig. 518), which ranges from Mazatlán, México, to Panamá. *S. pavonina* also is smooth, aside from a weakly sculptured pillar. It has, however, a larger protoconch than the Miocene forms and a deep siphonal notch, deeper than in other species of *Strombina* examined.

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

Subgenus *Sincola* Olsson and Harbison

Olsson and Harbison, Acad., Nat. Sci. Phila. Mon. 8, p. 230, 1953.
Type (orthotype and tautotype): *Strombina sincola* Olsson, Miocene, Costa Rica.

Though the species of *Sincola* are small, they have a large aperture and many, including the type species and those in Panamá, have a heavily margined aperture. Such species occur in the Miocene of Jamaica, the Dominican Republic, Costa Rica, Panamá, Colombia, and Trinidad, in the Pliocene of Trinidad and Ecuador, and in present eastern Pacific waters. *Strombina gibberula* (Sowerby) (Keen, 1958, p. 394, fig.

512), which ranges from Baja California to Perú, is the species living in eastern Pacific waters.

Strombina (Sincola) amphidyma Woodring, n. sp.

Plate 40, figures 7, 8, 14, 15

Small, slender to rapidly enlarging in diameter, horizontal cross section of body whorl moderately triangular. Dorsal hump weak, hump preceding dorsal hump moderately strong. Protoconch conical, 3- to 3½-whorled. End of protoconch marked by appearance of axial ribs, which disappear on penult whorl. Ribs strongly or slightly pinched adjoining suture and overridden by weak sutural cord. Outer lip strongly ascending toward suture.

Height 7.7 mm, diameter 4.1 mm (type, inflated form). Height 7.7 mm, diameter 3.6 mm (figured slender form).

Type: USNM 643642.

Type locality: 138c (USGS 21956, about 100 meters north of Transisthmian Highway and about 75 meters west of road to refinery on Payardi Island, Panamá; immediately east of Cativa and 100 meters north of USGS 16909), lower part of Gatun formation.

Strombina amphidyma, represented by an inflated form and a slender form, is distinguished from other species of *Sincola* by its moderately triangular cross section and pinched ribs. It occurs in the lower part of the Gatun formation at locality 138c, where five specimens were collected: two of the inflated form and three of the slender form. The ribs of one of the inflated specimens are only slightly pinched. That specimen, aside from the weaker humps, resembles *S. chiriquiensis*, the next species described.

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

Strombina (Sincola) chiriquiensis Olsson

Plate 40, figures 12, 13

Strombina chiriquiensis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 130, pl. 10, figs. 14, 24, 1922 (Miocene, Panamá). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 143, 1929 (Miocene, Colombia).

Pyrene (Strombina) chiriquiensis (Olsson), Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 621, pl. 29, figs. 6a, b, 1939 (Miocene, Colombia).

Small, rapidly enlarging in diameter, horizontal cross section of body whorl strongly triangular. Protoconch conical, 3½-whorled. End of protoconch marked by appearance of axial ribs, which disappear at beginning of body whorl. Second and third post-protoconch whorl bearing a faint sutural cord. Outer lip strongly ascending toward suture.

Height 8.3 mm, diameter 4.4 mm (figured specimen).

Type material: 3 syntypes, Paleontological Research Institution 21052.

Type locality: Water Cay [Cayo de Agua], Archipiélago de Bocas del Toro, Panamá, deposits of late Miocene age.

In the middle and upper parts of the Gatun formation *Strombina amphidyma* is replaced by the strongly triangular *S. chiriquiensis*. A few specimens were found at each of four localities. Three mature shells from locality 155c and two from locality 157 show microscopic undulating spiral striae on the body whorl.

S. chiriquiensis is more inflated than *S. sincola* Olsson (1922, p. 129, pl. 10, figs. 19, 21; middle Miocene, Costa Rica) and has stronger axial sculpture than *S. walli* Mansfield (1925, p. 47, pl. 8, figs. 5, 7; middle Miocene, Trinidad).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 155c; western area, locality 161c. Upper part, eastern area, locality 163. Middle Miocene, northeastern and southwestern Colombia. Late Miocene, northwestern Panamá.

Genus *Strombinella* Dall

Dall, in Guppy and Dall, U.S. Nat. Mus. Proc., v. 19, p. 312, 1896.

Type (orthotype): *Strombinella acufornis* Dall, Miocene, Dominican Republic.

Though *Strombinella* closely mimics small species of *Strioterebrum* in outline and sculpture, the apertural features give it away as a columbellid. So far only three species are known: an undescribed species from the Thomonde formation of Haiti (late early Miocene), smaller and more delicately sculptured than the type species; the type species from the Gurabo formation of the Dominican Republic (late middle Miocene); and *S. olssoni* from the middle part of the Gatun formation (late middle Miocene). The type species itself is rare. Four specimens are at the Academy of Natural Sciences of Philadelphia, two at the U.S. National Museum, and one, collected by Gabb, at Cornell University. *S. olssoni* is represented by 21 specimens and the Haitian species by about 100.

Strombinella olssoni Woodring, n. sp.

Plate 39, figures 6-8

Moderately small, moderately slender. Protoconch conical, 2½- to 2¾-whorled. End of protoconch marked by appearance of axial ribs. Ribs extending from suture to suture and continuing to varix near outer lip, 11 to 13 ribs on body whorl. Spiral sculpture appearing on first post-protoconch whorl, consisting of flat spiral bands separated by very narrow grooves,

6 or 7 bands on penult whorl. Sutural cord weak on earliest post-orthoconch whorls, strong on remaining whorls. Outer lip slightly ascending. Interior of outer lip bearing elongate denticles. Columellar lip strongly denticulate. Siphonal notch moderately deep.

Height (incomplete, 6 whorls) 11.8 mm, diameter 4.6 mm (type). Height (almost complete) 13.2 mm, diameter 4.8 mm.

Type: USNM 643645; paratype USNM 643646.

Type locality: 161c (USGS 8382, railroad cuts west of Gatun Dam, station B, Canal Zone), middle part of Gatun formation.

Strombinella olssonii is more elongate and more strongly sculptured spirally than *S. aciformis* Dall (Guppy and Dall, 1896, p. 312, pl. 29, fig. 6) and has more elongate and less beadlike axial ribs on the sutural cord. None of the 21 specimens, all of which were found in the middle part of the Gatun formation in the western area west of Gatun Lake, is undamaged. Twelve of the 21 were collected at the type locality.

This species is named for A. A. Olsson, who collected all the specimens some 40 years ago.

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

Family BUCCINIDAE

Genus *Hanetia* Jousseaume

Jousseaume, Le Naturaliste, 2d year, no. 42, p. 335, 1880.

Type (orthotype and tautotype): *Murex haneti* Petit, Recent, Brazil.

It is unfortunate that *Hanetia* supplants Dall's well known name *Solenosteira* (Dall, 1890-1903, p. 122, 1890; type (orthotype): *Pyrula anomala* Reeve, Recent, Baja California to Perú), for the habitat of *Hanetia haneti* is doubtful. Petit (1856, p. 90, pl. 2, figs. 7, 8) cited Brazil, but that locality record still awaits confirmation. Smith's (1939, p. 16, pl. 12, fig. 7) illustration of a worn Brazilian shell, under the name *Tritonalia haneti*, is not convincing as Petit's species. The specimen he illustrated, labeled *Ocenebra haneti* and collected by von Ihering, is in the U.S. National Museum (catalog no. 150767). Olsson and Harbison (1953, p. 227) recognized *Solenosteira* as a subgenus of *Hanetia*, but Petit's illustrations of his species do not support that solution; in fact, they suggest a small specimen of "*Pyrula*" *anomala* that has a rounded periphery.

Hanetia is widespread in middle and late Miocene deposits along the south border of the present Caribbean Sea and on the Pacific coast of northern South America. Though it apparently bypassed the West Indies, it reached Florida in late Miocene time. Pliocene species occur in Florida, Panamá, and on the

Pacific coast of northern South and Central America. Whether the genus survives in western Atlantic waters depends on the doubtful locality record for the type species.

Two incomplete impressions from the Toro limestone member of the Chagres sandstone are identified as *Hanetia*? sp.

Hanetia dalli dalli (Brown and Pilsbry)

Plate 41, figures 7, 9, 10, 11

Solenosteira dalli Brown and Pilsbry, Acad. Nat. Sci., Phila. Proc., v. 63, p. 348, pl. 24, fig. 14, 1911 (Miocene, Canal Zone). Pilsbry and Brown, idem, v. 69, p. 34, 1917 (Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 9,

no. 39, p. 113, pl. 8, fig. 8, 1922 (Miocene, Canal Zone). *Coralliophila gatunensis* Toulou, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 502, pl. 30, fig. 9, 1911 (Miocene, Canal Zone).

Coralliophila incerta Toulou, idem, p. 503, pl. 31, fig. 17, 1911 (Miocene, Canal Zone).

Cantharus dalli (Brown and Pilsbry), Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 622, pl. 29, fig. 12, 1939 (Miocene, Colombia).

Of medium size to moderately large, moderately inflated to strongly inflated, periphery rounded or subrounded. Protoconch conical, 2½-whorled. End of protoconch marked by appearance of axial and spiral sculpture. Axial ribs relatively narrow, widely spaced, seven to nine (generally eight) on body whorl. Spiral cords overriding ribs, five or six (generally six) on penult whorl. Spaces between cords bearing one to four secondary spiral threads. On large shells secondary spirals stronger between periphery and suture than elsewhere. Faint or microscopic lamellar sculpture formed by exaggerated growth lines. Siphonal fasciole conspicuous, but not set off, somewhat lamellar. Umbilical cleft wide.

Height (almost complete) 46 mm, diameter 32 mm (largest specimen, figured). Type: Acad. Nat. Sci. Phila. 3823. Type locality: Gatun Locks excavation, middle part of Gatun formation.

The representatives of the genus *Hanetia* in the Canal Zone and adjoining parts of Panamá are considered forms of one species: *Hanetia dalli*. They are found in the three parts of the Gatun formation and in the Chagres sandstone; that is, they have an age range of early middle Miocene to early Pliocene. Four subspecies are recognized, but they do not show a graded series from one end to the other. They probably are ecologic subspecies that have no age significance. *H. dalli protera*, the next subspecies described, is the prevailing form in the lower part of the Gatun formation. Though *H. dalli dalli* occurs in the lower part (two localities, eight specimens), with the ex-

ception of one specimen, it is the only form in the middle part (13 localities, 30 specimens) and continues into the upper part in the eastern area (eight localities, 20 specimens).

H. dalli dalli is characterized by its rounded or subrounded periphery and strong, relatively narrow, widely spaced axial ribs. The type (height 41 mm) was found in the middle part of the Gatun in the eastern area. In the collections at hand only one of 22 specimens from the middle part in the eastern area is as large as the type. The large specimen shown on plate 41, figures 10, 11, is the largest in a lot of five large specimens found in the upper part in the eastern area. *H. chiriquiensis* Olsson (1922, p. 114, pl. 8, fig. 3; upper Miocene, northwestern Panamá), of a size comparable to that of the large Canal Zone fossil, is considered a subspecies of *H. dalli* that has widely spaced spiral cords on the anterior part of the body whorl.

The type of Toulas' *Coralliophila gatunensis* (height 27.5 mm, diameter 17.5 mm) is an immature *H. dalli dalli* and the type of his *Coralliophila incerta* (height 11.3 mm, diameter 6.8 mm) is a still more immature specimen of the same form.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d. Middle part, eastern area, localities 139f, 142, 144b, 147h, 153 (identification doubtful), 155, 155a, 155b, 155c, 156 (identification doubtful), 157, 159; western area, locality 161a. Upper part, eastern area, localities 171, 172, 173, 175, 176, 177 (identification doubtful), 177b. Middle Miocene, northeastern Colombia, southwestern Colombia (Oinomikado's record).

Hanetia dalli protera Woodring, n. subsp.

Plate 42, figures 6, 7

Of medium size periphery angular or subangular. Peripheral spiral cord forming blunt spines on axial ribs. Axial ribs subdued or not subdued between periphery and suture on late whorls. Other features as in *Hanetia dalli dalli*.

Height (not quite complete) 39 mm, diameter 24.5 mm (type).

Type: USNM 643647; three paratypes, Stanford Univ.

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

Hanetia dalli protera is distinguished from *H. dalli dalli* by its angular or subangular periphery and the accompanying blunt peripheral spines. As in *H. dalli dalli*, both moderately inflated and strongly inflated forms are represented. The type is moderately inflated

and on late whorls its ribs are subdued between the periphery and the suture.

This is the prevailing subspecies of *H. dalli* in the lower part of the Gatun formation and was found in the middle part at locality 139f. In fact, it is the only form of *Hanetia* in all except two of eight collections from the lower part of the formation.

H. dalli protera is similar to *H. alternata* (Nelson), which occurs in the late Miocene of Perú (Nelson, 1870, p. 198, pl. 7, figs. 3, 4) and the Pliocene of southwestern Panamá (Olsson, 1942, p. 67, pl. 10, fig. 1), and to the Recent Panamic species for which Reeve's unavailable name "*Fusus*" *turbinelloides* (Reeve, 1847-48, species 56, pl. 15, 1848) has been used. Both of those species are larger than *H. dalli protera*. Moreover, the primary spirals of *H. alternata* are weaker and *H. "turbinelloides"* is more strongly angulated.

The subgeneric name *Fusinoesteira* (Olsson, 1932, p. 179; type (orthotype): *Purpura fusiformis* Blainville, Recent, Panamá to Perú) has been proposed for angulated species of *Solenosteira*; that is, *Hanetia*. *H. fusiformis*, however, may be treated as standing by itself, on account of its biconic outline, relatively massive peripheral spines, and widely spaced spiral cords.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 137a, 138, 138a, 138c, 138d. Middle part, eastern area, locality 139f.

Hanetia dalli medioamericana (Olsson)

Plate 42, figures 1, 2

Solenosteira vughani Dall var. *medioamericana* Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 113, pl. 8, fig. 7, 1922 (Miocene, northwestern Panamá and Costa Rica).

Of medium size, strongly inflated, periphery rounded. Protoconch not preserved. Axial ribs relatively wide and therefore closely spaced. Umbilical cleft narrow. Other features as in *H. dalli dalli*.

Height (practically complete) 35.3 mm, diameter (incomplete) 21 mm (figured specimen).

Type: Paleontological Research Institution 21013.

Type locality: Toro Cay [Cayo de Toro], Archipiélago de Bocas del Toro, Panamá, deposits of late Miocene age.

A specimen from the upper part of the Gatun formation in the western area—the only specimen of *Hanetia* from that area—is identified as *Hanetia dalli medioamericana*. The axial ribs are wider than those of *H. dalli dalli* and *H. dalli protera*. The narrow umbilical cleft suggests that this specimen is immature. The cleft is wider, however, on topotypes of *H. dalli medioamericana* of the same size as the fossil from the western area.

H. dalli did not reach southeastern United States. According to collections available through the kindness of Druid Wilson, two species of *Hanetia* are represented in the late Miocene deposits of Florida: *H. vaughani* (Dall) and *H. acilinensis* (Tucker and Wilson), both of which have a few more ribs (10 or 11 on body whorl) than *H. dalli*. *H. vaughani* is relatively small and strongly inflated. The typical form (Mansfield, 1930, p. 70, pl. 17, fig. 5), which occurs in northwestern Florida but is rare there, has very closely spaced ribs. A subspecies at Acline, in peninsular Florida, has more widely spaced ribs in a type of ribbing like that of *H. dalli medioamericana*. Perhaps Böse's (1906, p. 40, pl. 4, figs. 25, 26) *Melongena* (*Pugilina*) *mengeana* Dall, from deposits of Miocene, apparently middle Miocene, age near Tuxtepec in the western part of the Tehuantepec area, is this subspecies of *H. vaughani*. Nevertheless *H. dalli medioamericana* occurs, also in deposits apparently of middle Miocene age, farther east in the Tehuantepec area (USGS 10352, Peña Tecolotepec on Río Coatzacoalcas). *H. acilinensis* (Tucker and Wilson, 1932, p. 11, pl. 2, figs. 7, 8), also from Acline, resembles *H. dalli medioamericana* in outline. It has subdued ribs on the body whorl and also subdued primary spirals and strengthened secondary spirals.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 179. Middle Miocene, Costa Rica (Olsson's record). Middle(?) Miocene, Tehuantepec area, México. Late Miocene, northwestern Panamá.

***Hanetia dalli* (Brown and Pilsbry), subspecies**

Plate 47, figures 11, 14

Of medium size, strongly inflated, periphery subangular. Protoconch not preserved. Axial ribs moderately wide, suppressed between periphery and suture. Other features as in *Hanetia dalli dalli*.

Height (almost complete) 36 mm, diameter 26 mm.

The Chagres sandstone proper yielded a specimen representing a subspecies of *Hanetia dalli* that is strongly inflated, and has a subangular periphery and subdued axial ribs between the periphery and suture. It is more inflated than *H. dalli protera* and its ribs are more subdued than those of specimens of that subspecies that have a subangular periphery. The outline of the unnamed subspecies suggests the Miocene Colombian *H. hasletti* (Anderson, 1929, p. 134, pl. 16, figs. 7a, 8), but that species has more subdued axial ribs and finer spiral sculpture.

Occurrence: Chagres sandstone (early Pliocene), locality 208.

Genus *Trachypollia* Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 268, 1928. Type (orthotype): *Trachypollia sclera* Woodring, Miocene, Jamaica.

Trachypollia is related to the genus *Cantharus* (Röding, 1798, p. 132; type (logotype), Cossmann, 1889, p. 141: *Cantharus tranquebaricus* (Gmelin) [*Cantharus globularis* Röding=*Buccinum tranquebaricus* Gmelin], Recent, Indian Ocean), which has much larger shells. Species assigned to *Cantharus* are living on both sides of Central America. It is noteworthy, however, that only one such species has been found in the Tertiary deposits of the present Caribbean region: *Cantharus corrugatus* (Gabb) (Pilsbry, 1922, p. 348, pl. 22, fig. 15; Miocene, Dominican Republic). To be sure, *Hanetia* is given subgeneric rank under *Cantharus* by some zoologists and paleontologists, but that issue is not involved in the distribution under consideration.

***Trachypollia aneureta* Woodring, n. sp.**

Plate 42, figures 8, 9

Small, moderately slender, pillar short. Last $1\frac{1}{2}$ whorls of protoconch preserved. End of protoconch marked by appearance of axial and spiral sculpture. Axial ribs wide, six on body whorl. Spiral threads overriding ribs, three primary threads on penult whorl, a very fine secondary thread between them. Siphonal fasciole slightly swollen. Edge of outer lip broken, interior bearing five elongate denticles. Columellar lip bearing four elongate denticles and a parietal low swelling adjoining a faint channel.

Height (practically complete) 7.2 mm, diameter 3.8 mm (type).

Type: USNM 643651.

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

The type—the only specimen—of this minute buccinid was found in the lower part of the Gatun formation. The apertural features indicate that it is mature. It has fewer and wider axial ribs than the Miocene Jamaican *T. sclera* (Woodring, 1928, p. 269, pl. 16, figs. 7, 8), the type of the genus, and its primary spiral threads are less swollen on the ribs.

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

Genus *Metula* H. and A. Adams

H. and A. Adams, Genera of Recent Mollusca, v. 1, p. 84, 1853.

Type (hidden tautotype): *Metula hindsii* H. and A. Adams (= *Buccinum metula* Hinds), Recent, Pacific coast of Panamá.

Traditional usage of the name *Metula* can be saved by acceptance of hidden tautonymy (Woodring, 1928, p. 286; Keen, 1958, p. 405). The only internal evidence for that interpretation is H. and A. Adams' citation of "Syn. *Buccinum* sp., Hinds" and their citation of "*Hindsii* H. and A. Adams", but not any species of Hinds, among the four species of *Metula*. Strictly speaking the correlation of those two citations is a matter of presumption, but it is a matter of strong presumption. If hidden tautonymy is rejected, Kobelt's (1876-78, p. 39, 1876) designation of *Metula clathrata* (Adams and Reeve) *Buccinum clathratum* (Adams and Reeve) as the type species is to be accepted and *Antemetula* Rehder (1943, p. 199; type (orthotype): *Buccinum metula* Hinds) is the name to be used for the traditional *Metula*.

Whether *Metula* survives in western Atlantic waters is still as uncertain as it was when the matter was discussed some 30 years ago (Woodring, 1928, p. 286). Nothing has been found so far to supplement Guppy's (1881 [1882], p. 177, 178, pl. 7, fig. 18; Reprint, Harris, 1921, p. 98, 99, pl. 5, fig. 18) record of the dredging, in the Gulf of Paria, of a specimen which he thought might be a fossil.

The suggestion that *Metula* may be a columbellid genus (Woodring, 1928, p. 287) was ill advised.

Metula species

Molds and incomplete impressions of small specimens of *Metula* (height 17.8 mm, diameter 7 mm) occur in the uppermost part of the Culebra formation: in the transition zone between the Culebra and Cucaracha formations. These fossils represent the earliest known species of the genus in the present Caribbean region. If they are mature, the small size and fine sculpture suggest relationship to *M. cancellata* Gabb (Pilsbry, 1922, p. 349, pl. 22, figs. 19, 20; Miocene, Dominican Republic).

Occurrence: Culebra formation (early Miocene), localities 110, 112a.

Metula gabbi Brown and Pilsbry

Plate 40, figures 18, 19

Metula gabbi Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 351, pl. 25, figs. 4, 8, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 115, pl. 10, fig. 11, 1922 (Miocene, Canal Zone).

Moderately large, spire whorls only slightly bulging, sculpture moderately fine. Protoconch large, cylindrical, 2- to 2¼-whorled. End of protoconch marked by appearance of sculpture. Axial sculpture stronger than spiral, especially on spire whorls, where the axial cords are crowded. The two sets of sculpture rec-

tangular and more nearly equal on body whorl. Closely spaced interaxial spiral cords of spire whorls transformed on body whorl into more widely spaced cords, swollen at intersection with axial cords. Groove setting off one to three spirals adjoining suture generally deeper or wider than others, forming a weak, narrow sutural band or bands. This deeper or wider groove, or grooves, absent on earliest sculptured whorls and generally absent or subdued on later part of body whorl. Outer lip thickened. Interior of outer lip bearing short, elongate ridges.

Height (practically complete) 29 mm, diameter 10.5 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 1716.

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

Metula gabbi is a moderately large and moderately finely sculptured species. It is larger and more coarsely sculptured than *M. cancellata* Gabb, a species from the Gurabo formation of the Dominican Republic mentioned under the preceding species, and is a little more than half as large as the Pliocene to Recent Panamic *M. amosi* Vanatta (Olsson, 1942, p. 69, pl. 9, fig. 9), which has less crowded axial cords on spire whorls. The coarsely sculptured *M. limonensis* Olsson (1922, p. 116, pl. 10, figs. 5, 6; upper Miocene, Puerto Limón, Costa Rica) is the largest species from the present Caribbean region (height 37 mm).

M. gabbi is fairly widespread in the middle and upper parts of the Gatun formation, but is not abundant. Most of the specimens, like the type, are incomplete; in fact, only three, of a total of 38, are practically complete. The largest number (7) is in the collection from locality 177b. The only specimen from the lower part of the Gatun is a doubtfully identified tip of a few whorls.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c (identification doubtful). Middle part, eastern area, localities 146, 147b, 147h, 151, 155, 155b, 155c, 157; western area, locality 161a. Upper part, eastern area, localities 175, 176, 176a, 177b, 177c.

Genus *Tritiaria* Conrad?

Conrad, Am. Jour. Conchology, v. 1, p. 21, 1865.

Type (monotype): *Buccinum mississippiensis* Conrad, Oligocene, Miss.

Tritiaria? species

The marine member of the Bohio(?) formation yielded small poorly preserved fossils suggesting the genus *Tritiaria*. The protoconch consists of about 3½ or 4 whorls, the last of which bears arcuate axial riblets. The post-protoconch whorls are sculptured with

fairly wide, closely spaced axial ribs and narrower and more closely spaced spiral threads. The siphonal fasciole is slightly inflated. Apertural features are indeterminate. Approximate dimensions are as follows: height 8.5 mm, diameter 4.5 mm.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), localities 41a, 41b, 42.

Genus *Cymatophos* Pilsbry and Olsson

Pilsbry and Olsson, Acad. Nat. Sci. Phila. Proc., v. 93, p. 33, 1941.

Type (orthotype): *Cymatophos galerus* Pilsbry and Olsson, Pliocene, Ecuador.

The faunas of the Gatun formation include seven species of *Phos*-like gastropods assigned to three genera: *Cymatophos*, *Calophos*, *Antillophos* (and its subgenus *Rhipophos*). A fourth genus (*Amarophos*) is found in the Chagres sandstone. The largest and most boldly sculptured of these species are representatives of *Cymatophos*. The siphonal fasciole of *Cymatophos* is moderately inflated and is limited by a sharp, narrow thread. As in *Phos* and the other *Phos*-like genera of the present report, the columella bears a low basal fold, followed by a depression, and the interior of the outer lip bears long, narrow ridges.

Cymatophos is conspicuous in Miocene deposits of the present Caribbean region and on the Pacific side of northern South America. It survives in the eastern Pacific Panamic province (Pilsbry and Olsson, 1941, p. 33; Olsson, 1942, p. 72), but not in Caribbean waters.

***Cymatophos?* cf. *C. veatchi* (Olsson)**

Incomplete and fragmentary remains from the Culebra formation suggest an early *Cymatophos* comparable in general sculptural features to *C. veatchi*, which occurs in the Gatun formation. A restored height of 35 millimeters and diameter of 18 millimeters is indicated.

Occurrence: Culebra formation (early Miocene) localities 110, 112, 114, 115, 115a.

***Cymatophos veatchi veatchi* (Olsson)**

Plate 41, figures 5, 6, 8, 13

Phos veatchi Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 121, pl. 9, figs. 2, 3, 1922 (Miocene, Costa Rica).

Phos (Phos) buchivacoensis F. Hodson, idem, v. 16, no. 59, p. 33, pl. 16, figs. 1, 4, 1931 (Miocene, Venezuela).

Moderately large, fairly slender to somewhat inflated, periphery of later part of body whorl, as shown by outline of axial ribs, generally subangular. Protoconch generally worn or missing, consisting of 2½ smooth whorls. End of protoconch marked by appear-

ance of fine protractive axial ribs and two spiral threads. Axial ribs narrow and widely spaced on early whorls, wide and closely spaced on intermediate whorls, wide and widely spaced on late whorls; six to nine (generally eight) ribs on body whorl. Last rib, or last two ribs, generally stronger than others on later part of body whorl, varix-like, and extending farther toward suture than others. Spiral threads narrow; five to seven on intermediate whorls, about twice as many on late spire whorls through addition of secondaries. Siphonal fasciole sculptured with four to six closely spaced spiral threads.

Height 44.5 mm, diameter 22 mm (figured moderately slender specimen, periphery rounded). Height 43.5 mm, diameter 23 mm (figured moderately inflated specimen, periphery subangular).

Type material: Two syntypes, Paleontological Research Inst. 21021, 21022.

Type locality: Hill 1a, Río Banana, southeastern Costa Rica, deposits of middle Miocene age referred to Gatun formation.

This large *Phos*-like buccinid is extraordinarily abundant in the lower part of the Gatun formation. Some 600 specimens were collected during repeated visits at locality 138c, some 200 during a later visit at the same locality (138d), and about 120 at locality 136. In contrast to the abundance in the lower part of the Gatun, only two specimens have been found in the middle part: one at locality 139e and another at locality 155.

Variation affects chiefly the outline (both the degree of inflation and the outline of the periphery of the later part of the body whorl), the strength of axial ribs on the later part of the body whorl, and the width of spiral threads.

Cymatophos veatchi veatchi and closely related forms occur along the west and south borders of the middle Miocene Caribbean Sea. According to eight topotypes from southeastern Costa Rica, wide ribs on intermediate whorls and a subangular periphery on the later part of the body whorl are more general in Panamá than in the type region. On one of the topotypes the next to last rib is completely suppressed—a feature very rare in the Panamá specimens. The type of *C. buchivacoensis* closely resembles the prevailing Panamá form in width of ribs and in outline of periphery of body whorl. The Colombian *C. tuberaensis* (Anderson) (1929, p. 135, pl. 19, figs. 1–3) is more weakly sculptured.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 137a, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139e, 155. Middle Miocene, southeastern Costa Rica, Venezuela.

Cymatophos veatchi erymnus Woodring, n. subsp.

Plate 42, figures 10, 11

Moderately inflated, periphery of later part of body whorl rounded or subrounded. Protoconch and earliest sculptured whorl worn or missing. Axial ribs of intermediate whorls relatively narrow and relatively widely spaced, those of late whorls relatively narrow and widely spaced. Primary spiral threads exceptionally strong. Other features as in *Cymatophos veatchi veatchi*.

Height 40 mm, diameter 22 mm (type). Height 44 mm, diameter 24.3 mm (largest specimen).

Type: USNM 643655.

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

Though *Cymatophos veatchi veatchi* is very rare in the middle part of the Gatun formation and was not found in the upper part of the eastern area, the lineage of that species is continued by 10 specimens from the upper part at three localities in the western area. These 10 specimens constitute the subspecies *C. veatchi erymnus*, which is characterized by strong spiral threads and by relatively narrow axial ribs on intermediate and late whorls. Intermediate whorls of some specimens, like those of some specimens of *C. veatchi veatchi*, bear a weak narrow axial thread between the ribs.

C. turbacoensis (Anderson) (1929, p. 136, pl. 15, figs. 6, 7; middle Miocene, Colombia) also is sculptured with strong spiral threads, but they are absent between periphery and suture on the last two whorls and axial ribs are weak on the body whorl.

Occurrence: Upper part of Gatun formation, western area (late Miocene), localities 182, 182a, 185.

Cymatophos subsemicostatus (Brown and Pilsbry)

Plate 41, figures 1-4

Phos subsemicostatus Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 350, pl. 25, fig. 3, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 121, pl. 9, fig. 15, 1922 (Miocene, Canal Zone, Costa Rica).

Large, slender to moderately slender, periphery of body whorl rounded. Protoconch conical, 3-whorled. End of protoconch marked by appearance of fine protractive axial ribs and two or three spiral threads. Axial ribs gradually widening, generally separated by a weak narrow axial thread as they widen. Axial ribs disappearing on penult or body whorl (generally on penult) of mature shells, but reappearing on body whorl as an isolated strong, varix-like rib, or as a group of two to four such ribs. Outer lip of mature

shells bordered by one to three of the varix-like ribs. Spiral threads strong; eight to 10 primary threads on penult whorl. Secondary spiral threads rare. Siphonal fasciole sculptured with three to five spiral threads.

Height 51 mm, diameter 21.7 mm (figured slender specimen). Height 46.8 mm, diameter 22 mm (figured moderately slender specimen).

Type: Acad. Nat. Sci. Phila. 1715.

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

Cymatophos subsemicostatus probably is an offshoot from the lineage of *C. veatchi* that appeared in middle Gatun time and continued during the time when the upper part of the Gatun formation in the eastern area was deposited. The consistently rounded periphery and the suppression of axial ribs on the last whorl, or generally on the penult, distinguish *C. subsemicostatus* from *C. veatchi*. Moreover before the ribs are suppressed, they are not as wide or as widely spaced as those of *C. veatchi*. As compared with *C. veatchi*, the range of variation in outline is shifted toward greater slenderness. All of the five specimens from locality 155, one of which is illustrated (pl. 41, figs. 3, 4), are slender. The other illustrations (pl. 41, figs. 1, 2) show a moderately slender specimen.

Perhaps, however, *C. subsemicostatus* is descended from *C. semicostatus* (Gabb) (Pilsbry, 1922, p. 348, pl. 22, figs. 23-25; Dominican Republic), or *C. hodsoni* (Olsson) (1932, p. 174, pl. 18, figs. 4, 12; Perú), or *C. paraguaneensis* (F. Hodson) (Hodson and Hodson, 1931, p. 36, pl. 17, figs. 1, 5; Venezuela), all of which are small early Miocene species having sculpture similar to that of *C. subsemicostatus*. The mutual relations of these early Miocene forms have not been determined.

C. subsemicostatus is nowhere abundant. The five specimens mentioned are the largest number in any collection.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 155, 155a, 155c, 157, 159; western area, localities 161a, 161c (fragments, identification doubtful), 165 (poorly preserved, identification doubtful). Upper part, eastern area, locality 177b. Middle Miocene, southeastern Costa Rica.

Cymatophos? acolus Woodring, n. sp.

Plate 47, figures 3, 4, 7-10

Small, moderately inflated, periphery of late whorls subangular. Protoconch not preserved, early sculptured whorls missing or worn. Remaining whorls sculptured with narrow, widely spaced axial ribs and closely spaced subdued spiral threads. Eight or nine axial

ribs on body whorl. On penult whorl four primary spiral threads, separated by secondary threads, between anterior suture and periphery; crowded threads, not well defined as primaries and secondaries, between periphery and posterior suture. Primary, secondary, and tertiary threads, or only primary and secondary, on body whorl. Siphonal fasciole moderately inflated.

Height (incomplete) 26.2 mm, diameter 16 mm (type). Height (incomplete) 23 mm, diameter 13 mm (larger paratype).

Type material: Type, USNM 643695; two paratypes, USNM 643696.

Type locality: 208 (USGS 8437, Caribbean coast at mouth of Río Indios [Indio], station 5, Panamá), Chagres sandstone.

Despite the small size and subdued sculpture, the moderately inflated siphonal fasciole and general type of sculpture suggest that this species is to be assigned to *Cymatophos*. If it is a representative of *Cymatophos*, it is the latest species now known in the present Caribbean region. All of the 18 specimens from the type locality are imperfect and the only other specimen is a doubtfully identified fragment. Nevertheless *C. ? acolus* is a well defined species, no close allies of which are now recognized.

Occurrence: Chagres sandstone (early Pliocene), localities 197 (fragment, identification doubtful), 208.

Genus *Calophos* Woodring, n. gen.

Type: *Calophos ectyphus* Woodring, n. sp., Miocene, Gatun formation, Panamá.

Moderately large, somewhat slender to strongly inflated, sutural area of late whorls flat or distinctly constricted. Protoconch $1\frac{1}{4}$ - to $2\frac{1}{2}$ -whorled. End of protoconch marked by appearance of finely reticulate

sculpture. Axial sculpture disappearing on fourth to sixth sculptured whorl, or continuing in progressively more subdued form, or disappearing and reappearing on last whorl or last few whorls. Spiral sculpture continuing, but on mature body whorl strongest in sutural area and on and near siphonal fasciole, generally weak or absent on central part of whorl. Siphonal fasciole moderately inflated, sculptured with spiral threads, limited by a sharp narrow thread. Basal columellar fold strong, followed by a depression. Interior of outer lip bearing narrow ridges extending far into aperture.

Calophos is an extinct Miocene Caribbean genus that reached Florida in late Miocene time. The species now known are shown in the accompanying table. In features of protoconch, siphonal fasciole, and aperture *Calophos* and *Cymatophos* are similar, but in sculptural pattern they are notably different. Early whorls of *Calophos* bear finely reticulate sculpture, but on late whorls axial sculpture is weak or absent. *C. inornatus* and *C. ectyphus* bear weak, wide axial ribs on the last whorl or last few whorls. *C. plicatilis*, the unnamed upper Miocene species from Panamá, and the comparable upper Miocene form that occurs in the Isthmus of Tehuantepec have a few weak narrow ribs on the body whorl, chiefly or entirely near the outer lip. Late whorls of *C. baranoanus* and *C. rohri* lack axial sculpture. The trend toward suppression of axial sculpture is reversed, however, in the species from Florida—evidently the youngest species of all. On that species, subdued, relatively narrow axial ribs generally continue from the early sculptured whorls to the early part of the body whorl, or even almost to the outer lip. It seems improbable that the species from Florida is Böse's species.

Species of the genus *Calophos*

Age	Locality					
	Trinidad	Colombia	Panamá	Costa Rica	México	Florida
Late Miocene	<i>C. rohri</i> ¹ (Rutsch)		<i>C. n. sp.</i> ²		<i>C. aff. n. sp.</i> from Panamá ³	<i>C. n. sp.</i> ⁴
Middle Miocene		<i>C. baranoanus</i> (Anderson) ⁵	<i>C. ectyphus</i> Woodring, n. sp.		<i>C. plicatilis</i> (Böse) ⁶	
Early Miocene				<i>C. inornatus</i> (Gabb) ⁷		

¹ *Phos? rohri* Rutsch, 1942, p. 150, pl. 7, figs. 5, 6; Springvale formation.

² USGS 8318, 8345; Cayo de Agua, Bocas del Toro area, northwestern Panamá.

³ USGS 22279; Isthmus of Tehuantepec.

⁴ *Dorsanum? plicatilis* (Böse), Mansfield, 1930, p. 73, pl. 17, fig. 3; western Florida. *Dorsanum? plicatilis* (Böse), Tucker and Wilson, 1932, p. 14, pl. 5, fig. 7; peninsular Florida.

⁵ *Phos baranoanus* Anderson, 1929, p. 137, pl. 16, figs. 4, 5; northeastern Colombia.

⁶ *Cominella plicatilis* Böse, 1906, p. 39, pl. 4, figs. 22-24; near Tuxtepec, Vera Cruz.

⁷ *Phos inornata* Gabb, 1881, p. 338, pl. 44, fig. 2; Sapote.

Mansfield (1930, p. 73) doubtfully assigned the species from Florida to the genus *Dorsanum* on the grounds that it is related to the Miocene European *Buccinum veneris* Faujas, which has been referred to *Dorsanum*. Cossmann and Peyrot's (1927, p. 157, pl. 1, figs. 50-55) illustrations of *Dorsanum veneris* indicate that this European species is properly referred to *Dorsanum*. The posterior part of the siphonal fasciole of *Dorsanum* (Gray, 1847, p. 139; type (orthotype): *Buccinum politum* Lamarck (= *B. miran* Bruguière), Recent, Senegal) is strongly constricted adjoining the overhanging ledge limiting the fasciole. The fasciole indicates that *Dorsanum* is a nassarid genus. *Perunassa* (Olsson, 1932, p. 168; type (orthotype): *Argobuccinum zorritense* Nelson, Miocene, Perú) is more inflated than *Calophos*, has a channeled or shouldered sutural area, and the interior of the outer lip has weak elongate narrow ridges.

Mansfield (1930, p. 73) suggested that *Tritia golfoyaquensis* Maury (1917, p. 90, pl. 15, figs. 24, 25; Cercado formation, Dominican Republic) is congeneric with his *Dorsanum? plicatulum*. Though the type of Maury's species and the only other available specimen (a topotype) are immature, the weak axial sculpture on early whorls throws some doubt on the suggestion. The affinities of Maury's species, however, are uncertain until mature specimens are found.

***Calophos ectyphus* Woodring, n. sp.**

Plate 42, figures 12, 13, 16, 17

Moderately large, moderately slender to somewhat inflated, sutural area moderately constricted on late whorls. Protoconch generally missing or worn, 2½-whorled. Early fine axial sculpture disappearing on about fourth sculptured whorl. Axial ribs reappearing on penult or body whorl, or even on antepenult, as low, wide undulations of varying strength from very weak to fairly strong. Strongest ribs forming low, blunt spines on shoulder, adjoining constricted sutural area. Early narrow, closely spaced spiral threads continuing in sutural area and below periphery, suppressed in central part of late whorls. Siphonal fasciole sculptured with two to four weak spiral threads.

Height (practically complete) 40.7 mm, diameter 22 mm (type). Height (incomplete) 44.5 mm, diameter 26.5 (largest specimen).

Type: USNM 643658.

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.

Calophos ectyphus is variable in degree of inflation, constriction of the sutural area, strength of axial ribs

on late whorls, and suppression of spiral threads on the central part of late whorls. It seems to be most closely related to *C. inornatus* (Gabb) (see table, p. 262), but has a more strongly constricted sutural area on late whorls. The strength of late axial ribs on the type of *C. inornatus* is about midway between the extremes shown by *C. ectyphus*. The range of variation in *C. inornatus*, however, is unknown. The type of *C. ectyphus* (pl. 42, figs. 16, 17) has moderately strong axial ribs on late whorls. A weakly ribbed specimen is shown on plate 42, figures 12, 13. As already mentioned, axial ribs are absent on late whorls of *C. baranoanus* and *C. rohri*. *C. baranoanus* is more inflated than *C. ectyphus* and the typical form of *C. rohri* is more slender.

C. ectyphus, like *Cymatophos veatchi veatchi*, is abundant in the lower part of the Gatun formation and rare in the middle part. Some 70 specimens are in the collection from locality 138c, whereas seven were found in the middle part. One of the two mature shells from the middle part (locality 157) is exceptionally slender—but not more slender than one of seven from the lower part at locality 138a—and lacks axial ribs on late whorls, with the exception of narrow, crowded undulations near the outer lip.

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 (immature), 139e (immature), 155c (immature, slender form), 157 (weakly ribbed, slender form).

Genus *Antillophos* Woodring

Woodring. Carnegie Inst. Washington Pub. 385, p. 259, 1928. Type (orthotype): *Cancellaria candei* d'Orbigny, Recent, North Carolina to Cuba and eastern Gulf of Mexico.

Generic rank for *Antillophos* is preferable to subgeneric rank under *Tritiaria*—the arrangement adopted when the name was proposed.

Subgenus *Antillophos* s.s.

Antillophos s.s. occurs in the Caimito formation and probably in the Culebra formation, but the material from both is inadequate. Three species are found in the Gatun formation. In addition to the Gatun species described in the present report, Toula (1911, p. 502) recorded the occurrence in the Gatun of "*Phos* aff. *elegans* Guppy". His specimen is missing and no comparable species is in any of the collections examined.

***Antillophos* (*Antillophos*) species**

The shallow-water facies of the Caimito formation at locality 56 on the Panama Railroad yielded three defective specimens of a small species of *Antillophos*

s.s. (height about 14 mm, diameter 4.5 mm). The protoconch consists of $3\frac{1}{2}$ whorls, the last of which bears an anterior carina and at the end a few arcuate axial riblets extend from the carina to the suture. The post-protoconch axial sculpture begins as relatively wide, widely spaced ribs. With further growth the ribs are narrow and closely spaced (about 20 on body whorl). At irregular intervals on the last two whorls a rib is varix-like. Spiral threads (five or six on penult whorl) override the ribs. On the last two whorls some of the spaces between the threads bear a fine secondary thread. The siphonal fasciole is almost flat.

This species, the smallest species of *Antillophos* s.s. now known, extends the range of the genus back to late Oligocene time. It is more slender than immature specimens of *A. candei gatunensis* and, except on the earliest whorls, has more closely spaced ribs.

A minute shell from the upper part of the Bohio formation of Barro Colorado Island (locality 42d), listed as *Antillophos?* sp., seems to be related to the species from the Caimito formation.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), locality 56.

***Antillophos?* (*Antillophos?*) species (small)**

An incomplete fossil from the Culebra formation suggests a small species of *Antillophos* s.s. (estimated height 12 mm, diameter 5.5 mm). The protoconch, early sculptured whorls, and aperture are missing. The late sculpture is comparable to that of the Caimito species just described. Though the whorls seem to be somewhat turreted, the outline may be affected by distortion.

Occurrence: Culebra formation (early Miocene), locality 114.

***Antillophos?* (*Antillophos?*) species (large)**

Tritiaria sp., Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 25 (list), 1958 (Oligocene, Canal Zone).

Eight poorly preserved specimens of a *Phos*-like gastropod of medium size (height 27.5 mm, diameter about 12 mm) were found in the moderately deep-water facies of the Caimito formation on Barro Colorado Island. Though the protoconch is present on one of these fossils, the preservation is too poor to be certain of its features. With the exception of a wide varix-like rib at irregular intervals, the axial ribs of late whorls are narrow and widely spaced (about 12 on penult whorl). The spiral sculpture is subdued. The penult whorl bears nine or ten low, narrow spiral threads. A fine secondary thread lies between them and several secondary threads adjoin the suture.

The size and sculpture of this species suggest *Antillophos* s.s. rather than *Tritiaria*.

Occurrence: Caimito formation, Gatun Lake area (late Oligocene), localities 54g, 54h, 54j.

***Antillophos?* (*Antillophos?*) cf. *A. candei gatunensis* (Toula)**

A fourth unidentified and unillustrated species of *Phos*-like gastropods is represented by seven defective specimens from the Culebra formation. The dimensions (estimated height 25 mm, diameter 11 mm), outline, and sculptural plan of the best specimen (locality 114), suggest a small predecessor or small form of *Antillophos candei gatunensis*, the next form described.

Occurrence: Culebra formation (early Miocene), localities 102, 106, 111a, 112, 114.

***Antillophos* (*Antillophos*) *cande*i *gatunensis* (Toula)**

Plate 42, figures 3, 4

Phos gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 701, pl. 25, fig. 11, pl. 27, fig. 6, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 349, pl. 25, figs. 1, 2, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 117, pl. 9, figs. 4, 5, 1922 (Miocene, Canal Zone).

Phos (*Antillophos*) *gatunensis* Toula, Oinomikado, Geol. Soc. Japan Jour., vol. 46, p. 622, pl. 29, fig. 15, 1939 (Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 27, no. 106, p. 72, 1942 (Miocene or Pliocene, Panamá).

Cancellaria? cf. *C. dariena* n. sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, pl. 25, fig. 13, 1909 (Miocene, Canal Zone).

Of medium size, moderately inflated. Protoconch $3\frac{1}{2}$ -whorled, blunt-tipped; last whorl, or about last whorl, bearing an anterior carina and at end two to five arcuate axial riblets between carina and suture. Change to post-protoconch sculpture not abrupt. Post-protoconch sculpture consisting of closely spaced axial ribs and closely spaced spiral cords. Axial ribs progressively widening on first three or four whorls and then becoming narrower; 17 to 27 (generally 20 to 23) on body whorl. At irregular intervals a rib is wide and varix-like, or several crowded narrow ribs take the place of a wide rib. Narrow spiral cords over-riding ribs; 11 to 16 (generally 13 to 15) on body whorl, not including one or two minor spirals near suture. One to three strong secondary threads between cords. Siphonal fasciole slightly inflated, limited by a sharp, narrow thread. Outer lip bearing a wide, shallow notch near base. Basal columellar fold moderately strong, followed by a depression and that by several (generally two) short irregular ridges on columellar lip. Parietal wall bearing a strong narrow ridge.

Height 30.8 mm, diameter 14.5 mm (neotype). Height 34.5 mm, diameter 15.8 mm (largest specimen).

Type: Lost. Neotype: USNM 643660.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation. Locality for neotype: 159 (USGS 5211, Lock site at Gatun, Canal Zone), middle part of Gatun formation.

Both specimens that were available to Toulou when *Phos gatunensis* was described are missing. A lot of five specimens in the Toulou collection was forwarded by Rowland in 1910, a year after the description was published and therefore not available as primary type material. A neotype is selected from a lot of four specimens collected at the presumed type locality.

Antillophos candei gatunensis is widespread and locally abundant in the Gatun formation. It occurs in the three parts of the formation, but not in the upper part in the western area. The range of variation is not pronounced. The number of ribs on the body whorl is not significant in the event that several narrow crowded ribs take the place of a wide rib. The most distinctive feature is the conspicuous, sharply chiseled secondary spiral sculpture. The fine secondary spiral threads appear on the first or second post-PROTOCONCH whorl and even on the second whorl two threads appear in some of the spaces between the primary spirals.

A. candei gatunensis is a representative of a lineage that started during Miocene time and survived with little change on both sides of Central America. *A. candei candei* (d'Orbigny) (1841-47(?), v. 2, p. 129, pl. 21, figs. 23, 24, 1847(?), the type of *Antillophos*, is the survivor in western Atlantic waters and *A. veraguensis* (Hinds) (Keen, 1958, p. 406, fig. 565) in eastern Pacific waters. *A. veraguensis*—at least specimens from the Gulf of California, at the north end of its range—may be distinguished from *A. candei* by the absence of wide varix-like ribs on the eastern Pacific species and also by the absence of ridges on the columellar lip and parietal wall of that species. It seems remarkable that *A. candei* has withdrawn northward from the Caribbean Sea since Miocene time and that it has not been found in the Miocene or Pliocene of Florida.

The Gatun fossils are very closely related to *A. candei candei*, which ranges from North Carolina to the north coast of Cuba and the eastern part of the Gulf of Mexico in 25 to 110 fathoms (generally 50 to 90 fathoms). It is abundant off Key West and the Tortugas. The fossils have wider ribs on the third and fourth post-PROTOCONCH whorls and they have stronger spiral sculpture, especially stronger secondary sculpture, but also stronger primary sculpture between the axial ribs. The Recent shells tend to be a little smaller and a little more slender, but some lots include specimens as large and as inflated as the fossils.

Toulou's *Cancellaria?* cf. *C. dariena* is a poorly pre-

served specimen of *A. candei gatunensis*. The aperture is not completely exposed and the apex is missing.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 139f, 142, 146, 147b, 147c (impression, identification doubtful), 147g, 147h, 151, 155, 155a, 155b, 155c, 157, 158 (molds, identification doubtful), 159, 159a, 159b; western area, localities 161 (poorly preserved, identification doubtful), 161a, 161b, 164. Upper part, eastern area, localities 163 (immature), 171, 172, 173, 175, 176, 177a, 177b, 177d. Middle Miocene, southwestern Colombia. Burica formation (late Miocene or early Pliocene), southwestern Panamá.

Antillophos (Antillophos) mexicanus (Böse)

Plate 41, figure 12

Phos mexicanus Böse, Inst. Geol. México Bol. 22, p. 38, pl. 4, figs. 18-21, 1906 (Miocene, México). Olsson Bull. Am. Paleontology, vol. 9, no. 39, p. 117, pl. 9, figs. 10, 11, 1922 (Miocene, Panamá and Costa Rica).

Phos (Antillophos) mexicanus Böse, Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 622, pl. 29, fig. 16, 1939 (Miocene, Colombia).

Tritiaria (Antillophos) mexicana (Böse), Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 116, 1951 (Miocene, Ecuador).

Not *Phos mexicanus* Dall, U.S. Natl. Mus. Bull., v. 51, p. 578, 1917 (Recent, Pacific coast of México) = *P. gaudens* Hinds, 1844.

Of medium size, strongly inflated, late whorls slightly bulging. Pillar and siphonal canal short. Protoconch not preserved. Axial ribs relatively wide; 17 to 19 on body whorl. Ribs narrow and crowded near outer lip. Strong spirals in form of narrow flat cords overriding ribs; 12 or 13 on body whorl, not including one or two minor spirals near suture. One to three (generally one) fine secondary threads between cords. Columellar lip bearing two or three strong irregular ridges above basal columellar fold. Narrow ridge on parietal wall strong.

Height (practically complete) 31.9 mm, diameter 16.7 mm (figured specimen).

Type: Presumably at Instituto de Geología, Universidad Nacional Autónoma de México.

Type locality: Tuxtepec, Oaxaca, México, evidently middle Miocene.

Antillophos candei gatunensis was not found in the upper part of the Gatun formation in the western area, but locality 183 in that area yielded six somewhat worn specimens of the closely related *A. mexicanus*. That species is more inflated than *A. candei gatunensis* and has a shorter siphonal canal and pillar, flatter late whorls, and stronger ridges on the columellar lip.

Varix-like ribs are absent on *A. mexicanus* and the only narrow, crowded ribs are near the outer lip of mature specimens. *A. rutschi* (Olsson, 1942, p. 73, pl. 9, fig. 5; Pliocene, southwestern Panamá) is similar to *A. mexicanus* in outline and apertural features, but has more numerous, closely spaced axial ribs. *A. mexicanus bendrati* (Rutsch) (1934, p. 68, pl. 4, figs. 9-13; upper Miocene, Venezuela) is a form of *A. candeii* rather than of *A. mexicanus*.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 183. Middle Miocene, southeastern Costa Rica, Tehautepec area, México, southwestern Colombia. Daule formation (middle Miocene), Ecuador. Deposits of late Miocene age, northwestern Panamá.

***Antillophos (Antillophos) monachus* Woodring, n. sp.**

Plate 40, figures 20, 21

Of medium size, moderately slender, spire somewhat turreted. Protoconch not preserved. Axial ribs wide and relatively widely spaced; 14 on body whorl. A weak axial thread between the ribs on earliest preserved whorls. Primary spiral cords strong on axial ribs, moderately strong between them; 15 on body whorl. A fine secondary thread between the cords, except near base of body whorl. Edge of outer lip broken back. Siphonal fasciole slightly inflated. Irregular ridges on columellar lip and elongate ridge on parietal wall absent.

Height (almost complete) 34 mm, diameter 15.5 mm (type).

Type: USNM 643662.

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

This species is based on one specimen associated with *Antillophos mexicanus* at locality 183, in the upper part of the Gatun formation in the western area. The outline, general sculptural plan, and absence of ridges on the columellar lip and parietal wall suggest the middle Miocene Jamaican *A. moorei* (Guppy) (Woodring, 1928, p. 261, pl. 15, figs. 10, 11). The more distinctly turreted spire and secondary spiral sculpture of *A. monachus*, however, serve to distinguish it. The weak axial thread between the wide ribs on early whorls is like that found on many species of *Cymatophos*.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 183.

Subgenus *Rhipophos* Woodring, n. subgen.

Type: *Phos metuloides* Dall, Miocene, Gatun formation, Canal Zone.

Relatively small, moderately slender. Late whorls turreted; sutural area of late whorls narrowly tabulated or slightly channeled. Protoconch consisting of three whorls, at the end of which three or four faint spiral threads and one to three arcuate axial riblets, or spiral threads only, are visible. Change from protoconch sculpture to post-protoconch sculpture not abrupt. Sculpture of early post-protoconch whorls like that of *Antillophos* s.s., sculpture of intermediate and late whorls narrowly cancellate, *Metula*-like. Basal part of outer lip bearing a very wide and very shallow indentation. Siphonal fasciole slightly inflated, limited by a narrow thread, sculptured with narrow spiral cords about as wide as those on basal part of body whorl beyond fasciole. Basal columellar fold moderately weak. Interior of outer lip bearing elongate narrow ridges.

The narrowly tabulated, or slightly channeled, sutural area and *Metula*-like sculpture are characteristic features of *Rhipophos*. The protoconch is like that of *Antillophos* s.s., but is modified by suppression of the carina. The carina-forming thread of *Antillophos* s.s. continues as the anteriormost spiral on post-protoconch whorls, just as the faint spiral threads on the protoconch of *Rhipophos* continue as post-protoconch spirals. The *Metula*-like sculpture is the result of modification of early sculpture like that of *Antillophos* s.s.

Rhipophos is monotypic and the type species is endemic in Panamá.

***Antillophos (Rhipophos) metuloides* (Dall)**

Plate 40, figures 11, 24, 25

Phos metuloides Dall, in Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 310, pl. 28, fig. 15, 1896 (Miocene, Dominican Republic, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 350, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 88, pl. 14, fig. 17, 1917 (Dall's record and illustration). Olsson, idem, v. 9, no. 39, p. 122, pl. 9, fig. 16, 1922 (Miocene, Canal Zone).

Size, outline, protoconch, and apertural features as described under the subgenus. Early post-protoconch sculpture consisting of narrow, widely spaced axial ribs and narrower, more narrowly spaced spiral threads. On later part of third post-protoconch whorl sculpture gradually transformed into narrow, closely spaced axial ribs overridden by narrow, closely spaced spiral cords, producing a *Metula*-like effect. As sculpture changes, sutural area becomes narrowly tabulated or slightly channeled. Twenty-five to 42 (generally 30 to 40) axial ribs and seven to nine (generally seven)

spiral cords on penult whorl. Spiral cord adjoining sutural area single or doubled, either unequally or equally. Body whorl thickened and slightly ascending near outer lip. Axial ribs suppressed or absent in thickened area.

Height (almost complete) 20.2 mm, diameter 9.7 mm (type).

Type: USNM 113665.

Type locality: Recorded as Ponton, Dominican Republic, but that record is rejected in favor of Mount Hope, Canal Zone, upper part of Gatun formation.

The type and 18 other specimens in the type lot are entered in the catalog record as having been collected by "T. Bland?" in the Dominican Republic. They presumably were collected by J. Rowell and there is no reasonable doubt that they were collected at or near the present Mount Hope (Monkey Hill of Rowell's time). (See discussion on p. 46, which was written under the misapprehension that Rowell was recorded as the collector of the type lot of *Phos metuloides*.) Other species that occur in the upper part of the Gatun formation at Mount Hope, but not in the Dominican Republic, are alleged to have been collected by "T. Bland?" at Ponton: for example, *Hanetia dalli dalli*, *Metula gabbi*, and *Antillophos candei gatunensis*. Aside from the rejected record for the Dominican Republic, *Antillophos metuloides* has not been found outside the Canal Zone, nor has any closely related species been found elsewhere.

A. metuloides occurs in the middle part of the Gatun formation, but is more abundant in the upper part in the eastern area, especially near Mount Hope. Forty-eight specimens are in the collection from locality 175 and 24 from locality 177b.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 147b, 147g, 147h, 151, 153a, 155, 155b. Upper part, eastern area, localities 173, 175, 176, 176a, 177 (mold and fragment, identification doubtful), 177b, 177c, 177d, 178.

Genus *Amarophos* Woodring, n. gen.

Type: *Amarophos bothrus* Woodring, n. sp., Pliocene, Chagres sandstone, Panamá.

Relatively small or of medium size, moderately to strongly inflated. At least intermediate and late whorls turreted, sutural area channeled. Protoconch worn or missing. Earliest preserved post-protoconch whorls (estimated to be third or fourth) sculptured with fairly widely spaced axial ribs, overridden by closely spaced spiral threads. Sculpture of intermediate and late whorls dominated by narrow spiral cords, noded

by greatly reduced, very narrow, crowded remnants of axial ribs. Secondary spiral threads conspicuous. Siphonal fasciole slightly inflated, limited by a narrow thread, sculptured with spiral cords like those beyond fasciole. Basal columellar fold fairly strong. Interior of outer lip bearing elongate narrow ridges.

Amarophos carried modification of ordinary *Phos*-like outline and sculpture farther than *Rhipophos*. The sutural area of *Amarophos* is wider and more strongly channeled. Its axial ribs are so greatly reduced and so closely crowded that they are no longer ribs. *Amarophos*, however, could not have arisen from *Rhipophos*, unless *Rhipophos* appeared earlier than is now apparent. The earliest species of *Amarophos* are found in the early Miocene part of the Uscari shale of Costa Rica (*Ptychosalpinx? dentalis* Olsson, 1922, p. 109, pl. 15, figs. 14, 18) and in the early Miocene Las Perdices shale of Colombia (Olsson, personal communication). The genus occurs also in strata of late Miocene age in the Bocas del Toro area of northwestern Panamá. *Amarophos*, like *Rhipophos*, is not known to be living.

Amarophos bothrus Woodring, n. sp.

Plate 47, figures 1, 2

Relatively small, moderately inflated, sutural channel narrow. Protoconch and earliest post-protoconch whorls worn or missing. Early axial ribs gradually transformed into narrow, crowded, low nodes on spiral cords. Nodes separated by grooves. Near outer lip and at irregular intervals on later part of body whorl nodes narrower than elsewhere. Six to eight (generally six) narrow spiral cords on penult whorl. One to three secondary spiral threads between cords. Threads of equal or unequal width, if more than one. Apertural features as described under the genus.

Height (almost complete) 24.7 mm, diameter 13.2 mm (type).

Type: USNM 643697.

Type locality: 208 (USGS 8437, Caribbean coast at mouth of Río Indio, Panamá), Chagres sandstone.

Amarophos bothrus is based on 10 specimens collected from the Chagres sandstone at the mouth of Río Indio, on the Caribbean coast 37 kilometers southwest of Colón (chapter A, fig. 3, p. 45). It is more slender and more delicately sculptured than *A. dentalis*, and smaller and more slender than an undescribed species found in strata of late Miocene age in the Bocas del Toro area of northwestern Panamá (USGS 8322, Valiente Peninsula).

Occurrence: Chagres sandstone (early Pliocene), locality 208.

Genus *Nicema* Woodring, n. gen.

Type: *Nicema amara* Woodring, n. sp., Miocene, Gatun formation, Panamá.

Moderately large, strongly inflated, siphonal canal and pillar moderately short. Late whorls strongly shouldered; later part of penult whorl and body whorl channeled between shoulder and suture. Early whorls sculptured with axial ribs and overriding spiral threads. Sculpture subdued on later part of penult and on body whorl. Axial ribs reappearing as one wide, low hump, or several humps, on shoulder of later part of body whorl. Edge of outer lip frilled, interior smooth beyond frills. Siphonal fasciole strongly swollen. Parietal wall bearing a low ridge bordering a narrow channel.

Aside from the hump-bordered channel, the general features of *Nicema* suggest the Recent Panamic monotypic genus *Triumphis* Gray (1856, p. 41; type (monotype): *Triumphis distorta* [*Buccinum distortum* Wood], Recent, Costa Rica to Ecuador); in fact, the type species of *Nicema* has been referred to *Triumphis* (Marks, 1951, p. 118). *Triumphis*, however, at maturity has an ascending outer lip and a remarkable ear-like posterior extension of the aperture. Moreover, its siphonal canal is very short—so short that the outline of the outer lip is not affected—its siphonal fasciole is practically flat, and the outer part of its columellar lip bears low wrinkles. The hump-bordered channel itself recalls the genus *Northia* Gray (the next genus cited), also a Recent Panamic genus that is monotypic at the present time. The slender outline, deep siphonal notch, and flat siphonal fasciole limited by a strong thread distinguish *Northia*. Despite the hump-bordered channel, perhaps the Panamic species, for which the name *Cominella subrostrata* (Wood) has been used recently (Keen, 1958, p. 402, fig. 546), is the closest Recent ally of *Nicema amara*.

Nicema embraces two channeled species and possibly a nonchanneled species. Marks (1951, p. 118) recognized that the channeled "*Struthiolaria*" *guttifera* Grzybowski (Olsson, 1932, p. 170, pl. 20, fig. 3, 9; assigned to *Northia*), an early Miocene Peruvian species, is closely related to *Nicema amara*. The Peruvian species is more slender and has stronger axial sculpture on the penult whorl. *Cantharus* (*Triumphis*) *predistortus* Marks (1951, p. 117, pl. 7, figs. 8, 10, 11), from the middle Miocene Daule formation of Ecuador, seems to be a nonchanneled species of *Nicema* rather than a species of *Triumphis*. At all events the features of siphonal canal and siphonal fasciole indicate assignment to *Nicema*.

Nicema amara Woodring, n. sp.

Plate 42, figures 14, 15

Protoconch not preserved. Early axial ribs gradually widening and gradually restricted to shoulder region, disappearing at about beginning of mature body whorl or on later part of penult whorl. Ribs reappearing as wide, low humps on shoulder of later part of body whorl; the hump near outer lip stronger than others, or that hump the only one. Early spiral threads gradually widening until sculpture consists of closely spaced narrow grooves, or striae, strongest between siphonal fasciole and periphery and in channel between shoulder and suture. For other features see description of genus.

Height (practically complete) 49.2 mm, diameter 27.7 mm (type).

Type: USNM 643665; nine paratypes, Stanford Univ.

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

Nicema, like *Cymia* (p. 223), is a conspicuous genus found in the lower part of the Gatun formation, but not in other parts of the Gatun. *Nicema amara* is represented in four collections. Twelve specimens were collected at the type locality, but only one or two at other localities. Even the largest collection from the lower part of the Gatun (locality 138c) includes only two specimens.

As outlined in the discussion of the genus, this species is closely allied to *N. guttifera*, from the lower Miocene of Perú.

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

Genus *Northia* Gray?

Gray, Zool. Soc. London Proc., p. 140, 1847.

Type (orthotype): *Northia pristis* Deshayes [*Buccinum pristis* Deshayes] (= *Nassa northiae* Gray, which is also the tautotype), Recent, Gulf of California to Ecuador.

Northia? cf. *N. northiae* (Gray)

Plate 39, figures 23, 24

A poorly preserved fossil from the Culebra formation, deformed by dorso-ventral compression, is doubtfully identified as a species of *Northia* comparable to *N. northiae*. It is a mold, but the outline of the shell is partly impressed on it. The early whorls, siphonal fasciole, and apertural features are missing. The general shape and the sloping sutural shelf on whorls that show the shell outline suggest *Northia*. The

earliest preserved whorl shows no indication of narrow axial ribs. The dimensions are as follows: height (incomplete) 48 mm, lateral diameter (increased by crushing) 30.5 mm, dorso-ventral diameter (decreased by crushing) 19.5 mm.

If this fossil is a species of *Northia*, it is the earliest species of that genus, which now is monotypic and is endemic in the eastern Pacific Panamic province.

Occurrence: Culebra formation (early Miocene), locality 115a.

***Northia*? species**

Plate 43, figures 10, 12

Another doubtfully identified species of *Northia* is found in the lower part of the Gatun formation. The only specimen is slender and consists of a not clearly distinguishable protoconch and about seven post-protoconch whorls (incomplete height 22.5 mm, diameter 9 mm). The anterior part of the last whorl is missing, and therefore the features of siphonal fasciole and aperture are unknown. The shell is too immature to determine whether a sutural shelf or channel is formed at a later stage. The early post-protoconch whorls, like those of *N. northiae*, are sculptured with narrow axial ribs and spiral threads. The spiral threads are coarser than those of *N. northiae*. On the sixth whorl the axial ribs disappear and the spiral threads also disappear, except three, and later two, in the sutural area. Instead of disappearing, as all those of *N. northiae*, the threads in the sutural area become stronger.

The Costa Rican *N. miocenica* Olsson (1922, p. 124, pl. 9, figs. 7, 14), the only Miocene *Northia* so far known, has a fairly strong sutural thread at the stage marked by disappearance of the axial ribs.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 136a.

Family NASSARIIDAE

Genus *Pallacera* Woodring, n. gen.

Type: *Nassa myristicata* Hinds, Recent, eastern Pacific Ocean, Nicaragua to Panamá.

Of medium size, *Phos*-like, whorls rounded or slightly shouldered. Protoconch small, slender, consisting of 1½ to 2 whorls. Axial ribs wide; on spire whorls separated by spaces about as wide as ribs; on later part or all of body whorl more closely spaced. Spiral threads narrow, generally including both primary and secondary threads. Siphonal fasciole strongly inflated, limited by a strong, narrow thread, which is bordered by a deep, narrow depression (fossa). Sigmoid axial swellings conspicuous on siphonal fasciole. Base of columellar lip bordered by

a wide smooth platform. Outer lip not varicose, its interior bearing long, narrow ridges. Columellar lip bearing a basal fold. Minor folds and parietal ridge present or absent.

This *Phos*-like genus may be recognized by its small protoconch, deep fossa, strongly inflated siphonal fasciole that bears sigmoid axial swellings, and wide smooth platform bordering the lower part of the columellar lip. Species of *Pallacera* have been referred to *Phos* and *Nassa*. According to an oral communication from A. A. Olsson, the radula of the type species of *Pallacera* is nassarid. In fact, "*Nassa*" *myristicata* was chosen as the type species because its radula is known. Many years ago Dall (*in* Guppy and Dall, 1896, p. 311–312; *in* Dall and Simpson, 1901, p. 402) assigned species of *Pallacera* to *Strongylocera*. It has been pointed out that that name is not suitable (Woodring, 1928, p. 260). The species of *Pallacera* that have slightly shouldered whorls bear a superficial resemblance to *Engoniophos* (Woodring, 1928; p. 263; type (orthotype): *Phos erectus* Guppy, Miocene, Jamaica). *Engoniophos*, however, has an *Antillophos*-like protoconch, a less inflated fasciole, and lacks a fossa and axial swellings on the siphonal fasciole. It may be treated as a subgenus of *Antillophos*.

The earliest species of *Pallacera* are of early Miocene age and are found in the Dominican Republic, Haiti, Puerto Rico, and Florida: "*Phos*" *costatus* Gabb (Pilsbry, 1922, p. 349, pl. 22, figs. 10, 14; Dominican Republic, Haiti, Puerto Rico), "*Phos*" *chipolanus* Dall (Gardner, 1926–47, p. 460, pl. 50, fig. 20, 1944; Florida), and "*Phos*" *pedanus* Gardner, (*idem*, p. 461, pl. 50, fig. 19; Florida), which may be a synonym of "*Phos*" *costatus*. Middle Miocene species occur in the Dominican Republic, Canal Zone, and Florida: "*Phos*" *fasciolatus* Dall (*in* Guppy and Dall, 1896, p. 311, pl. 28, fig. 12), the species now described as *Pallacera* cf. *P. guadelupensis*, and "*Phos*" *tribakus* Gardner (1926–47, p. 461, pl. 50, fig. 22, 1944), respectively. There are no late Miocene records. "*Nassa*" *solidula* Guppy (1866, p. 579, pl. 26, fig. 11, a poor illustration), from the Cumaná area of Venezuela—the only Pliocene species—is closely related to the Recent West Indian "*Nassa*" *guadelupensis*. The genus survives on both sides of Central America: "*Nassa*" *guadelupensis* Petit (1852, p. 56, pl. 2, figs. 3, 4) in the Caribbean Sea and the type species in the Panamic region. Dall (1889, p. 178; *in* Dall and Simpson, 1901, p. 402) used Say's (1827, p. 211) name *Nassa uncinata* for the Caribbean species. Say, however, cited South Carolina as the locality for his unillustrated species and his description is not convincing as a description of the Caribbean

species. The type seems to be lost. Hinds' (1844-1845, p. 36, pl. 9, figs. 10, 11, 1844) record of the Cape of Good Hope for his "*Nassa*" *myristicata* is considered erroneous (Pilsbry and Lowe, 1932, p. 68, pl. 6, fig. 1). Two beach-drift specimens of Hinds' species, collected at Panamá, in the collections of the U. S. National Museum are labeled types of "*Alectrion gorgon* Dall," which evidently is a nude name.

***Pallacera* aff. *P. guadelupensis* (Petit)**

Plate 43, figures 2, 6

Relatively small, whorls slightly shouldered. Protoconch not preserved. Axial ribs wide and widely spaced; seven on last preserved whorl. Spiral threads of unequal width, greatly subdued, narrow, closely spaced. Sigmoid axial swellings on siphonal fasciole moderately strong. Basal fold on columellar lip strong. Supplementary folds and parietal ridge absent.

Height (almost complete) 15.3 mm, diameter 8.6 mm (figured specimen).

One somewhat worn specimen of this species was found in the middle part of the Gatun formation at locality 155. It probably is immature, although the basal fold on the columellar lip is strong for the size of the shell. The whorls of some specimens of *Pallacera guadelupensis* are slightly shouldered, but not as distinctly shouldered as those of the fossil, which has also wider and more widely spaced axial ribs than the Recent species.

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

Genus *Nassarius* Duméril

Duméril, Zoologie analytique, p. 166, 1806 (genus without species).

Type (monotype. Froriep, C. Duméril's analytische Zoologie, p. 167, 1806; quoted from Iredale, Malacol. Soc. London Proc., v. 12, p. 83, 1916): *Buccinum arcularia* Linné (*ancularia*, by error). Recent, western Pacific Ocean.

For the time being *Nassarius*, like *Naticarius* (p. 85), is treated arbitrarily as a new name. Should it be treated as a substitute name for Lamarck's *Nassa*, the type species would be *Buccinum mutabile* Linné (Woodring, 1928, p. 264).

Though many names have been proposed for minor groups of *Nassarius*-like species, the relations of these minor groups have not been determined.

Subgenus *Uzita* H. and A. Adams

H. and A. Adams, The Genera of Recent Mollusca, v. 1, p. 120, 1853.

Type (logotype, Cossmann, Essais de paléoconchologie comparée, pt. 4, p. 205, 1901): *Buccinum migum* Bruguière (cited by H. and A. Adams as [*Nassa*] *miga* Adanson), Recent, West Africa.

***Nassarius* (*Uzita*?) *praeambiguus* (Brown and Pilsbry)**

Plate 43, figures 1, 4

Nassa (*Hima*) *praeambigua* Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 506, pl. 22, figs. 6, 7, 1913 (Miocene, Canal Zone).

Small, moderately inflated, spire whorls practically flat. Protoconch small, consisting of $2\frac{1}{4}$ to $2\frac{1}{2}$ whorls. Axial ribs about as wide as spaces between them on spire whorls, generally wider than spaces on body whorl. Ten to 14 ribs on body whorl, not including terminal varix. Spiral threads strong on axial ribs, weak to almost absent in spaces between ribs. Generally three threads on penult whorl, rarely four through doubling of sutural thread. Outer lip strongly varicose. Siphonal fasciole slightly inflated; fossa (depression limiting siphonal fasciole) very shallow. Elongate denticles on interior of outer lip heavy, except near insertion of lip. Columellar lip bearing narrow, elongate denticles. Parietal ridge strong.

Height 6 mm, diameter 4 mm (specimen from La Boca formation). Height 6.5 mm, diameter 3.8 mm (figured specimen, Gatun formation). Height 8 mm, diameter 4.5 mm (largest specimen from La Boca formation).

Type material: 2 syntypes, Acad. Nat. Sci. Phila. 3825.

Type locality: "Lignitic clay below the *Pecten* bed at Tower N, Culebra Cut", Canal Zone [northern Gaillard Cut area, La Boca formation below Emperador limestone member].

The type material of *Nassarius praeambiguus* was found in strata formerly classified as part of the Culebra formation, but now assigned to the La Boca formation (p. 244). It can still be collected from fine-grained rocks underlying the Emperador limestone member, as at locality 101 (pl. 8). The La Boca specimens, like those of the associated *Bittium scotti* (p. 178), are in poor condition owing to a partial crust of gypsiferous tuffaceous material. Attempts to clean them invariably led to damage. Except for the gross features, the preceding description is based on specimens from the Gatun formation that are considered conspecific—that is, conspecific on the basis of what the poorly preserved La Boca specimens show. The body whorl axial ribs, however, tend to be narrower on the La Boca fossils. The illustrations represent a Gatun fossil.

N. praeambiguus is fairly common in the lower part of the Gatun formation, but only two specimens are in collections from the middle part. A specimen from locality 138c is exceptionally large (height 9 mm, diameter 5 mm). It has a heavy varix on the penult

whorl, in a position corresponding to the terminal varix of other mature specimens.

Despite its name, this species is not in the lineage of the Recent Caribbean species formerly known as *N. ambiguus* (Montagu), but now designated *N. albus* (Say) (Abbott, 1958, p. 74). *N. praeambiguus* is smaller and has flatter whorls, smaller protoconch, and shallower fossa. In fact, the fossa is so shallow that assignment to the subgenus *Uzita* is doubtful. Early Miocene forms related to *N. praeambiguus*—perhaps one variable species—are found in Florida: *N. cinclis* (Gardner) (1926-47, p. 472, pl. 51, fig. 8, 1944), *N. dasynema* (Gardner) (Idem, p. 473, pl. 51, fig. 9), and *N. dasynema cestus* (Gardner) (Idem, p. 474, pl. 51, fig. 14). The Florida forms have a less massive terminal varix, more delicate apertural denticles, and deeper fossa.

Occurrence: La Boca formation (early Miocene), localities 99b, 100, 100a, 101. Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 137, 137a, 138, 138a, 138c, 138d. Middle part, eastern area, locality 147i.

***Nassarius (Uzita) cercadensis* (Maury)**

Alectrion cercadensis Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 90, pl. 15, figs. 19, 20, 1917 (Miocene, Dominican Republic).

Alectrion brassica Maury, Idem, v. 10, no. 42, p. 210, pl. 36, fig. 12, 1925 (Miocene, Trinidad).

Alectrion brassoensis Mansfield, U.S. Natl. Mus. Proc., v. 66, art. 22, p. 46, pl. 7, fig. 3, 1925 (Miocene, Trinidad).

Nassarius (Uzita) cercadensis (Maury), Woodring, Carnegie Inst. Washington Pub. 385, p. 266, pl. 16, fig. 4, 1928 (Miocene, Jamaica).

Small, strongly inflated, spire whorls almost flat. Protoconch consisting of $3\frac{1}{4}$ whorls, the last of which bears three or four weak axial riblets. Axial ribs wide and widely spaced; nine on body whorl, not including terminal varix. Spiral threads narrow and closely spaced; five on penult whorl. Outer lip strongly varicose. Siphonal fasciole strongly inflated; fossa moderately deep. Apertural features like those of *Nassarius praeambiguus*.

Height 4.4 mm, diameter 2.4 mm.

Type material: Lectotype (specimen represented by Maury's fig. 20), Cornell University 36856.

Type locality: Río Mao, Dominican Republic, Cercado formation.

Five small shells from the middle and upper parts of the Gatun formation are identified as *Nassarius cercadensis*. All are imperfect, one so imperfect that the identification is doubtful. The largest is not much more than half as large as large shells from the Dominican Republic.

The small *Nassarius* in the middle Miocene part of the Brasso formation of Trinidad, named *N. brassicus* and *N. brassoensis*, seems to be indistinguishable from *N. cercadensis*.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 139c (identification doubtful); western area, locality 161c. Upper part, eastern area, locality 163. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Middle Miocene part of Brasso formation, Trinidad.

Subgenus *Nanarius* Woodring, n. subgen.

Type: *Uzita paraprasta* Gardner, Miocene, Florida and Canal Zone.

Very small to small, slender to strongly inflated. Protoconch large for size of shell, small-tipped. Sculpture reticulate. Axial ribs narrow to wide; spiral threads narrow and delicate. Outer lip strongly varicose. Siphonal fasciole slightly inflated; fossa absent. Elongate ridges on interior of outer lip fairly strong, except at insertion of lip, where they are weak. Columellar lip bearing weak elongate denticles. Parietal ridge weak to fairly strong.

The diminutive size, large protoconch, and absence of a fossa are characteristic features of *Nanarius*. Aside from the occurrence in the Canal Zone, the only forms of *Nanarius* that have come to my attention are found in the middle Miocene Shoal River formation of Florida: *Nassarius paraprastus paraprastus* (Gardner) (1926-47, p. 480, pl. 51, fig. 27, 1944) and *N. pristus* (Gardner) (Idem, p. 481, pl. 51, fig. 28).

***Nassarius (Nanarius) paraprastus acolus* Woodring, n. subsp.**

Plate 40, figures 16, 17

Very small, slender. Protoconch consisting of $3\frac{1}{4}$ to $3\frac{1}{2}$ whorls, the last of which bears two to four axial riblets. Axial ribs of post-protoconch whorls narrow and widely spaced; nine to 12 on body whorl, not including the much wider terminal varix. Spiral threads very narrow and widely spaced; three or four on penult whorl. Elongate ridges on interior of outer lip delicate. Elongate denticles on columellar lip and parietal ridge weak.

Height 3.3 mm, diameter 1.8 mm (type).

Type: USNM 643668.

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.

This minute nassarid occurs in the middle part of the Gatun formation in the eastern area. It is abundant along the Panama Railroad southeast of Gatun, extraordinarily abundant at the type locality, where several thousand specimens were collected. With few exceptions these little fossils are remarkably uniform. The most notable exceptions are three unusually large specimens: two from the type locality and one from locality 147g. Though they have a height of four millimeters, resulting from the addition of a whorl or a fraction of a whorl, their diameter is the same, or practically the same, as that of mature specimens of normal size. Two of these relatively large fossils bear a varix on the body whorl in addition to the terminal varix. A few other specimens of normal size also have an extra varix on the body whorl.

Nassarius paraprismus acolus is more slender and a little smaller than *N. paraprismus paraprismus* (cited in description of *Nanarius*).

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), localities 146, 147b, 147f, 147g, 147h, 147i (identification doubtful), 151, 153a.

***Nassarius (Nanarius) paraprismus conarus* Woodring, n. subsp.**

Plate 43, figures 3, 8

Larger than *N. paraprismus paraprismus* and larger and more inflated than *N. paraprismus acolus*. Terminal varix more massive than that of those subspecies and apertural ridges and denticles correspondingly coarser.

Height 4.7 mm, diameter 2.8 mm (type).

Type: USNM 643669.

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

Nassarius paraprismus conarus is found in the lower part of the Gatun formation and in strata near the base of the middle part. It evidently is a shallow-water analog of *N. paraprismus acolus*. In size *N. paraprismus paraprismus* is intermediate between the two Gatun subspecies, but in degree of inflation it is like *N. paraprismus conarus*. *N. pristus* (cited in description of *Nanarius*) is much like *N. paraprismus paraprismus*, but has wider axial ribs and weaker spiral threads.

One of some 70 specimens from locality 139b is exceptionally large (height 6.2 mm, diameter 3.3 mm) and has an extra body-whorl varix. The occurrence of an occasional exceptionally large specimen, already noted for *N. praeambiguus* and *N. paraprismus acolus*, is not unusual among small species of *Nassarius*.

Occurrence: Lower and middle part of Gatun forma-

tion (middle Miocene). Lower part, localities 136a, 137, 137a, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 139e, 139f.

Subgenus?

Nassarius species

Two imperfect specimens from the middle part of the Gatun formation are assigned to an unidentified species of *Nassarius*. The protoconch consists of 3½ whorls, the last of which bears five arcuate axial riblets. The axial ribs of post-protoconch whorls are relatively wide and the spiral threads are narrow and strong. The last preserved whorl bears nine axial ribs and the penult whorl three spiral threads. There is no fossa. Dimensions of the larger specimen, not quite complete, are as follows: height 4.6 mm, diameter 2.6 mm.

The larger sculptured protoconch, stronger spiral threads, and absence of even a shallow fossa distinguish this species from *Nassarius praeambiguus*. The slightly smaller protoconch, arcuate protoconch riblets, and wider axial ribs serve to distinguish it from *N. paraprismus*.

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), locality 147g.

Genus *Leptarius* Woodring, n. gen.

Type: *Leptarius leptus* Woodring, n. sp., Miocene, Gatun formation, Canal Zone.

Moderately small, very slender, columbellid-like. Sculpture dominated by nodes at intersection of suppressed axial ribs and suppressed spiral threads. Nodes absent on flattened apertural face of body whorl, except near suture. Siphonal fasciole moderately inflated; fossa moderately deep. Outer lip varicose, its interior bearing relatively weak ridges. Columellar lip smooth. Parietal ridge moderately strong, bordering a narrow posterior channel.

This monotypic genus suggests a columbellid. Its apertural features, however, are nassarid. *Nassarius acutus* Say (1822, p. 234), which ranges from North Carolina to Texas, is slender for a species of *Nassarius*, but not nearly as slender as *Leptarius leptus*. Though the spiral threads of *N. acutus* are swollen on the axial ribs to form elongate nodes, the nodes are connected by a distinct spiral thread. The sculpture is reduced on the apertural face of the body whorl of *N. acutus*, but is not entirely suppressed.

Leptarius leptus Woodring, n. sp.

Plate 44, figures 1, 5

Outline, siphonal fasciole, fossa, and apertural features as described under the genus. Protoconch

small, apparently consisting of about $2\frac{1}{2}$ whorls. Sculpture suppressed at an early stage, possibly on first post-protoconch whorl, to take the form of slight axial swellings connecting bead-like nodes arranged in two, later three, spiral rows. Spiral threads faint or absent between nodes on spire whorls. Ten or 11 axial rows of nodes on penult whorl. Axial swellings and nodes disappearing on flattened apertural face of body whorl, except near suture. Flattened face bordered by a wide axial swelling bearing elongate nodes. Later axial swellings narrower and later nodes bead-like, both suppressed on basal part of whorl. Spiral threads, progressively more ledge-like toward base, appearing on body whorl. Near outer lip these threads are faint or disappear, except three at base of whorl. Siphonal fasciole bearing four closely spaced spiral threads.

Height 9 mm, diameter 3.6 mm (type).

Type USNM 643670.

Type locality: 170 (USGS 8368, Headwaters of Quebrada Caña [Río Caño Quebrado], station 4a, Panamá), middle part of Gatun formation.

The middle part of the Gatun formation in the western area yielded three specimens of this slender columbellid-like species, as well as the only specimens of the Terebrid-like columbellid *Strombinella olssoni* (p. 255). Though the tip is preserved on the type of *Leptarius leptus*, it is somewhat worn. The type presumably is not quite mature. A larger specimen (locality 161c) that lacks several early whorls has a heavier terminal varix. It would have an estimated height of 10.5 millimeters, if it were complete.

Occurrence: Middle part of Gatun formation, western area (middle Miocene), localities 161c, 170.

Family MELONGENIDAE

Genus *Melongena* Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 212, 1817.

Type (monotype): *Melongena fasciata* Schumacher (= *Murex melongena* Linné, which is also the tautotype), Recent, West Indies.

Melongena species

Fragmentary and otherwise poorly preserved remains of *Melongena*, which presumably are to be referred to one species, occur in the Culebra and La Boca formations. Early whorls are strongly shouldered and the shoulder bears a row of blunt spines. At maturity, as shown by a Culebra fragment that has a diameter of about 80 mm (locality 108c), the shoulder is rounded and spineless. A smaller La Boca specimen, which lacks the spire and shoulder (locality 99d), shows fairly strong, relatively coarse

spiral sculpture and a row of spines on the lower part of the body whorl.

The material is inadequate to determine the affinities of this species.

Occurrence: Culebra formation (early Miocene), localities 108c, 110, 110a. La Boca formation (early Miocene), localities 99a, 99b, 99d.

Melongena melongena consors (Sowerby)

Plate 44, figures 2, 4, 6, 8

Pyrula consors Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 49, 1850 (Miocene, Dominican Republic).

Melongena melongena (Linné), Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 205, 1873 (Miocene, Dominican Republic).

Pyrula melongena (Linné), Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 523, 1876 (Miocene, Dominican Republic).

Melongena consors (Sowerby), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 1, p. 121, 1890 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 85, pl. 14, fig. 5, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 347, pl. 31, fig. 5, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 112, pl. 9, fig. 1, 1922 (Miocene, Costa Rica). ?Maury, Idem, v. 10, no. 42, p. 208, (part), not pl. 35, fig. 12 (= *M. colombiana* Weisbord), 1925 (Miocene, Trinidad). Weisbord, Idem, v. 14, no. 54, p. 44, pl. 7, fig. 5, 1929 (Miocene, Colombia). ?Tucker and Wilson, Idem, v. 18, no. 65, p. 176, pl. 19, fig. 4, 1932 (Pliocene, Florida) [?= *M. corona* (Gmelin)].

Melongena melongena consors (Sowerby), Olsson, Idem, v. 19, no. 68, p. 176, pl. 19, fig. 4, 1932 (Miocene, Perú).

Large, subglobose, spire partly enveloped by late whorls. Suture not channeled or slightly channeled. Early whorls angulated at shoulder. Early axial sculpture consisting of swellings, which are weak above shoulder and strong on and just below shoulder. Early spirals weak and threadlike above shoulder, strong and cordlike on and just below shoulder. Axial swellings on shoulder developing into blunt spines. Shoulder rounded on late whorls. Early parts of body whorl of mature shells bearing one or two rows of spines in peripheral area; later part two or three (generally three) rows. Lower part of body whorl bearing a row of smaller spines. Spiral sculpture weak on mature body whorl. Thick parietal callus filling space between apex of anal notch and suture on later part of mature body whorl.

Height 130 mm, diameter (without spines) 87 mm (large figured specimen).

Type: British Mus. (Natural History), Geol. Soc. London collection 12814.

Type locality: Northern part of Dominican Republic, Miocene.

Fifteen specimens—14 from the lower part of the Gatun formation and one from the middle part—are referred to *Melongena melongena consors*. These

fossils are very similar to the Recent West Indian *M. melongena melongena* (Clench and Turner, 1956, p. 165, pl. 98), but lack the deeply channeled suture of the Recent form.

M. melongena consors appeared in early Miocene time in the Dominican Republic and was widely distributed in middle Miocene deposits in the Dominican Republic, Costa Rica, Panamá, Colombia, and probably in Trinidad. According to Olsson's identification, it occurs also in the early Miocene Zorritos formation of Perú. The specimen he illustrated is greatly inflated in the peripheral area. Immature specimens from the middle Miocene Manzanilla Formation of Trinidad (USGS 21750, 9197b) probably represent *M. melongena consors*. Maury's illustrated specimen from that formation, however, and other Manzanilla fossils (USGS 21082) are identified as *M. colombiana* Weisbord (1929, p. 43, pl. 7, figs. 2-4). Her records for other Miocene formations in Trinidad were tentative. Both *M. columbiana* and *M. melongena consors* are found in middle Miocene deposits in Colombia. *M. colombiana* occurs at other localities in the southern part of the Miocene Caribbean province: in Venezuela (Hedberg, 1937, p. 2,012, pl. 8, figs. 9a, 9b), Ecuador (Marks, 1951, p. 118), and Perú (Olsson, 1932, p. 177, pl. 19, fig. 1). It is a remarkable species, characterized by a thick deposit of parietal callus that appears at an early stage and partly envelops the spire, as well as by a row of spines adjoining the suture and by strong spiral sculpture. It is closely related to—and probably a descendant of—the much smaller *M. orthacantha* Pilsbry and Johnson of the Dominican Republic (Pilsbry, 1922, p. 348, pl. 28, figs. 13-16) and Haiti (Woodring, Brown and Burbank, 1924, p. 182, 193, pl. 16, fig. 5).

It seems to be probable that Tucker and Wilson's Pliocene *Melongena* from Florida is an aberrant representative of the lineage of *M. corona* (Gmelin). Aside from this doubtful record, the lineage of *M. melongena* is unknown in Florida, fossil or Recent.

M. melongena consors evidently is the predecessor of *M. melongena melongena* and also of the Recent Panamic *M. patula* (Broderip and Sowerby) (Clench and Turner, 1956, p. 168, pl. 99), both of which have a deeply channeled suture. *M. patula* has one row of spines in the peripheral area or none, and generally lacks the row of small spines on the lower part of the shell. An occasional specimen of *M. melongena melongena* lacks spines. Such specimens may be distinguished from *M. patula* by their lighter coloration—a feature that would be unavailable in fossils of ordinary preservation. The status of the middle Mio-

cene Colombian *M. propatulus* Anderson (1929, p. 133, pl. 11, figs. 1, 2) is undetermined.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 137a, 138, 138c. Middle part, eastern area, localities 139e, 155b. Baitoa formation (early Miocene), Cercado and Gurabo formations (middle Miocene), Dominican Republic. Zorritos formation (early Miocene), Perú. Deposits of middle Miocene age, Costa Rica and Colombia. Manzanilla formation (middle Miocene), Trinidad (identification doubtful).

Family FASCIOLARIIDAE

Genus *Latirus* Montfort

Montfort, Conchyliologie systématique, vol. 2, p. 531, 1810.

Type (orthotype): *Latirus aurantiacus* Montfort (= *Murex gibbulus* Gmelin), Recent, Australia.

Subgenus *Polygona* Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 241, 1817.

Type (monotype): *Polygona fusiformis* Schumacher (= *Murex infundibulum* Gmelin), Recent, West Indies.

Two incomplete fossils from the Caimito formation of Pato Horqueto Island, in Gatun Lake (locality 55b), suggest a relatively low-spined, inflated species of *Latirus*.

Contrary to expectation, *Latirus* is not represented in any of the collections from the Gatun formation at hand. Toulou's (1909, p. 702) unillustrated *Fusus* (*Latirus*) sp. aff. *F. iriae* Bellardi was not included in the shipment of his Gatun gastropods (p. 154) and evidently is no longer in his collection.

Latirus (*Polygona*) *anapetes* Woodring, n. sp.

Plate 47, figure 12

Of medium size, slender, widely umbilicate; whorls slightly constricted in sutural area. Protoconch not preserved. Axial ribs wide; seven on body whorl. Four primary spiral cords on penult whorl; seven on inflated part of body whorl. Three secondary spiral threads on constricted sutural area; tertiary threads between them and between primary cords. Pillar sculptured with six widely spaced spiral cords and weak secondary threads. Columellar lip bearing four low folds and, near the edge, three low swellings or short ridges.

Height (incomplete) 50.7 mm, diameter 21 mm (type).

Type: USNM 643698.

Type locality: 208 (USGS 8437, Caribbean coast at mouth of Río Indios [Indio], station 5, Panamá, Chagres sandstone.

The type—the only specimen of this slender, widely umbilicated species—was found in the Chagres sand-

stone at locality 208. Its ribs are more strongly constricted in the sutural area, and are fewer and more widely spaced than those of *Latirus taurus* Olsson (1922, p. 108, pl. 8, fig. 4), from the upper Miocene of northwestern Panamá. A Recent species living along the coast of southeastern Florida, *L. mcgintyi* Pilsbry (1939, p. 84, pl. 5, fig. 8), is more inflated and its periphery is angulated.

Occurrence: Chagres sandstone (early Pliocene), locality 208.

Genus *Fasciolaria* Lamarck

Lamarck, Soc. Histoire Nat. Paris. Mém., p. 73, 1799.

Type (monotype): *Murex tulipa* Linné, Recent, Florida and West Indies.

The fossils from the Culebra formation include two specimens (one immature, the other a fragment) of a bluntly spinose *Fasciolaria* (locality 116a). The protoconch is smaller than that of *F. gorgasiana*—the next species described—and, according to the fragment, the spines of intermediate whorls are not as strongly compressed.

Fasciolaria gorgasiana Brown and Pilsbry

Plate 43, figures 5, 7, 11

?*Fasciolaria* sp. undet., Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., vol. 63, p. 348, 1911 (Miocene, Canal Zone).

Fasciolaria gorgasiana Brown and Pilsbry, Idem, v. 64, p. 506, pl. 22, fig. 5, 1913 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 105, pl. 8, fig. 9, 1922 (Miocene, Canal Zone, Costa Rica).

Moderately large, shoulder bearing blunt spines. Protoconch large, cylindrical, 1½-whorled, last whorl sculptured with closely spaced axial riblets. Axial ribs of first post-protoconch whorl gradually transformed into blunt shoulder spines compressed in a plane perpendicular to axis of shell. Spiral sculpture fairly strong on early whorls, weak on intermediate and late whorls.

Height (practically complete) 63.5 mm, diameter 30 mm (figured immature specimen). Height 102 mm (figured body-whorl fragment).

Type: Acad. Nat. Sci. Phila. 3832.

Type locality: Gatun Locks excavation, Canal Zone, Gatun formation.

Though *Fasciolaria gorgasiana* was found at three localities in the lower part of the Gatun formation and at four in the middle part, it is not abundant and mature specimens are represented only by fragments. It is a species of a Miocene Caribbean small group characterized by compressed blunt spines. *F. kempi* Maury (1917, p. 81, pl. 12, fig. 4), which occurs in the early Miocene Baitoa formation of the Dominican Republic, is the earliest species of this group. It is a

little more slender than *F. gorgasiana* and fairly strong spiral sculpture between the periphery and the suture lasts until a later stage. Anderson's (1929, p. 132) *F. kempi*, from the middle Miocene of Colombia, may be *F. gorgasiana*, but the Colombian specimens are not well preserved. *F. macdonaldi* Olsson (1922, p. 106, pl. 8, fig. 1; middle Miocene, Costa Rica) has strong spiral sculpture and strongly compressed spines.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139c, 139e, 153, 155, 155b, 155c. Deposits of middle Miocene age, Costa Rica.

Fasciolaria gorgasiana Brown and Pilsbry, subspecies

Plate 45, figure 17

Fasciolaria (*Pleuroploca*) cf. *gorgasiana* Brown and Pilsbry, Rutsch, Schweizer. Palaeont. Gesell. Abh., Band 54, no. 3, p. 74, pl. 5, fig. 3, 1934 (Miocene, Venezuela).

Two fragments of a large mature shell (height of figured body-whorl fragment 99.5 mm) show that a form of *Fasciolaria gorgasiana* occurs in the upper part of the Gatun formation in the western area. On late whorls, especially on the mature body whorl, the spines of this form are more strongly compressed in a plane perpendicular to the axis of the shell than those of *F. gorgasiana* proper. The spines of the Miocene Costa Rican *F. macdonaldi*, already mentioned under *F. gorgasiana* proper, also are strongly compressed, but the spiral sculpture of that species is strong.

This unnamed subspecies of *F. gorgasiana* is found in the Punta Gavilán formation, which, like the upper part of the Gatun formation in the western area, is considered of late Miocene age. *F. gorgasiana* left no descendants in western Atlantic or eastern Pacific waters.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 182. Punta Gavilán formation (late Miocene), Venezuela.

Family FUSINIDAE

Genus *Fusinus* Rafinesque

Rafinesque, Analyse de la nature, p. 145, 1815. Emended name for *Fusus* Lamarck, 1799 (not *Fusus* Helbling, 1779).

Type (monotype of *Fusus* Lamarck): *Murex colus* Linné, Recent, western Pacific Ocean.

A poorly preserved fossil from the lower part of the Caimito formation of Madden basin (locality 71) is listed as *Fusinus?* sp. Another from the La Boca formation (locality 99b) and three from the Culebra formation (locality 111a) are also listed as *Fusinus?* sp.

Fusinus empleus Woodring, n. sp.

Plate 43, figures 9, 13

Moderately large, moderately inflated, whorls almost evenly inflated. Protoconch not preserved. Early whorls sculptured with wide axial ribs; 10 on antepenult whorl. Ribs gradually suppressed on early part of penult and disappearing on later part. Primary spiral cords strong throughout; 10 on penult. Secondary spiral threads strong in peripheral region of body whorl. Microscopic axial sculpture fairly strong. Siphonal canal long, straight. Parietal callus absent.

Height (incomplete) 90.5 mm, diameter 30 mm (type).

Type: USNM 643674.

Type locality: 185 (USGS 8383, Caribbean coast, west of Río San Miguel [Río Miguel], station 26 plus 100 feet (30 meters), Panamá), upper part of Gatun formation.

Though *Fusinus* is fairly common in the Miocene faunas of the Caribbean region, the type of *Fusinus empleus* is the only specimen of the genus in the collections from the Gatun formation at hand.

F. empleus is most closely related to *F. veatchi* (Maury) (1917, p. 79, pl. 12, fig. 3; Cercado formation, Dominican Republic) and perhaps is to be treated as a subspecies of that species. The whorls of *F. veatchi* are more distinctly constricted in the sutural area. *F. springvalensis* (Maury) (Vokes, 1938, p. 23, figs. 27, 28; Springvale formation, Trinidad) and *F. magdalenensis* Anderson (1929, p. 133, pl. 15, figs. 1-3; Miocene, Colombia) not only have whorls that are more distinctly constricted in the sutural area, they have also heavier spiral sculpture and wider axial ribs. The name *F. magdalenensis* probably is to be suppressed in favor of *F. springvalensis*.

The Recent *F. closter* (Philippi) (Grabau, 1904, p. 38, pl. 3, figs. 1, 8), from the coast of Venezuela, enlarges more rapidly in diameter. The Recent Panamic *F. dupetitthouarsi* (Kiener) (Keen, 1958, p. 418, fig. 610) has heavier spiral sculpture and reaches a much larger size. Its whorls are angulated or rounded.

Occurrence: Upper part of Gatun formation, western area (late Miocene), locality 185.

Fusinid, genus?

An unidentified, apparently unnamed, fusinid genus is represented by three immature specimens found in the middle part of the Gatun formation in the eastern area: one at locality 155c and two at locality 157. These fossils have a low spire, which rapidly enlarges in diameter, almost evenly inflated whorls, and a long straight siphonal canal. The protoconch is notably

unlike that of *Fusinus*. It is conical, 3½-whorled, and smooth. Its end is marked by a varix and the abrupt appearance of sculpture. The axial ribs are low and narrow. They disappear at an early stage (estimated to be the fifth post-protoconch whorl) on one specimen and do not quite disappear at the same stage on another. The spiral cords are narrow. A secondary thread, or threads, appears between some of them. Dimensions of the largest of these fossils are as follows: restored height about 30 mm, diameter 12.5 mm.

The outline suggests the Miocene to Recent genus *Heilprinia* (Grabau, 1904, p. 87; type (orthotype): *Fusus caloosaensis* Heilprin, Pliocene, Florida), of southeastern United States. The protoconch of *Heilprinia* is cylindrical and sculptured with axial riblets, and the early and intermediate post-protoconch whorls are constricted in the sutural area. The outline suggests also the Miocene European genus *Euthriofusus* (Cossmann, 1901, p. 27; type (orthotype): *Fusus burdigalensis* Basterot). The early whorls of that genus are subangular and its protoconch is cylindrical. The protoconch is described as bearing axial riblets on the last whorl (Grabau, 1904, p. 93). Though some 50 specimens of the type species are available, none shows the protoconch.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155c, 157.

Family OLIVIDAE

Poorly preserved small olivids of undetermined affinities occur in the Gatuncillo formation and in the marine member of the Bohio (?) formation.

Subfamily OLIVINAE

Genus *Oliva* Bruguière

Bruguière, Encyclopédie méthodique, Histoire naturelle des vers, v. 1, p. XV, 1789 (genus without species).

Type (monotype and tautotype, Lamarck, Soc. Histoire Nat. Paris Mém., p. 70, 1799): *Voluta oliva* Linné, Recent, western Pacific Ocean.

Subgenus *Oliva* s. s.

Unidentifiable remains, listed as *Oliva* sp., indicate the occurrence of a relatively small species of *Oliva*, comparable in size to *O. liodes* Dall (Gardner, 1926-47, p. 378, pl. 46, fig. 1, 1937 (1938); Miocene, Florida), in the Caimito formation of the Gatun Lake area and in the La Boca formation. The Caimito species is the earliest so far found in the Caribbean region.

Oliva (*Oliva*) *gatunensis* Toulou

Plate 45, figs. 12, 13, 16

Oliva gatunensis Toulou, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 702, pl. 25, fig. 12, 1909 (Miocene, Canal Zone).

Cossmann, Jour. Conchyliologie, v. 61, p. 58, pl. 5, figs. 9-12, 1913 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 89, pl. 7, fig. 5, 1922 (Miocene, Canal Zone).

Oliva (Neocylindrus) gatunensis Toulou, Engerrand and Urbina, Soc. Geol. Mexicana Bol., t. 6, p. 126, figs. 18, 19 (Toulou's illustrations); probably not figs. 20, 21, 1910 (Miocene, México).

Oliva reticularis gatunensis Toulou, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 348, 1911 (Miocene, Canal Zone).

Of medium size, moderately slender, spire moderately high. Outline of apical whorls slightly concave; outline of remaining spire whorls smoothly tapering or slightly convex. Tip of protoconch small. Second whorl from tip rapidly enlarging in height. Sutural groove narrow, beginning on third whorl from tip of protoconch. Sutural callus thick, bulging. Parietal plaits moderately strong.

Height 32 mm, diameter 14.5 mm (figured topotype). Height 36.3 mm, diameter 14.6 mm (largest figured specimen). Height 42.3 mm, diameter 18.6 mm (largest specimen).

Type material: Lectotype, Tech. Hochschule, Vienna.

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

Oliva gatunensis is widespread in the three parts of the Gatun formation and at many places is abundant. In the upper part in the western area, however, it is replaced by a small subspecies of *O. reticularis*. Several hundred specimens of *O. gatunensis* were collected at locality 138d, in the lower part of the formation.

The two specimens illustrated by Toulou are the only ones now in his collection. The larger (height 28.9 mm, diameter 12.9 mm) is designated the lectotype. The lectotype and topotypes, such as that shown on plate 45, figure 13, are relatively small. Other localities, especially several in the middle part of the Gatun, have yielded also only relatively small specimens. Though the tip of the protoconch is small, without magnification the apical whorls produce the effect of a large tip, owing to the height of the second whorl. As indicated by the illustrations, there is some variation in the degree of inflation and in the height of the spire, but the range is not great. Slender specimens generally are high-spined. Slender, high-spined shells (pl. 45, fig. 16) and relatively large shells are most prevalent in the upper part of the Gatun in the eastern area.

In view of difficulties involved in the classification of many fossil species of *Oliva*, it is not surprising that the geographic and stratigraphic range of *O. gatunensis* are uncertain. The outline and thick sutural callus of *O. sayana immortua* Pilsbry and Brown

(1917, p. 33, pl. 5, fig. 6; middle Miocene, Colombia) suggest that it is a form of *O. gatunensis*. It is doubtful whether *O. gatunensis* occurs in the Miocene of Chiapas, México, as reported by Engerrand and Urbina. The Gatun species seems to be closely related to the Recent Caribbean *O. reticularis* Lamarck (Abbott, 1954, p. 245, pl. 12, fig. c), which is larger, has a thinner sutural callus, wider sutural groove, and generally has a higher spire. In size and height of spire *O. gatunensis* is similar to *O. caribaeensis* Dall and Simpson (1901, p. 391, pl. 56, fig. 9), also a Recent Caribbean species. That Recent species may be distinguished by its wider sutural groove.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136 (identification doubtful), 136a (immature), 137a, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139b (immature), 139c, 139e, 139f, 141 (identification doubtful), 142, 147a (identification doubtful), 147b, 153, 153a, 154 (identification doubtful), 155, 155a, 155b, 155c, 156, 157, 159, 159a, 159b; western area, localities 161, 161a, 161c, 161d (immature) 162 (immature identification doubtful). Upper part, eastern area, localities 171, 172 (immature), 175, 176a, 177, 177a, 177b, 177c, 177d.

Oliva (Oliva) reticularis Lamarck, subspecies

Plate 45, figure 15

Of medium size, moderately slender, spire generally high. Outline of spire whorls smoothly tapering. Protoconch whorls naticoid. Sutural groove relatively wide, beginning on third whorl from tip of protoconch. Sutural callus moderately thick, flat, or slightly bulging. Parietal plaits moderately strong.

Height 36 mm, diameter 15.3 mm (figured specimen). Height (not quite complete) 38.7 mm, diameter 17.7 mm (largest specimen).

The *Oliva* in the upper part of the Gatun formation in the western area is identified as a small subspecies of the Recent Caribbean *Oliva reticularis*. These fossils have a thinner sutural callus and wider sutural groove than *O. gatunensis*, and most of them have a higher spire. Only one specimen shows the protoconch. Its second whorl does not increase as rapidly in height as that of the typical form of *O. reticularis* and *O. gatunensis*. This subspecies may be *O. reticularis trochala* Woodring (1928, p. 226, pl. 13, figs. 3-5; Miocene, Jamaica), which, however, is larger and has a protoconch like that of the typical form of *O. reticularis*. The typical form of *O. reticularis* occurs in the late Miocene deposits of the Bocas del Toro area in northwestern Panamá (USGS locality 8318, Cayo de Agua, and other localities).

The subspecies of *O. reticularis* is in seven of the eight collections from the upper part of the Gatun in the western area. Thirteen specimens—the largest number in any collection—were recovered at locality 182.

Occurrence: Upper part of Gatun formation, western area (late Miocene), localities 179, 180, 181, 182, 182a, 183, 185.

Oliva (Oliva) cristobalcoloni cristobalcoloni Maury?

The middle part of the Gatun formation at the Gatun Third Locks excavation yielded two incomplete and badly damaged specimens of a large, slender, high-spired *Oliva*. If the larger one were complete, it would have an estimated height of 75 mm; its diameter is 26 mm. Though these fossils leave much to be desired, they probably are to be referred to *O. cristobalcoloni cristobalcoloni*.

O. cristobalcoloni cristobalcoloni (Maury, 1917, p. 67, pl. 10, fig. 15) seems to be the proper name for the large *Oliva* found in the Cercado and Gurabo formations of the Dominican Republic and the Bowden formation of Jamaica. Gabb collected the largest specimens from the Dominican Republic (height 81.5 and 101 mm), named *O. proavia* by Pilsbry and Johnson (Pilsbry, 1922, p. 335, pl. 23, fig. 1). In 1928 the large species was identified as *O. plicata* Guppy (Woodring, 1928, pl. 13, fig. 7). That identification, however, was a serious error. As shown under the next heading, instead of being an immature specimen of the large species, the type of *O. plicata* is a mature specimen of the subgenus *Strephonella*. Under the name *O. plicata*, a small form of *O. cristobalcoloni* has been recognized in deposits of middle or late Miocene age in the Tehuantepec area (Perrilliat Montoya, 1960, p. 25, pl. 4, figs. 1, 2).

Two other large forms of *Oliva*, of a size comparable to *O. cristobalcoloni cristobalcoloni*, are known in the Caribbean region. Both are of Miocene age: *O. couvana* Maury (1925, p. 195, pl. 33, fig. 6; upper Miocene, Trinidad) and *O. tuberaensis* Anderson (1929, p. 128, pl. 17, figs. 2, 3; middle Miocene, Colombia). *O. couvana* may be treated as a subspecies of *O. cristobalcoloni* that tends to be more slender than the typical form—the treatment adopted by Rutsch (1942, p. 157, pl. 8, fig. 4). *O. tuberaensis* is more inflated than *O. cristobalcoloni*.

O. cristobalcoloni left no descendant in Caribbean or Panamic waters.

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

Subgenus *Strephonella* Dall

Dall, U.S. Geol. Survey Prof. Paper 59, p. 32, 1909.

Type (orthotype): *Lamprodoma (Strephonella) undatella* (Lamarck) (*Oliva undatella* Lamarck), Recent, Baja California to Ecuador.

On account of its small size *Oliva undatella* generally is referred to *Olivella*. That action was taken by Dall when he proposed the name *Strephonella*. He pointed out, however, that anatomical features observed by others indicate that it is to be referred to *Oliva*. That it is indeed a species of *Oliva* is confirmed by the radula (Olsson, in Keen, 1958, p. 422). As a matter of fact, the thin parietal callus and elongate parietal plaits point to *Oliva*.

The small size and the groove between the middle of the body whorl and the edge of the siphonal band are characteristic features of *Strephonella*. On *Oliva undatella* the groove marks the upper limit of a band differing in texture and color from adjoining parts of the whorl.

Strephonella is one of many genera and subgenera that lived in Caribbean waters during Miocene time, then reached extinction there, but survive in eastern Pacific waters.

Oliva (Strephonella) plicata Guppy

Plate 45, figures 4-7

Oliva plicata Guppy, in Guppy and Dall, U.S. Natl. Mus. Proc., v. 19, p. 308, pl. 30, fig. 12, 1896 (Miocene, Jamaica).

Oliva dimidiata Pilsbry and Johnson, Acad. Nat. Sci. Phila. Proc., v. 69, p. 165, 1917 (Miocene, Dominican Republic). Pilsbry, Idem, v. 73, p. 336, pl. 23, fig. 8, 1922 (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.

Oliva (Oliva) plicata Guppy, Woodring, Carnegie Inst. Washington Pub. 385, p. 228, pl. 13, fig. 6; not fig. 7 (= *O. cristobalcoloni* Maury), 1928 (Miocene, Jamaica).

not *Oliva (Oliva) plicata* Guppy, Perrilliat Montoya, Paleontología Mexicana, no. 8, p. 25, pl. 4, figs. 1, 2. (= *O. cristobalcoloni* Maury), 1960 (Miocene, México).

Small, slender, spire of moderate height. Second whorl from tip of protoconch enlarging rapidly in height. Sutural groove wide for size of shell. Sutural callus moderately thick. Body-whorl groove close to siphonal band on immature shells; closer to middle of whorl on mature shells. Parietal callus thin. Columellar lip and parietal callus bearing plaits like those of *Oliva* s.s.

Height (incomplete) 9.2 mm, diameter 4.5 mm (larger figured specimen). Height 7.2 mm, diameter 3.6 mm (smaller figured specimen).

Type: USNM 107090.

Type locality: Bowden, Jamaica, Bowden formation (middle Miocene).

This rare species, as well as *Strombinella* and *Leptarius*, was found in the middle part of the Gatun formation in the western area, west of Gatun Lake. All of the five specimens, except the smallest (pl. 45, figs. 4, 5), is damaged and on even the smallest the edge of the outer lip is broken back. The largest would have an estimated height of about 12 mm, if it were complete. It therefore is about as large as the type of *Oliva plicata* and the type of *O. dimidiata*. As shown by the illustrations, the body-whorl groove is shifted toward the middle of the whorl as the shell grows.

O. plicata was not recognized as a species of *Strephonnella* in 1928. Three specimens, all in the Guppy collection, have been found so far at Bowden, Jamaica. On all three the outer layer of the body whorl is peeled between the suture and the groove. In apertural view the edge of the shell layer extending up to the groove is irregularly nicked, as shown in the apertural view of the type (Woodring, 1928, pl. 13, fig. 6). On two of the specimens, however, including the type, the edge shows as a clean line in dorsal view.

Pilsbry and Johnson realized that their *O. dimidiata* is allied to the Recent Panamic *O. undatella*. The fossil species is smaller and less inflated. The late early Miocene Thomonde formation of Haiti (USGS 9945, 9946) has yielded the earliest *Strephonnella* now known. It is slightly smaller and more slender than *O. plicata*.

Occurrence: Middle part of Gatun formation, western area (middle Miocene), locality 170. Bowden formation (middle Miocene), Jamaica. Miocene, Dominican Republic.

Subfamily ANCILLINAE

Genus *Ancilla* Lamarck

Lamarck, Soc. Hist. Nat. Paris Mém., p. 70, 1799 (genus without binominally named species).

Type (monotype, Lamarck, *Système des animaux sans vertèbres*, p. 73, 1801): *Ancilla cinnamomea* Lamarck, Recent, Indian and western Pacific Oceans.

The type of *Ancilla* was discussed in the Bulletin of Zoological Nomenclature, v. 9, pt. 7, p. 219-220, 1954. Action has not been taken, however, on the proposed ruling by the International Commission on Zoological Nomenclature. Under the recent adopted Code action by the Commission is unnecessary, except to place *Ancilla* and *Ancilla cinnamomea* on the Official Lists.

Poorly preserved remains from the Caimito formation of Barro Colorado Island are listed as *Ancilla?* sp.

Subgenus *Eburna* Lamarck

Lamarck, *Système des animaux sans vertèbres*, p. 78, 1801.

Type (monotype): *Eburna flavida* Lamarck (= *Buccinum glabratum* Linné), Recent, Caribbean Sea.

Ancilla (*Eburna*) *pinguis* (Guppy)

Plate 45, figures 1, 2

Ancillaria pinguis Guppy, Sci. Assoc. Trinidad Proc., v. 2, no. 2, p. 83, pl. 1, fig. 3, 1873 (Miocene, Jamaica) (Reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 67, 1921). Guppy, Geol. Mag., decade 2, v. 1, p. 434, pl. 16, fig. 3, 1874 (Miocene, Jamaica).

Ancilla (*Eburna*) *pinguis* (Guppy), Woodring, Carnegie Inst. Washington Pub. 385, p. 235, pl. 14, figs. 6, 7, 1928 (Miocene, Jamaica).

Small, moderately slender. Late spire whorls slightly overhanging, though covered with glaze of enamel. Spire enamel ending along sharply defined spiral edge on upper part of body whorl. Parietal callus joining spire enamel, but tapering outward to a thin edge. Edge of siphonal band marked by a ledge, beyond which lies a deep, narrow groove. Middle of siphonal band bearing a shallow groove emerging at middle of siphonal notch. Umbilical rib narrow. Two or three minor subdued plaits bordering undercut base of columellar lip.

Height 16.5 mm, diameter 7.8 mm (figured specimen).

Type: USNM 115567.

Type locality: Bowden, Jamaica, Bowden formation (middle Miocene).

Two small shells from the middle part of the Gatun formation are identified as *Ancilla pinguis*. They are considerably smaller than the type (height 21.7 mm) and the largest available topotype (height 29.7 mm). They are also a little more slender than a small Bowden shell of comparable size. Whether the Panamá fossils are a small form of *A. pinguis* or are not quite mature is at present indeterminable.

A. pinguis is practically a miniature replica of *A. caroniana* Maury (1925, p. 198, pl. 33, figs. 4, 10, 12), a late Miocene species from Trinidad, which is three times as large. Both species are closely related to the large Recent Caribbean *A. glabrata* (Linné), the type of the subgenus *Eburna*. The late whorls of *A. glabrata* are slightly shouldered and the glaze of spire enamel extends down on the body whorl almost to the groove lying above the siphonal band. *A. glabrata speciosa* Rutsch (1934, p. 78, fig. 10, pl. 5, figs. 6, 7; upper Miocene, Venezuela) seems to be very similar to *A. caroniana*. *A. aquaensis* Olsson (1922, p. 94, pl. 7, fig. 10), a remarkable small, slender late Miocene species from northwestern Panamá, stands by itself among the few

Caribbean fossil and Recent species of *Eburna*. No species is living in Panamic waters.

Occurrence: Middle part of Gatun formation, eastern area (middle Miocene), locality 139c. Bowden formation (middle Miocene), Jamaica.

Subfamily OLIVELLINAE

Genus *Olivella* Swainson

Swainson, Zoological Illustrations, ser. 2, v. 2, explanation of pl. 58, (*Oliva*, pl. 2), 1831.

Type (logotype, Dall, U.S. Geol. Survey Prof. Paper 59, p. 31, 1909): *Oliva purpurata* Swainson (= *Voluta dama* Mawe), Recent Pacific coast of México.

Unidentified species of *Olivella* were found in the Caimito formation of the Gatun Lake area and the Culebra formation, and questionably in the La Boca formation. The Caimito species is the earliest in the Caribbean region.

Subgenus *Niteoliva* Olsson

Olsson, Acad. Nat. Sci. Phila. Proc., v. 108, p. 189, 1956.

Type (orthotype): *Olivella minuta* (Link) (*Porphyria minuta* Link), Recent, Caribbean area.

Three of the subgenera recognized by Olsson in his recent study of *Olivella* form a graded series in the development of short plaits on the columellar lip and the platform on which the plaits are seated: *Dactylidella*, *Niteoliva*, and *Mansfieldella*. (The plaits and platform are parts of Olsson's pillar structure.) Furthermore, these three subgenera are similar in the development of ridges on the interior of the outer lip. The ridges, however, are not invariably present.

Olivella (*Niteoliva*) *terryi* Olsson

Plate 45, figures 3, 10, 11

Olivella muticoides (Gabb), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 92, pl. 7, figs. 14, 17, 18; not fig. 11, = *O. muticoides* (Gabb), 1922 (Miocene, Costa Rica).

Olivella (*Niteoliva*) *terryi* (Olsson), Acad. Nat. Sci. Phila. Proc., v. 108, p. 193, pl. 13, figs. 4, 4a, 1956 (Miocene, Costa Rica).

Small, slender to moderately inflated, spire moderately high. Parietal callus thick, continuing up to sutural groove and around spire whorls as a glaze of enamel. Columellar lip bearing five to eight strong, slightly oblique, short plaits (not including upper border of platform and the basal fold), seated on a platform. Outer border of platform extending downward to form border of a wide basal swelling adjoining a narrower swelling along extension of parietal callus. Central part of siphonal band slightly swollen. Interior of outer lip smooth or bearing narrow ridges.

Height 11.2 mm, diameter 4 mm (figured large slen-

der specimen). Height 8 mm, diameter 4 mm (figured inflated specimen).

Type: Paleontological Research Institution 20998.

Type locality: Red Cliff Creek, southeastern Costa Rica, deposits of middle Miocene age.

Olivella terryi is locally abundant in the lower and middle parts of the Gatun formation. It may occur in the upper part in the eastern area, but the few specimens are so immature that they are identifiable only as *Olivella* sp.

The illustrations give an indication of the range of variation in outline. The bulk of the fossils are more inflated than the specimen shown on plate 45, figure 3. The interior of the outer lip is smooth on all the specimens from the lower part of the Gatun that show the interior of the lip (several score of a total of several hundred). On the contrary, the lip bears ridges on all those from the middle part that show the interior (11 of a total of 13), one of which is illustrated on plate 45, figure 10. The lower part at locality 136 yielded four specimens, at least two of which have ridges. These specimens, however, have a conical spire and are identified as *Olivella* sp.

Though the fossils from the Gatun formation are identified as *O. terryi*, they are a little smaller than Costa Rican shells, and they have slightly stronger plaits on the columellar lip and a greater range of variation in outline. *O. colpus* Woodring (1928, p. 234, pl. 14, figs. 4, 5; middle Miocene, Jamaica), which was assigned to the subgenus *Dactylidella* when it was described, has a weaker platform and plaits. *O. minuta* (Link) (Olsson, 1956, p. 190, pl. 9, figs. 1, 2, 2a, 2b, pl. 12, figs. 2, 2a)—the Caribbean species generally known as *O. nitidula* (Dillwyn)—is the most closely allied Recent species. Its outline ranges from moderately inflated to strongly inflated; that is, as compared with *O. terryi*, it represents a shift toward greater inflation.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 137, 138, 138a, 138b, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 139e, 139f; western area, locality 170. Middle Miocene, Costa Rica.

Subgenus *Toroliva* Olsson and Harbison

Olsson and Harbison, Acad. Nat. Sci. Phila. Mon. 8, p. 187, 1953.

Type (orthotype). *Olivella goliath* Olsson, Miocene, Costa Rica.

The large size, extensive parietal callus, and narrow, strongly oblique plaits seated on a narrow platform on the lower part of the columellar lip are characteristic of *Toroliva*.

Olivella (Toroliva) goliath Olsson

Plate 45, figure 9

Olivella goliath Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 92, pl. 7, figs. 22, 23, 1922 (Miocene, Costa Rica).

Olivella (Toroliva) goliath Olsson, Olsson, Acad. Nat. Sci. Phila. Proc., v. 108, p. 199, pl. 13, figs. 2, 2a, 1956, (Miocene, Costa Rica).

Large, slender, high-spined. Parietal callus moderately thick, in attenuated form extending up to suture and around whorls of spire as a glaze of enamel. Lower part of columellar lip bearing five narrow, strongly oblique plaits (not including upper border of platform and the basal fold), seated on a narrow platform. Siphonal band flat. Anterior end of aperture and siphonal notch wide.

Height 19.7 mm, diameter 8.2 mm (figured specimen).

Type: Paleontological Research Institution 21001.

Type locality: Red Cliff Creek, southeastern Costa Rica, deposits of middle Miocene age.

This large species occurs in the middle part of the Gatun formation, but only a few specimens have been found: a worn incomplete shell at locality 155c, the illustrated specimen and six others, all smaller, at locality 161c, and three doubtfully identified immature shells at locality 170. Even the large illustrated fossil is smaller than those from Costa Rica (height 24 to 27 mm).

According to Olsson (1956, p. 199), the middle Miocene strata at Tubará, Colombia, contain *O. goliath* or a closely related species. No comparable species is known to be living in Caribbean or Panamic waters.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 155c; western area, localities 161c, 170 (immature, identification doubtful). Middle Miocene, Costa Rica. Middle Miocene, Colombia (identification doubtful).

Subfamily AGARONIINAE

Genus *Agaronia* Gray

Gray, The zoology of Captain Beechey's voyage, p. 131, 1839.

Type (monotype): *Agaronia hiatula* [Gmelin] (*Voluta hiatula* Gmelin), Recent, "Inhab. South America". [*Agaronia hiatula* (Gmelin) is a West African species.]

Gray cited South America as the habitat for the species he identified as *Agaronia hiatula*. It is uncertain whether he had a species from the Atlantic coast of southern South America, or the Pacific coast of northern South America, or a misplaced West African specimen. Regardless of how this matter is resolved, usage of the name *Agaronia* would not be affected, as the species of the genus in those three areas are very similar.

The fossils from the Culebra formation include poorly preserved remains of an unidentified slender, high-spined species of *Agaronia*.

Agaronia testacea mancinella (Olsson)

Plate 45, figure 8

Oliva mancinella Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 91, pl. 7, figs. 8, 9, 1922 (Miocene, Costa Rica).

Of medium size, slender, high-spined. Spire whorls flat. First whorl small; last half whorl more loosely coiled than preceding whorls. Parietal callus moderately thick, not thickening as it extends upwards, continuing on lower half to two-thirds of spire whorls as thin glaze of enamel. Outer lip moderately flaring, producing a relatively narrow aperture.

Height 43.2 mm, diameter 17.8 mm (figured specimen).

Type material: Two syntypes, Paleontological Research Institution 20990, 20991.

Type locality: East Grape Point Creek, southeastern Costa Rica, deposits of middle Miocene age.

Nine specimens of a slender, high-spined *Agaronia* were recovered at six localities in the lower and middle parts of the Gatun formation and a tenth doubtfully identified, poorly preserved specimen at an additional locality. These fossils are identified as *A. testacea mancinella*. They are smaller than *A. testacea testacea* (Lamarck) (Keen, 1958, p. 423, fig. 630), living in the Panamic region from the Gulf of California to Perú, and have a smaller initial whorl. They are also consistently slender, whereas *A. testacea testacea* is slender to moderately inflated. An occasional Recent shell is about as slender as the fossils. Doubtless on account of the difference in size at maturity, the outermost plait on the columellar lip of the fossils is a little stronger than that of Recent shells of the same size and forms a more distinct ledge. Aside from their smaller initial whorl, the fossils are also very similar to slender specimens of the Recent West African *A. hiatula*. The close relationship between *A. testacea* and *A. hiatula* is more readily understandable in view of the occurrence, in the Miocene Caribbean Sea, of a form so closely resembling those two species.

Olsson (1922, p. 90; Olsson and McGinty, 1958, p. 17) recorded the occurrence of *A. testacea* in the Caribbean Sea at Bocas Island [Isla de Colon], in northwestern Panamá. A small *Agaronia*, smaller and more inflated than *A. testacea mancinella*, is represented in the collections of the U.S. National Museum by a suite of 13 specimens from the Caribbean coast of Nicaragua and one from the mouth of Río Coclé del Norte, in Colón Province, Panamá, west of the Canal Zone. If these 14 specimens can be accepted as a fair

sample of the Caribbean form, it may be treated as a small subspecies of *A. testacea*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 138, 138c (identification doubtful). Middle part, eastern area, localities 155, 155b. Middle Miocene, Costa Rica.

Agaronia testacea hadra Woodring, n. subsp.

Plate 47, figure 6

Of medium size, moderately inflated, low-spined. Spire whorls somewhat rounded, owing to thick glaze of enamel. First whorl or two missing; last half whorl as tightly coiled as preceding whorls. Parietal callus moderately thick, thickening as it extends upward to suture, continuing on spire whorls as thick glaze of enamel. Outer lip strongly flaring, producing a wide aperture.

Height (not quite complete) 42 mm, diameter 19.8 mm (type).

Type: USNM 643685.

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.

As shown by the descriptions and illustrations, this *Agaronia*, based on only the type, is notably different from *A. testacea mancinella*, found at the same locality. Nevertheless it is treated as a subspecies of *A. testacea*. Aside from the thick glaze of enamel, which affects the outline of spire whorls, and the more flaring outer lip, it is similar to some specimens of *A. testacea testacea*. The spire of the fossil appears to be lower than it actually would be, if the first whorl or two were not missing.

A. testacea costaricensis Olsson (1922, p. 90, pl. 7, figs. 12, 13; middle Miocene, Costa Rica), has a less flaring outer lip. It evidently includes high-spined and low-spined forms. Perhaps the recognition of three middle Miocene subspecies of *A. testacea* in the Costa Rican-Panamá area means that the range of variation of all three forms is still unknown.

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

Family MITRIDAE

Subfamily MITRINAE

Genus Mitra Röding

Röding, Museum Boltenianum, p. 135, 1798.

Type (hidden tautotype): *Mitra episcopalis* Röding (= *Voluta mitra* Linné), Recent, western Pacific Ocean.

If Dodge's (1955, p. 121-123) recommendation concerning *Voluta mitra* is accepted, that species is the tautotype of *Mitra*. Under *Mitra episcopalis*, Röding cited Gmelin's *Voluta episcopalis*, which is *Voluta mitra* Linné of Dodge's recommendation. *Mitra episcopalis* Röding was also designated as the type by Winckworth (1945, p. 141).

Mitra mitra (Linné) has long been known as *Mitra episcopalis* (Linné).

Subgenus Pleioptygma Conrad?

Conrad, Acad. Nat. Sci. Phila. Proc., 1862, p. 563, 1863.

Type (monotype): *P. (Mitra) carolinensis* (Conrad) (*Voluta carolinensis* Conrad), Miocene, N. C.

The subgeneric name *Pleioptygma* is hardly suitable for *Mitra swainsonii* and its allies. The species of *Pleioptygma* are more inflated and their spire whorls have weaker spiral and axial sculpture.

Mitra (Pleioptygma?) limonensis Olsson

Plate 46, figure 1

Mitra swainsonii limonensis Olsson. Bull. Am. Paleontology, v. 9, no. 39, p. 100, pl. 6, fig. 1, 1922 (Miocene, Costa Rica).

Moderately large, slender. Spire whorls sculptured with narrow spiral cords and fine axial threads lying between the cords. Penult whorl bearing five to seven primary spiral cords and a secondary thread in some of the spaces between them. Spiral and axial sculpture gradually suppressed on later part of penult and body whorls, but spiral sculpture not entirely disappearing on main part of body whorl and persisting on pillar. Columellar lip bearing four or five folds.

Height (incomplete) 77 mm, diameter 24.5 mm (figured specimen).

Type: Paleontological Research Institution 20959.

Type locality: Puerto Limón, Costa Rica, deposits of late Miocene age.

Two incomplete specimens—and a doubtfully identified fragment—of this moderately large *Mitra* were recovered from the middle and upper parts of the Gatun formation. The sculpture, especially both spiral and axial sculpture of spire whorls, is stronger than that of the Recent Panamic *M. swainsonii swainsonii* Broderip (Reeve, 1844, pl. 1, species 4) and its western Atlantic analog *M. swainsonii antillensis* Dall (1889, p. 158, pl. 38, fig. 7). Both of those forms are also slightly shouldered, producing a slight turreted effect. Though no specimens of *M. swainsonii swainsonii* are available, Reeve's illustration indicates that *M. zaca* Strong, Hanna, and Hertlein (1933, p. 120, pl. 5, fig. 10), dredged off southern Baja California, is a northern subspecies of *M. swainsonii*, if not the nominate subspecies itself.

Weisbord's (1929, p. 48, pl. 6, fig. 13; middle Miocene, Colombia) *M. cf. M. limonensis* has short bulging spire whorls. The spiral cords of Rutsch's (1934, p. 86, pl. 7, fig. 6; upper Miocene, Venezuela) *M. cf. M. swainsonii limonensis* are wider than those of *M. limonensis*. The somewhat turreted outline and weak sculpture of his (Idem, p. 86, pl. 7, fig. 5) *M. cf. M. swainsonii*, also of late Miocene age, suggests a direct predecessor of the two Recent forms living on opposite sides of Central America.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 155b. Upper part, eastern area, localities 175 (identification doubtful), 177b. Upper Miocene, Costa Rica.

Subgenus *Tiara* Swainson

Swainson, Zoological Illustrations, ser. 2, v. 2, explanation of pl. 50 (Mitranæ, pl. 5), 1831.

Type (logotype, Herrmannsen, Indiciis generum malacozoorium, v. 2, p. 576, 1849): *Mitra isabella* (Swainson) (*Tiara isabella* Swainson), Recent, western Pacific Ocean.

Should *Tiara* be considered unsuitable for the American species, *Subcancilla* Olsson and Harbison (1953, p. 190; type (orthotype): *Mitra sulcata* (Swainson) (= *Mitra sulcata* Sowerby), Recent, Gulf of California to Ecuador) is available.

Small species of the subgenus *Tiara* occur in the Bohio and Culebra formations, but are too poorly preserved for identification at the specific level.

Mitra (Tiara) longa longa Gabb

Plate 47, figure 5

Mitra longa Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 219, 1873 (Miocene, Dominican Republic). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, 346, pl. 24, fig. 11, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 74, pl. 11, fig. 11, 1917 (Miocene, Dominican Republic). Pilsbry and Brown, Acad. Nat. Sci. Phila. Proc., v. 69, p. 32 (listed only), 1917 (Miocene, Colombia). Pilsbry, Idem, v. 73, p. 339, pl. 24, fig. 3, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 101, pl. 6, fig. 10, 1922 (Miocene, Canal Zone). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 130, 1929 (Miocene, Colombia).

Not *Mitra longa* Gabb, Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 203, 1925; probably *M. longa rhadina* Woodring (Miocene, Trinidad).

Large, very slender, slightly turreted. Protoconch consisting of four small, slender whorls. End of protoconch marked by abrupt appearance of spiral cords. Primary spiral cords narrow, widely spaced; four or five on penult whorl, 10 to 15 on body whorl, not including weak threads on siphonal fasciole.

Secondary spiral sculpture consisting of one or more very narrow, subdued threads between primary cords on last three or four whorls, or consisting of one strong thread midway between primary cords. One or two secondary threads near suture. Narrow, closely spaced axial threads between primary spiral cords, and between a primary cord and a strong secondary thread. Columellar lip bearing three distinct folds and near base one or two weak folds.

Height (not quite complete) 54 mm, diameter 12.6 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3263.

Type locality: Dominican Republic, Miocene.

This large, very slender *Mitra* occurs in the three parts of the Gatun formation, but is not abundant and mature shells are rare. The figured specimen is the only practically complete mature shell. Three that are incomplete indicate a height of up to 65 mm. The figured specimen is unlike other large shells in having a strong secondary spiral thread midway between the primary spiral cords on the last three whorls, whereas the others have one or more very narrow, subdued threads.

Mitra longa longa has a fairly wide distribution in middle Miocene deposits in the Caribbean region: the Dominican Republic, Panamá, and Colombia. A comparable form is found in the upper Miocene Punta Gavilán formation of Venezuela (Rutsch, 1934, p. 84). *M. rhadina* Woodring (1928, p. 243, pl. 14, fig. 14) is better treated as a small subspecies of *M. longa*. It occurs in the Bowden formation of Jamaica and the Manzanilla formation of Trinidad (USGS 21745), both of middle Miocene age, and in deposits of middle or late Miocene age in the Tehuantepec area (Perrillat Montoya, 1960, p. 23, pl. 3, figs. 16, 17). The fauna of the upper Miocene Springvale formation of Trinidad includes *M. longa couvensis* Maury (1925, p. 203, pl. 35, figs. 1, 4), which is slightly more inflated than *M. longa longa*.

M. gigantea Reeve (Keen, 1958, p. 430, fig. 660), living in the Panamic region from Panamá to Ecuador, is a close Recent ally. It is a little larger, a little less slender, and its secondary spiral sculpture is microscopic. No closely related species has survived in the Caribbean Sea or elsewhere in western Atlantic waters.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c. Middle part, eastern area, localities 147b, 147g, 155, 155a; western area, locality 161d. Upper part, eastern area, locality 175. Middle Miocene, Colombia. Cercado and Gurabo formations (middle Miocene), Dominican Republic.

Mitra (Tiara) *dariensis* Brown and Pilsbry

Plate 42, figure 5

Mitra dariensis Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 346, pl. 24, fig. 9, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 101, pl. 6, fig. 25, 1922 (Miocene, Canal Zone, northwestern Panamá). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 129, 1929 (Miocene, Colombia).

Mitra colombiana Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 47, pl. 6, figs. 11, 12, 1929 (Miocene, Colombia).

Small, moderately slender. Protoconch consisting of about four small, slender whorls, set off by abrupt appearance of spiral cords. Primary spiral cords narrow, widely spaced; three on penult whorl, 9 to 11 on body whorl, not including thread limiting siphonal fasciole and weak threads on fasciole. In addition, body whorl and spire whorls bearing a spiral thread near suture. Narrow, closely spaced axial threads between spiral cords. Columellar lip bearing three distinct folds only, or three distinct folds and near base a weak fold.

Height (not quite complete) 24.3 mm, diameter 7.8 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 1704.

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

Small, moderately slender specimens of *Mitra* are identified as *Mitra dariensis*. The fossils so identified were collected from the lower and middle parts of the Gatun formation. They are rare except at one locality in the lower part (138c), where 11 were collected. Only one of four specimens from the middle part is large enough for unreserved identification. The less slender outline and the absence, or rare occurrence, of secondary spiral sculpture distinguish these small fossils from immature specimens of *M. longa longa*. None in the collections at hand has secondary spiral sculpture, but the type has a secondary thread on the body whorl between the first and second primary spiral cords (the first and second from the suture).

Six names have been proposed for small, or moderately small, Miocene Caribbean species of *Mitra* that differ chiefly in the proportions of the body whorl. At least one of those names, as shown by the synonymy of *M. dariensis*, is considered superfluous and perhaps others are. *M. dalli* Engerrand and Urbina (1910, p. 127, pl. 59, figs. 31, 32; not *M. dalli* Gardner and Aldrich, 1919, p. 25, pl. 1, figs. 4, 8) is the only one of these names that antedates *M. dariensis*. According to their illustrations, Engerrand and Urbina's species from the Miocene of Chiapas is more inflated than *M. dariensis*. Perhaps the Venezuelan *M. dariensis venezuelana* F. Hodson (*in* Hodson and Hodson 1931, p. 42, pl. 20,

figs. 6, 7) is more closely related to *M. longa* than to *M. dariensis*.

M. desmia Gardner (1926-47, p. 409, pl. 48, fig. 12, 1938; middle Miocene, Florida) has the outline of *M. dariensis*. Its spiral cords, however, slope down to wide V-shaped interspiral spaces. *M. sulcata* Sowerby Keen, 1958, p. 430, fig. 662) is the most closely allied Recent species. It is more inflated than the Gatun fossils and its axial sculpture is finer.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 138c, 138d. Middle part, eastern area, localities 139b (immature, identification doubtful), 146 (immature, identification doubtful), 155c. Middle Miocene, Colombia. Upper Miocene, Bocas del Toro area, northwestern Panamá.

Subfamily VEXILLINAE

Genus *Uromitra* Bellardi

Bellardi, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 5, p. 277, 1887.

Type (logotype, Harris, Catalogue of Tertiary Mollusca in the Department of Geology of the British Museum (Natural History); pt. 1, The Australasian Tertiary Mollusca, p. 125, 1897): *Uromitra antegressa* Bellardi, Miocene, Italy.

Generic rank for *Uromitra* is preferred, instead of subgeneric rank under the much larger, coarsely sculptured genus *Vexillum* Röding (1798, p. 138; type (logotype, Woodring, 1928, p. 244, 1928): *Vexillum plicatum* Röding (= *Voluta plicaria* Linné), Recent, western Pacific Ocean.

Uromitra aff. *U. cucurrupeensis* (Oinomikado)

Plate 44, figure 7

Moderately small, moderately slender, faintly turreted. Protoconch small, slender, about 3-whorled, set off by appearance of sculpture. Axial ribs narrow; 13 on body whorl, not including varix-like thickening near outer lip. Spiral cords narrow, separated by narrower grooves; seven cords on penult whorl. Base of body whorl sculptured with spiral threads, closely spaced on siphonal fasciole, more widely spaced beyond fasciole. Thread limiting fasciole wider and stronger than others. Outer lip and siphonal canal broken back. Columellar lip bearing four folds.

Height (almost complete) 16.1 mm, diameter 3.8 mm (figured specimen).

The middle part of the Gatun formation yielded one specimen of a moderately small *Uromitra* closely related to *U. cucurrupeensis* Oinomikado (1939, p. 623, pl. 29, figs. 10a, 10b), from the middle Miocene of southwestern Colombia. It is smaller and more slender than the Colombian species. Miocene species of *Uromitra* similar to *U. cucurrupeensis* have been recog-

nized in Trinidad (*Turricula bristoli* Maury, 1925, p. 205, pl. 35, fig. 5) and the Dominican Republic (*Vexillum tortuosellum* (Pilsbry and Johnson), Pilsbry, 1922, p. 341, pl. 24, fig. 9). *U. callipicta* (Woodring) (1928, p. 248, pl. 14, fig. 20; Miocene, Jamaica) is more slender than the Gatun fossil.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 147b.

Uromitra elachista Woodring, n. sp.

Plate 44, figure 3

Very small, slender. Early sculptured whorls, or all of sculptured spire whorls, bearing a faint sutural collar. Protoconch small, slender, 3- to 3½-whorled, set off by appearance of sculpture. First few axial ribs crowded and arcuate, followed by widely spaced narrow ribs; 12 to 14 ribs on body whorls, or last few replaced by narrower crowded ribs. Spiral sculpture strong or faint, consisting of narrow cords, separated by very narrow, shallow grooves, which disappear, or practically disappear, on last few whorls of some specimens. Pillar sculptured with four threads. Columellar lip bearing three folds.

Height 5 mm, diameter 1.8 mm (type). Restored height 6.5 mm, diameter 2.2 mm (largest specimen).

Type: USNM 643690.

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 species of *Uromitra* occurs in the middle part of the Gatun formation at four localities and in the upper part at one locality. The largest number of specimens (16) is in the collection from the type locality: a collection that is rich in small specimens. Two of the 16 have weak spiral sculpture. The others and the nine from other localities have strong or moderately strong spiral sculpture.

This is the first minute species of *Uromitra* from the Caribbean region to be described. Though minute Miocene and Pliocene species are found in Florida, they are more inflated than *U. elachista* and have a blunt protoconch of 1½ whorls. *U. ctenota* (Gardner) (1926-47, p. 414, pl. 48, figs. 24, 25, 1938) is an example of the Miocene species and *U. holmesii* (Dall) (Olsson and Harbison, 1953, p. 193, pl. 32, figs. 4, 4a) of the Pliocene species. Other species are described in the publications just cited.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 146, 147b, 147g, 147h. Upper part, eastern area, locality 177c.

Family XANCIDAE

Genus Xancus Röding

Röding, Museum Boltenianum, p. 134, 1798.

Type (logotype, Dall, Jour. Conchology, v. 11, p. 296, 1906): *Xancus pyrum* Röding (= *Voluta pyrum* Gmelin = *Voluta pyrum* Linné), Recent, Indian Ocean.

When Dall designated *Voluta pyrum* as the type, he neglected to specify Röding's name for that species. Winckworth (1945, p. 145) cited Dall's designation in the proper form.

I am unable to accept Opinion 489 of the International Commission on Zoological Nomenclature, suppressing *Xancus* in favor of its objective junior synonym *Turbinella* Lamarck, 1799.

Xancus is one of the few genera or subgenera that formerly lived in both western Atlantic and eastern Pacific waters, and now survive in the Caribbean Sea but not in the eastern Pacific Ocean. Only three genera or subgenera so far considered in the present report fall in that class: *Muracypraea* (p. 194), *Sconsia* (p. 200), and *Xancus*. In the eastern Pacific region *Xancus* is represented in the Eocene of Perú and in the Miocene of the Darien area of Panamá.

The earliest species of *Xancus* were formerly thought to be of Oligocene age. Middle or late Eocene species are now known in Perú, Colombia, and the Canal Zone.

An embarrassing number of names—a total of 18—is available for Miocene forms of *Xancus* from the Caribbean region, although the total number of species surely is far less.

Xancus cf. *X. peruvianus* Olsson

Plate 39, figure 19

Relatively small, slender, *Clavilithes*-like. Whorls narrowly shouldered, gently sloping from suture to shoulder. Body whorl subcylindrical above the strongly constricted pillar. Protoconch not preserved. Earliest preserved whorls sculptured with wide, swollen axial ribs and narrow, low spiral cords. Aside from faint undulations on shoulder and weak spiral threads on pillar, sculpture disappearing on body whorl, estimated to be fifth or sixth post-protoconch whorl. Columella bearing two folds.

Height (incomplete) 32.5 mm, diameter 15.3 mm (figured specimen).

The silicified fossils from the Gatuncillo formation in the Río Casaya area include the figured specimen (broken at both ends) and an apical fragment. Unsatisfactory as this material may be, it establishes the presence of an Eocene species of *Xancus* in the Canal Zone.

The shouldered, *Clavilithes*-like outline suggests that this species is related to the much larger and more inflated *Xancus peruvianus* Olsson (1928, p. 89, pl. 21, fig. 5), a Peruvian species ranging in age from middle Eocene to Oligocene, rather than to *X. talarensis* Olsson (1930, p. 47, pl. 7, figs. 2, 3, 5; upper Eocene, Perú) or *X. paytensis* Olsson (Idem, p. 48, pl. 7, figs. 1, 4, 6; upper Eocene Perú). *X. peruvianus* has three columellar folds, whereas the other two Peruvian species, like the species from the Gatuncillo formation, have two folds. It is doubtful, however, whether the species having two folds are to be grouped together solely on the basis of that feature. The subgeneric name *Eoxancus* was proposed by Olsson (1930, p. 47; type (orthotype): *Xancus talarensis*) for *X. talarensis* and *X. paytensis*.

A greatly inflated form of *X. peruvianus*—*X. peruvianus colombianus* Clark (in Clark and Durham, 1946, p. 42, pl. 22, fig. 11)—has been recognized in late Eocene deposits in Colombia.

Occurrence: Gatuncillo formation (middle Eocene locality 38).

Xancus species

A limestone in the lower part of the Caimito formation of Madden basin yielded a poorly preserved *Xancus* of medium size (incomplete height 61 mm, diameter 36.5 mm). The preserved whorls are shouldered and the shoulder bears low rounded knobs. The gently sloping shelf between the suture and the shoulder is sculptured with relatively strong retractive axial threads. More closely spaced, weaker axial threads are visible elsewhere. Closely spaced spiral cords are conspicuous on the pillar and less conspicuous on the upper part of the body whorl and on spire whorls.

The low shoulder knobs and relatively strong retractive axial threads between the suture and the shoulder suggest that the Caimito fossil may be allied to *Xancus rex* Pilsbry and Johnson (Pilsbry, 1922, p. 342, pl. 26, figs. 5, 8), which occurs in the Baitoa formation of the Dominican Republic and the Thomonde formation of Haiti, both of early Miocene age. The shelf between the suture and the shoulder of that species is wider and more steeply sloping.

Occurrence: Lower part of Caimito formation (late Oligocene), Madden basin, locality 71.

Xancus cf. *X. rex* Pilsbry and Johnson

Three specimens from the Culebra formation are too poorly preserved for identification. All are of medium size (incomplete height of largest 81.5 mm, diameter 49.5 mm). In outline, especially in the steeply sloping shelf between the suture and the knob-bearing shoulder, these fossils are more similar to *Xancus rex* than

the specimen from the Caimito formation and may indeed be that species.

Occurrence: Culebra formation (early Miocene), localities 104a, 104b, 116a.

Xancus validus validus (Sowerby)?

Plate 47, figure 13

Large, slender to moderately slender, late whorls strongly shouldered. Whorls steeply sloping between suture and shoulder. Early whorls not preserved. Late whorls bearing strong, low knobs on shoulder; 11 to 13 on body whorl. Four widely spaced, subdued spiral cords on main part of body whorl between shoulder and pillar. Microscopic spiral lineation on entire shell. Retractive growth lines somewhat exaggerated on slope between suture and shoulder. Columella bearing three folds.

Height (incomplete) 140 mm, diameter 95 mm (figured specimen). Height (incomplete) 275 mm, diameter 100 mm.

Eleven specimens of *Xancus* of large and medium size from the Gatun formation are available. Three, all of which were collected near Gatun, bear strong shoulder knobs. Unfortunately two of them (locality 159b), which are in better condition and are less incomplete than that shown on plate 47, figure 13, were overlooked until the plates were already prepared. The largest, if complete, would have a height of at least 300 millimeters. Nevertheless the illustration gives a fair representation of the essential features.

This strongly knobbed form is doubtfully identified as *X. validus validus* (Sowerby, 1950, p. 50), which occurs in the Dominican Republic, presumably in the Cercado or Gurabo formation. The Gatun fossils, however, are more strongly knobbed than the specimen of *X. validus validus* illustrated by Pilsbry (1922, p. 342, pl. 25, fig. 3). Maury's (1917, p. 83, pl. 13, fig. 5) *X. validus* is *X. rex*, already mentioned. *X. textilis* (Guppy) (Pilsbry, 1922, p. 343, pl. 25, fig. 5; Woodring, 1928, p. 250, pl. 15, fig. 3; Miocene, Jamaica) has strong shoulder knobs, but even at a moderately late stage is sculptured with relatively strong spiral cords and threads and relatively strong, almost microscopic axial threads.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155, 159b.

Xancus validus falconensis H. K. Hodson

Plate 46, figures 4-6

Xancus praevoides (error for *praevoides*; see errata following p. 251) Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 83, pl. 14, fig. 18, 1917 (Miocene, Dominican Republic). Not *Turbinella praevoides* Vredenberg, 1916.

Not *Xancus praeovoides* (error for *praeovoides*) Maury, Maury, Idem, v. 10, no. 42, p. 207, pl. 38, fig. 1, 1925 (Miocene, Trinidad); = *X. trinitatis* Maury.

Xancus falconensis H. K., Hodson, in Hodson and Hodson, Idem, v. 16, no. 59, p. 40, pl. 22, figs. 1, 3, 1931 (Miocene, Venezuela).

Large, moderately slender to somewhat inflated, intermediate and late whorls faintly shouldered to rounded. Protoconch cylindrical, narrow (diameter 3.5 mm), 3-whorled. First four or five post-protoconch whorls sculptured with *Fusinus*-like swollen axial ribs and spiral cords and threads. Sculpture gradually suppressed on later whorls. Axial sculpture represented on late whorls by weak undulations on a faint shoulder or completely disappearing. Spiral sculpture represented on late body whorl by traces of five or six widely spaced cords, including one in position of shoulder, and by closely spaced, weak cords and threads on pillar. Slightly exaggerated retractive growth lines between suture and position of shoulder on some specimens. Columella bearing three folds.

Height (incomplete) 220 mm, diameter 85 mm (figured large, slender specimen). Height (incomplete) 140 mm, diameter 67 mm (figured inflated specimen of medium size).

Type: Paleontological Research Inst. 24111.

Type locality: Cantaura [Cantaure], Paraguaná Peninsula, Falcón, Venezuela, Miocene.

Fifteen specimens in eight lots from the lower and middle parts of the Gatun formation are referred to *Xancus validus falconensis*. As indicated by the name, they are presumed to represent the same species as the form that bears strong shoulder knobs, just described. These two forms have the same pattern of weak, widely spaced spiral cords on the main part of the body whorl and the same pattern of somewhat exaggerated growth lines between the suture and the shoulder. The fossils identified as *X. validus falconensis* include moderately slender shells that have a faint shoulder and faint shoulder knobs (pl. 46, fig. 5) and moderately inflated shells that have a rounded body-whorl outline (pl. 46, fig. 6). The type of Maury's *X. praeovoides* is moderately slender and lacks even a faint shoulder and even indications of shoulder knobs. All the specimens from the Cercado and Gurabo formations of the Dominican Republic in the collections of the U.S. National Museum are similar to Maury's type. Contrary to Maury's conclusion, in which I acquiesced (Woodring, 1928, p. 104, footnote), her *X. praeovoides* is not closely related to the Recent Brazilian species formerly designated *X. ovoideus* (Kiener) and now designated *X. laevigatus* (Anton) (Abbott, 1950, p. 207, pl. 91). The type of *X. validus falconensis* has

less bulging whorls than Maury's *X. praeovoides* and also less bulging than those of the Gatun fossils. A strongly inflated Venezuelan *Xancus*, possibly a strongly inflated form of *X. validus falconensis*, was named *X. praeovoides riosecanus* by H. K. Hodson (in Hodson and Hodson, 1931a, p. 12, pl. 11, fig. 1, pl. 12, fig. 1).

Moderately slender and inflated forms of *Xancus* are found in the late Miocene Springvale formation of Trinidad. It seems to be proper to group both under *X. trinitatis* Maury (1925, p. 208, pl. 39, fig. 1), the name proposed for the moderately slender form. The early whorls of *X. trinitatis* are tightly coiled and axial sculpture is lost at an early stage.

As noted by Hodson (in Hodson and Hodson, 1931, p. 40), *X. validus falconensis* occurs also in the middle Miocene deposits of the Darién area of eastern Panamá. The largest specimen in six lots from that area in the collections of the U.S. National Museum has a restored height of almost 300 mm (USGS 8477, Río Tuyra).

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138e. Middle part, eastern area, localities 139c (immature), 139e, 140, 144, 155, 157; western area, locality 161a. (A specimen from the upper part in the eastern area at locality 176a, listed as *Xancus* sp., is too immature for identification). Middle Miocene, Darién area, Panamá. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Miocene, Falcón, Venezuela.

Family VOLUTIDAE

Subfamily VOLUTINAE

Genus *Voluta* Linné

Linné, Systema naturae, 10th ed., p. 729, 1758.

Type (logotype) Montfort, Conchologie systématique, v. 2, p. 551, 1810: *Voluta musicus* (*Voluta musica* Linné), Recent, West Indies.

Voluta alfaroi eurytera Woodring, n. subsp.

Plate 45, figures 14, 18, 19

Of medium size, top-shaped, broad at shoulder. Protoconch cylindrical, relatively narrow. Early post-protoconch whorls weakly sculptured with axial swellings, pinched off on posterior part of whorls and forming knobs on shoulder of later whorls. Shoulder of largest specimens bearing 10 knobs. Spiral sculpture limited to weak threads on lower part of body whorl. Siphonal fasciole slightly inflated. Columella bearing five or six folds, not including minor folds on parietal wall and minor folds that may alternate with main folds.

Height 48.7 mm, diameter 30.5 mm (type). Height (not quite complete) 50 mm, diameter 36 mm (large figured specimen).

Type: USNM 643691.

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.

Nine specimens of *Voluta*, most of which are somewhat corroded, were collected at two localities in the upper part of the Gatun formation in the western area near the mouth of Río Miguel. The Chagres sandstone yielded one specimen, also somewhat corroded. These fossils are the first Tertiary remains of the genus to be found in the Caribbean region outside Costa Rica. They are identified as a wide-shouldered, weakly sculptured subspecies of *Voluta alfaroi* Dall (Olsson, 1922, p. 99, pl. 8, fig. 2). The specimen shown on plate 45, figure 14, is exceptionally wide at the shoulder. Its apertural face is badly corroded. *V. alfaroi alfaroi* is common in middle Miocene deposits in southeastern Costa Rica, especially on Río Banana.

The narrow protoconch and slightly swollen siphonal fasciole of *V. alfaroi* indicate that it is more closely related to *V. virescens* Solander (Reeve, 1849, pl. 9, species 19) than to *V. musica* Linné (Idem, pl. 8, species 18). The blunter knobs and weaker spiral sculpture of *V. alfaroi* distinguish it from *V. virescens*. *V. musica* is widely distributed in the Caribbean region, whereas *V. virescens* has a more restricted distribution along the west and south borders of the Caribbean Sea. *V. virescens*, or a form of that species, is fairly common in deposits of late Miocene age at Limón, Costa Rica. The protoconch of these late Miocene fossils is wider than that of Recent specimens of *V. virescens*, but is not as wide as that of *V. musica*.

No species of *Voluta* reached the eastern Pacific Ocean during Tertiary time and none is now living there.

Occurrence: Upper part of Gatun formation, western area (late Miocene), localities 182, 182a. Chagres sandstone (early Pliocene), locality 208.

Subfamily LYRINAE

A poorly preserved fossil from the La Boca formation at locality 99d may represent the genus *Lyria*.

Genus *Ctenilyria* Woodring, new genus

Type: *Ctenilyria ctenista* Woodring, n. sp., Eocene, Canal Zone.

Small, biconical, turreted. Protoconch small. Axial sculpture consisting of strong, widely spaced ribs, bent inward toward suture. Spiral threads weak. Inner

edge of outer lip denticulate. Siphonal fasciole slightly inflated. Columella bearing three or four folds.

The strong, widely spaced ribs, turreted outline, and denticulate outer lip distinguish *Ctenilyria* from *Lyria* Gray (1847, p. 141; type (orthotype): *Voluta nucleus* Lamarck, Recent, Australia). *Voluta coroni* Morlet (1888, p. 217, pl. 10, figs. 7, 7a, 7b) is the only species of *Ctenilyria*, other than the type species, that has come to my attention. It is a rare species in the middle and upper Eocene of the Paris basin and the middle Eocene deposits at the mouth of the Loire River. According to Cossmann (1896, p. 236, pl. 9, figs. 10, 11), immature specimens of *Ctenilyria coroni* lack denticles on the outer lip.

In the plan of sculpture and in the presence of denticles on the outer lip *Ctenilyria* is similar to *Pseudolyria* Martin (1931, p. 17). *Pseudolyria* was proposed for *Pseudolyria ventricosa* Martin (Idem, p. 17, pl. 3, figs. 3, 3a), a small upper Eocene species from Java. It has a greatly inflated outline, wide aperture, strong folds on the columella and parietal wall, and strong elongate denticles on the outer lip. These features suggest that *Pseudolyria* and *Ctenilyria* arose independently from *Lyria*, which was widely distributed during Eocene time.

Ctenilyria ctenista Woodring, n. sp.

Plate 39, figures 25, 26

Small, biconical, turreted, spire moderately low. Protoconch blunt, consisting of about 1½ whorls. Axial ribs wide, strong, widely spaced, abruptly bent inward toward suture, producing a turreted outline; eight ribs on body whorl. Spiral sculpture limited to weak, narrow threads. Outer lip thickened, ascending, its inner edge coarsely denticulate. Siphonal fasciole slightly inflated. Columella bearing four folds; second from base strongest. Three minor folds on parietal wall.

Height 16 mm, diameter 9 mm (type).

Type: USNM 643622.

Type locality: 38 (USGS 17166, Río Casaya area, Quebrada de Oro, a northwestward-flowing tributary of Río Casaya, 3.3 kilometers southeast of east end of Gamboa bridge, Canal Zone), Gatuncillo formation.

Ctenilyria ctenista is based on one specimen in the collection of Gatuncillo silicified fossils from the Río Casaya area. It is twice as large as *C. coroni*, the middle to upper Eocene European species already mentioned, and has wider ribs and coarser denticles on the outer lip.

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

Genus *Enaeta* H. and A. Adams

H. and A. Adams, The genera of Recent Mollusca, v. 1, p. 167, 1853.

Type (logotype, Dall, Smithsonian Misc. Coll., v. 50 (Quart. Issue, v. 4, pt. 1), p. 13, 1907): *Enaeta barnesii* (Gray) (*Voluta barnesii* Gray), Recent, Gulf of California to Perú.

The citation for the type species properly should be "*Voluta harpa* Barnes, 1824, not Mawe, 1823, = *Voluta barnesii* Gray, 1825 (*barnsii* by error)."

The earliest species of *Enaeta* is of early Miocene age. The genus survives in both western Atlantic and eastern Pacific waters.

Enaeta eonomia Woodring, n. sp.

Plate 46, figures 2, 3

Of medium size, columbelloid, inflated, spire rapidly tapering. Body whorl bearing a faint sutural collar. Protoconch worn and partly missing. First three post-protoconch whorls bearing low, wide axial ribs. Ribs more subdued and retractive on remaining spire whorls; 18 ribs on body whorl. Spiral sculpture limited to weak threads, aside from a stronger thread bordering siphonal fasciole. Outer lip thickened, ascending, interior bearing a heavy denticle about two-thirds of distance from anterior end to posterior end of lip. Siphonal fasciole moderately inflated. Columella bearing four folds, not including two minor folds on parietal wall.

Height 20.2 mm, diameter 11.5 mm (type).

Type: USNM 643693.

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.

The somewhat worn type of *Enaeta eonomia*—the only specimen—was found in the lower part of the Gatun formation. It has eastern Pacific affinities, as it is closely related to the type of the genus, *E. barnesii* (Gray) (Keen, 1958, p. 432, fig. 665). The smaller size, faint sutural collar, stronger thread limiting the siphonal fasciole, slightly stronger axial ribs, slightly stronger columellar folds, and heavier denticle on the outer lip distinguish the fossil from the Recent species, but these differences are slight. No comparable species is living in western Atlantic waters. *E. cylleniformis* (Sowerby) (1847, p. 214, pl. 55, figs. 112, 113), which ranges from southern Florida to the Bahamas, has a strong sutural collar. The rare Caribbean species *E. guildingii* (Sowerby) (idem, p. 214, pl. 55, figs. 110, 111) is small and slender.

Two other fossil species are now known: *Mitra* (*Strigatella*?) *perturbatrix* Maury (1917, p. 76, pl.

14, figs. 1, 2; middle Miocene, Dominican Republic) and *Caricella isabellae* Maury (1910, p. 17, pl. 4, fig. 7; lower Miocene, Florida). Neither is similar to *E. eonomia* or to any of the Recent species. *Strigatella americana* Dall (1915, p. 61, pl. 9 fig. 2; Pilsbry and Olsson, 1954, p. 24, pl. 3, fig. 3), as already pointed out by Gardner (1926-47, p. 419, 1938), is a synonym of "*Caricella*" *isabellae*.

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

Subfamily?

Genus *Glyptostyla* Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 232, 1892. Type (orthotype): *Glyptostyla panamensis* Dall, Eocene or Oligocene, Canal Zone.

This distinctive early Tertiary genus is found in the Canal Zone, Colombia, and Perú. The earliest species are of late Eocene age and the last are late Eocene or early Oligocene. The Peruvian species was described by Olsson as the type of the genus *Peruficus* (Olsson, 1929, p. 25; type (orthotype): *Peruficus lagunitensis* Olsson). Despite features that readily distinguish the Peruvian species from *Glyptostyla panamensis*, *Peruficus* is considered a synonym of *Glyptostyla*. The diagnostic features of *Peruficus lagunitensis* are discussed under *Glyptostyla panamensis*.

Glyptostyla presumably is a volutid. Its subfamily affinities, however, are uncertain. When Dall described it, he thought a Paleocene California species, *Turbinnella crassitesta* Gabb, is to be assigned to it. Later he designated that species as the type of a new genus *Retipirula* (Dall, 1907, p. 5, 12). *Retipirula crassitesta*, which is a volutid and has been placed in the subfamily Athletinae (Pilsbry and Olsson, 1954, p. 15), bears little resemblance to *Glyptostyla*. Aside from its less strongly bent siphonal canal and less swollen siphonal fasciole, *Glyptostyla* has the outline of the early Tertiary genus *Strepsidura* Swainson (1840, p. 90; type (orthotype): *Fusus ficulneus* Lamarck, Eocene, northwestern Europe). *Glyptostyla*, however, has fairly strong reticulate sculpture and two heavy or fairly heavy columellar folds, whereas *Strepsidura* has weak sculpture and a slender basal fold. The family status of *Strepsidura* is uncertain. Cossmann (1901, p. 130) proposed to place *Strepsidura* and *Glyptostyla* in a family "Strepturidae" (properly Strepsiduridae), but that is not a satisfactory solution.

Glyptostyla panamensis Dall

Plate 39, figures 21, 22

Glyptostyla panamensis Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 233, pl. 13, fig. 5, 1892 (Eocene or Oligocene,

Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 348, 1911 (Dall's record).

Of medium size, pyriform, adult body whorl slightly depressed near suture. Protoconch poorly preserved, apparently small and slender. First few (generally three) post-protoconch whorls sculptured with narrow axial ribs and narrower spiral threads. At later stage sculpture gradually becoming narrowly reticulate. Spiral threads of reticulate sculpture more widely spaced and a little stronger than axial threads. On body whorl some axial threads wider than general width, as much as twice as wide. Siphonal canal of moderate length, moderately bent. Siphonal fasciole barely inflated. Edge of outer lip flaring. Columella bearing two heavy folds; posterior fold wider than anterior. Parietal callus thick.

Height (almost complete) 29 mm, diameter 18.7 mm (type).

Type: USNM 112263.

Type locality: 40 (Vamos Vamos station, Panama Canal, in a cut about two meters above level of canal, Canal Zone), marine member of Bohio(?) formation.

The type and a fragmentary specimen were forwarded by Alexander Agassiz to Dall in 1891, in the first lot of fossils collected at Vamos Vamos. This locality is now under the waters of Gatun Lake (p. 22; Woodring, 1958, fig. 1). All the available specimens are from the type locality. Hill collected three and MacDonald and Vaughan 16, almost half of which are fragmentary. The pillar is broken on all except the type and even on the type it is nicked. The broken pillar produces the effect of a short, almost straight siphonal canal.

The typical form of *Glyptostyla lagunitensis* (Olsson) (1929, p. 26, pl. 8, fig. 11; Olsson, 1930, p. 73, pl. 12, figs. 5, 7, 8), the type of *Peruficus*, occurs in the late Eocene Talara and Samán formations of north-western Perú. It is smaller than *G. panamensis* and has stronger and more widely spaced axial riblets, a thickened outer lip, and three varix-like thickened axial ribs on the body whorl. The more slender columellar folds of the Peruvian form are expectable in view of its small size. The type material of *G. lagunitensis charanalensis* (Olsson) (1931, p. 111, pl. 17, figs. 10, 11, 13) was collected in an area underlain by conglomerate of the Máncora formation, assigned to the middle Oligocene by Olsson. The fossils may have weathered out of boulders in the conglomerate (Idem, p. 13). The same form, however, is recorded from the Chira shale, of late Eocene or early Oligocene age. Though *G. lagunitensis charanalensis* is not as strongly sculptured as *G. lagunitensis lagunitensis*, it has a thickened outer lip and varix-like

axial ribs on the body whorl, like those of the typical form. The late Eocene Colombian species, *G. olsoni* (Clark) (in Clark and Durham, 1946, p. 40, pl. 21, figs. 20, 22, 23), is more similar to *G. panamensis* than the Peruvian fossils, but has stronger axial sculpture and a thickened outer lip.

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

Subfamily AMPULLINAE

Genus *Ampulla* Röding

Röding, Museum Boltenianum, p. 110, 1798.

Type (logotype, Pilsbry, Nautilus, v. 22, p. 83, 1908): *Ampulla priamus* Röding (= *Bulimus priamus* Bruguière), Recent, eastern Atlantic Ocean.

Risso's name *Halio* is more familiar as the name for this genus.

Ampulla americana (Olsson)

Halio americana Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 79, pl. 4, fig. 7, 1922 (Miocene, Canal Zone).

The type (Paleontological Research Institution 20921), found in the upper part of the Gatun formation at Mount Hope, is the only known specimen of this species. Moreover, *Ampulla americana* is the only American species of a genus that occurs in the Miocene and Pliocene of the Mediterranean region and is now living in eastern Atlantic waters from Spain to Senegal. As pointed out by Olsson, the lower part of the body whorl of the Gatun fossil is sculptured with low spiral bands, whereas the other species are smooth.

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INDEX

[Italic numbers indicate descriptions]

A	Page
<i>acanthodes</i> , <i>Mitrella</i>	247
<i>aciculata</i> , <i>Mazatlanella</i>	246
<i>acinenensis</i> , <i>Hanetia</i>	258
<i>aculus</i> , <i>Cymatophos</i> ?.....	241, 246, 261; pl. 47
<i>Nassarius</i> (<i>Nanarius</i>) <i>parapristus</i>	271;
pl. 40, tab. 1	
<i>parapristus</i>	272
<i>acufornis</i> , <i>Strombinella</i>	256
<i>acutus</i> , <i>Nassarius</i>	272
Additions to localities at which fossils were	
collected.....	242
<i>Agaronia</i>	281
<i>hiatula</i>	281
<i>testacea</i>	281, 282
<i>costaricensis</i>	282
<i>hadra</i>	282; pl. 47, tab. 1
<i>mancinella</i>	281; pl. 45, tab. 1
<i>testacea</i>	281, 282
sp.....	244
<i>Agaroniinae</i>	281
<i>albus</i> , <i>Nassarius</i>	271
<i>Alectrion</i> <i>brassica</i>	271
<i>brassoensis</i>	271
<i>cercadensis</i>	271
<i>gorgon</i>	270
<i>alfaroi</i> , <i>Voluta</i>	288
<i>alfaroi</i> , <i>Voluta</i>	288
<i>eurytera</i> , <i>Voluta</i>	246, 287; pl. 45, tab. 1
<i>Voluta</i> <i>alfaroi</i>	288
<i>alternata</i> , <i>Hanetia</i>	257
<i>amara</i> , <i>Nicema</i>	242, 246, 268; pl. 42, tab. 1
<i>Amarophos</i>	241, 260, 267
<i>bothrus</i>	241, 246, 267; pl. 47
<i>dentalis</i>	267
<i>ambiguus</i> , <i>Nassarius</i>	271
<i>americana</i> , <i>Ampulla</i>	290; tab. 1
<i>Halia</i>	290
<i>Strigatella</i>	289
<i>amosi</i> , <i>Metula</i>	259
<i>amphidyma</i> , <i>Strombina</i>	255
(<i>Sincola</i>).....	255; pl. 40, tab. 1
<i>Ampulla</i>	290
<i>americana</i>	290; tab. 1
<i>priamus</i>	290
<i>Ampullinae</i>	290
<i>Anachis</i>	248, 249, 250
<i>fugax</i>	249
<i>mira</i>	249
<i>fugax</i>	249
<i>mira</i>	249
<i>stevensoni</i>	249
(<i>Alia</i>) cf. <i>A. fenestrata</i>	248
(<i>Costoanachis</i>) <i>mira</i> <i>fugax</i>	249; pl. 40, tab. 1
<i>mira</i>	248; pl. 39, tab. 1
<i>stibara</i>	250; pl. 40, tab. 1
sp.....	250; tab. 1
<i>anapetes</i> , <i>Latirus</i> (<i>Polygona</i>).....	246, 274; pl. 47
<i>Ancilla</i>	279
<i>aquaensis</i>	279
<i>caroniana</i>	279
<i>cinnamomea</i>	279
<i>glabrata</i>	279
<i>speciosa</i>	279
<i>punguis</i>	279

	Page
<i>Ancilla</i> ? sp.....	243, 279
<i>Ancilla</i> (<i>Eburna</i>) <i>punguis</i>	279; pl. 45, tab. 1
<i>Ancillaria</i> <i>punguis</i>	279
<i>Ancillinae</i>	279
<i>ancularia</i> , <i>Buccinum</i>	270
<i>aneureta</i> , <i>Trachypollia</i>	268; pl. 42, tab. 1
<i>angulifera</i> , <i>Littorina</i> aff. <i>L</i>	244
<i>anomala</i> , <i>Pyrula</i>	256
" <i>Pyrula</i> ".....	256
<i>antegressa</i> , <i>Uromitra</i>	284
<i>Antemetula</i>	259
<i>antillensis</i> , <i>Mitra</i> <i>swainsonii</i>	245, 282
<i>Antillophos</i>	241, 242, 245, 260, 263, 264, 265, 266, 269
<i>candei</i>	265, 266
<i>candei</i>	245, 265
<i>gatumensis</i>	245, 264, 265, 267
<i>Antillophos</i> ? cf. <i>A. candei</i> <i>gatumensis</i>	241, 243
<i>Antillophos</i> <i>metuloides</i>	267
<i>mexicanus</i>	265, 266; tab. 1
<i>bendratii</i>	266
<i>monachus</i>	266
<i>moorei</i>	266
<i>rutshi</i>	266
<i>veraguensis</i>	245, 265
sp.....	243
<i>Antillophos</i> ? sp.....	243, 264
<i>Antillophos</i> (<i>Antillophos</i>) <i>candei</i> <i>gatumensis</i>	264;
pl. 42, tab. 1	
<i>Antillophos</i> ? (<i>Antillophos</i> ?) cf. <i>A. candei</i> <i>gatu-</i>	
<i>nensis</i>	244
<i>Antillophos</i> (<i>Antillophos</i>) <i>mexicanus</i>	265;
pl. 41, tab. 1	
<i>monachus</i>	266; pl. 40, tab. 1
sp.....	243, 263
<i>Antillophos</i> ? (<i>Antillophos</i> ?) sp.....	243, 244, 264
<i>Antillophos</i> (<i>Rhiphophos</i>) <i>metuloides</i>	268;
pl. 40, tab. 1	
<i>aquaensis</i> , <i>Ancilla</i>	279
<i>arcularia</i> , <i>Buccinum</i>	270
<i>Argobuccinum</i> <i>zorritense</i>	263
<i>asema</i> , <i>Mitrella</i>	248
<i>Astyrus</i> <i>fusiformis</i>	248
<i>aurantiacus</i> , <i>Latirus</i>	274

B	Page
<i>baranoanus</i> , <i>Calophos</i>	262, 263
<i>Phos</i>	262
<i>barnesii</i> , <i>Enaeta</i>	245, 289
<i>Voluta</i>	289
<i>barnsii</i> , <i>Voluta</i>	289
<i>bassii</i> , <i>Strombina</i>	254
<i>bendratii</i> , <i>Antillophos</i> <i>mexicanus</i>	266
Bibliography.....	290
<i>Bittium</i> <i>scottii</i>	270
Bohio formation.....	241, 243
Bohio(?) formation, marine member.....	241, 243
<i>bothrus</i> , <i>Amarophos</i>	241, 246, 267; pl. 47
<i>brassica</i> , <i>Alectrion</i>	271
<i>brassoensis</i> , <i>Alectrion</i>	271
<i>Nassarius</i>	271
<i>bristoli</i> , <i>Turricula</i>	285
<i>Buccinid</i> ?.....	243
<i>Buccinidae</i>	241, 242, 243, 246, 256

	Page
<i>Buccinum</i> <i>ancularia</i>	270
<i>arcularia</i>	270
<i>clathratum</i>	259
<i>distortum</i>	268
<i>glabratum</i>	279
<i>metula</i>	258
<i>migum</i>	270
<i>miran</i>	263
<i>mississippiensis</i>	259
<i>mutabile</i>	270
<i>politum</i>	263
<i>tranquebaricus</i>	258
<i>veneris</i>	263
sp.....	259
<i>buchivacoensis</i> , <i>Cymatophos</i>	260
<i>Phos</i> (<i>Phos</i>).....	260
<i>Bulimus</i> <i>priamus</i>	290
<i>burdigalensis</i> , <i>Fusus</i>	276
<i>bushii</i> , <i>Nassarina</i>	250

C	Page
Calmito formation.....	241, 243
Gatun Lake area.....	243
lower part, Madden Basin.....	243
<i>callipicta</i> , <i>Uromitra</i>	285
<i>caloosensis</i> , <i>Fusus</i>	276
<i>Calophos</i>	241, 245, 260, 262
<i>baranoanus</i>	262, 263
<i>ectyphus</i>	241, 246, 262, 263; pl. 42, tab. 1
<i>inornatus</i>	262, 263
<i>plicatilis</i>	262
<i>rohri</i>	262, 263
n. sp.....	262
<i>Calophos</i> aff. n. sp.....	262
<i>Cancellaria</i> <i>candei</i>	263
<i>Cancellaria</i> ? cf. <i>C. dariena</i>	264, 265
<i>cancellata</i> , <i>Metula</i>	259
<i>candei</i> , <i>Antillophos</i>	265, 266
<i>Antillophos</i> <i>candei</i>	245, 265
<i>candei</i> , <i>Antillophos</i>	245, 265
<i>gatumensis</i> , <i>Antillophos</i>	245, 264, 265, 267
<i>Antillophos</i> ? cf.....	241, 243
<i>Antillophos</i> (<i>Antillophos</i>).....	264; pl. 42, tab. 1
<i>Antillophos</i> ? (<i>Antillophos</i> ?) cf.....	244
<i>Cancellaria</i>	263
<i>Cantharus</i>	258
<i>corrugatus</i>	258
<i>dalli</i>	256
<i>globularis</i>	258
<i>tranquebaricus</i>	258
(<i>Triumphis</i>) <i>predistortus</i>	268
<i>caribaeensis</i> , <i>Oliva</i>	277
<i>Caricella</i> <i>isabellae</i>	289
<i>carolinensis</i> , <i>Pleioptygma</i> (<i>Mitra</i>).....	282
<i>Voluta</i>	282
<i>caroniana</i> , <i>Ancilla</i>	279
<i>cercadensis</i> , <i>Alectrion</i>	271
<i>Nassarius</i>	271
(<i>Uzita</i>).....	271; tab. 1
<i>cestus</i> , <i>Nassarius</i> <i>dasyneuma</i>	271
Chagres sandstone.....	241, 246
<i>charanalensis</i> , <i>Glyptostyla</i> <i>lagunitensis</i>	290
<i>chipolanus</i> , " <i>Phos</i> ".....	269

	Page
<i>chiriquiensis</i> , <i>Hanetia</i>	257
<i>Pyrene</i> (<i>Strombina</i>).....	255
<i>Strombina</i>	253
(<i>Sincola</i>).....	255; pl. 40, tab. 1
<i>cinclis</i> , <i>Nassarius</i>	271
<i>cinnamomea</i> , <i>Ancilla</i>	279
<i>clathrata</i> , <i>Metula</i>	259
<i>clathratum</i> , <i>Buccinum</i>	259
<i>closter</i> , <i>Fusinus</i>	276
<i>Colombella fusiformis</i>	248
<i>colombiana</i> , <i>Melongena</i>	273, 274
<i>Mitra</i>	284
<i>colombianus</i> , <i>Xancus peruvianus</i>	286
<i>colpus</i> , <i>Olivella</i>	280
<i>Columbella</i>	248
<i>fenestrata</i>	248
<i>gracilis</i>	248, 249
<i>gradata crassa</i>	252
<i>lanceolata</i>	252
<i>minor</i>	248
<i>recurva</i>	252
<i>scalarina</i>	248
(<i>Anachis</i>) <i>turrita</i>	248
(<i>Attila</i>) <i>gracilis</i>	248
(<i>Strombina</i>) <i>gatumensis</i>	253
<i>Columbellid?</i>	242
<i>Columbellidae</i>	242, 245, 246; tab. 1
<i>Columbellopsis</i>	248
<i>colus</i> , <i>Murex</i>	275
<i>Cominella plicatilis</i>	262
<i>subrostrata</i>	268
<i>conarus</i> , <i>Nassarius parapristus</i>	272
(<i>Nanarius</i>) <i>parapristus</i>	272; pl. 43, tab. 1
<i>consors</i> , <i>Melongena</i>	273
<i>Melongena melongena</i>	273; pl. 44, tab. 1
<i>Pyruia</i>	273
<i>Coralliophila gatumensis</i>	256, 257
<i>incerta</i>	256, 257
<i>coromandeliana</i> , <i>Strombina</i>	252
<i>corona</i> , <i>Melongena</i>	274
<i>coroni</i> , <i>Ctenilyria</i>	288
<i>Voluta</i>	288
<i>corrugatus</i> , <i>Cantharus</i>	258
<i>costaricensis</i> , <i>Agaronia testacea</i>	282
<i>Strombina</i>	254
<i>costatus</i> , "Phos".....	269
<i>Costoanachis</i>	248
<i>couvana</i> , <i>Oliva</i>	278
<i>couvensis</i> , <i>Mitra longa</i>	283
<i>crassa</i> , <i>Columbella gradata</i>	252
<i>crassitesta</i> , <i>Retipirula</i>	289
<i>Turbinella</i>	289
<i>cristobalcoloni</i> , <i>Oliva</i>	278
<i>cristobalcoloni</i>	278
<i>cristobalcoloni? Oliva (Oliva) cristobalcoloni</i>	278; tab. 1
<i>cristobalcoloni cristobalcoloni</i> , <i>Oliva</i>	278
<i>cristobalcoloni? Oliva (Oliva)</i>	278; tab. 1
<i>Ctenilyria</i>	242, 288
<i>coroni</i>	288
<i>clenista</i>	241, 242, 288; pl. 39
<i>clenista</i> , <i>Ctenilyria</i>	241, 242, 288; pl. 39
<i>clenota</i> , <i>Uromitra</i>	285
<i>Cucaracha</i> formation.....	244
<i>cucurrupeensis</i> , <i>Uromitra</i>	284
<i>Uromitra</i> aff.....	284-285; pl. 44, tab. 1
<i>Culebra</i> formation.....	241, 242, 243, 244
<i>cylleniformis</i> , <i>Enaeta</i>	289
<i>Cymatophos</i>	241, 245, 246, 260, 262, 266
<i>Cymatophos? acolus</i>	241, 246, 261; pl. 47
<i>Cymatophos buchivacoensis</i>	260
<i>galerus</i>	260
<i>hodsoni</i>	261
<i>paraguensis</i>	261
<i>semicostatus</i>	261
<i>subsemicostatus</i>	261; pl. 41, tab. 1
<i>tuberaensis</i>	260
<i>turbacoensis</i>	261
<i>veatchi</i>	260, 261

	Page
<i>Cymatophos? cf. C. veatchi</i>	241, 243, 244, 260
<i>Cymatophos veatchi erymnus</i>	246, 261; pl. 42, tab. 1
<i>veatchi</i>	245, 260, 261, 263; pl. 41, tab. 1
<i>Cymia</i>	268
<i>Cypraea</i>	245
D	
<i>Dactylidella</i>	280
<i>dalli</i> , <i>Cantharus</i>	254
<i>Hanetia</i>	256, 257, 258
<i>dalli</i>	256, 257, 258; pl. 41, tab. 1
<i>dalli</i> , <i>Hanetia</i>	256, 257, 258; pl. 41, tab. 1
<i>medioamericana</i> , <i>Hanetia</i>	257; pl. 42, tab. 1
<i>protera</i> , <i>Hanetia</i>	256, 257, 258; pl. 42, tab. 1
<i>subsp.</i> , <i>Hanetia</i>	246, 258; pl. 47
<i>Mitra</i>	284
<i>Solenosteira</i>	256
<i>dama</i> , <i>Voluta</i>	280
<i>dariena</i> , <i>Cancellaria? cf. C.</i>	264, 265
<i>dariensis</i> , <i>Mitra</i>	284
<i>Mitra (Tiara)</i>	284; pl. 42, tab. 1
<i>venezuelana</i> , <i>Mitra</i>	284
<i>dasyneuma</i> , <i>Nassarius</i>	271
<i>cestus</i> , <i>Nassarius</i>	271
<i>debooyi</i> , <i>Mitrella</i>	247
<i>dentalis</i> , <i>Amarophos</i>	267
<i>Ptychosalpinx?</i>	267
<i>dentilabris?</i> , <i>Terebralia</i>	244
<i>desmia</i> , <i>Mitra</i>	284
<i>dimidiata</i> , <i>Oliva</i>	278, 279
<i>distorta</i> , <i>Triumphis</i>	268
<i>distortum</i> , <i>Buccinum</i>	268
<i>Dorsanum</i>	263
<i>Dorsanum? plicatile</i>	262
<i>plicatulum</i>	262, 263
<i>Dorsanum veneris</i>	263
<i>dupetitthouarsi</i> , <i>Fusinus</i>	276

E	
<i>Eburna</i>	279, 280
<i>flavida</i>	279
<i>ecnomia</i> , <i>Enaeta</i>	245, 246, 289; pl. 46, tab. 1
<i>ectyphus</i> , <i>Calophos</i>	241, 246, 262, 263; pl. 42, tab. 1
<i>elachista</i> , <i>Uromitra</i>	285; pl. 44, tab. 1
<i>elegans</i> , <i>Phos</i> aff.....	263
<i>empicus</i> , <i>Fusinus</i>	276; pl. 43, tab. 1
<i>Enaeta</i>	289
<i>barnesii</i>	245, 289
<i>cylleniformis</i>	289
<i>ecnomia</i>	245, 246, 289; pl. 46, tab. 1
<i>guldinii</i>	289
<i>Engina</i>	250
<i>Engoniophos</i>	269
<i>vadosus</i>	251
<i>Eocene</i> or <i>Oligocene</i> series.....	243
<i>Eocene</i> series.....	242
<i>Eorancus</i>	286
<i>epacta</i> , <i>Mitrella</i>	241, 243, 247; pl. 39
<i>episcopalis</i> , <i>Mitra</i>	282
<i>Voluta</i>	282
<i>erectus</i> , <i>Phos</i>	269
<i>erymnus</i> , <i>Cymatophos veatchi</i>	246, 261; pl. 42, tab. 1
<i>estrellensis</i> , <i>Strombinophos</i>	252
<i>Strombinophos</i> cf.....	252; tab. 1
<i>eurytera</i> , <i>Voluta alfaroi</i>	246, 287; pl. 45, tab. 1
<i>Euthriofusus</i>	276

F	
<i>falconensis</i> , <i>Xancus</i>	287
<i>validus</i>	286; pl. 46, tab. 1
<i>fasciata</i> , <i>Melongena</i>	273
<i>Fasciolaria</i>	275
<i>gorgasiana</i>	276; pl. 43, tab. 1
<i>subsp.</i>	276; pl. 45, tab. 1
<i>kempi</i>	275
<i>macdonaldi</i>	275
<i>sp.</i>	244, 275
(<i>Pleuroploca</i>) cf. <i>gorgasiana</i>	275
<i>Fasciolaridae</i>	246, 274

	Page
<i>fasciolatus</i> , "Phos".....	269
Faunal summaries of species.....	242
<i>fenestrata</i> , <i>Anachis (Alia)</i> cf.....	248
<i>Columbella</i>	248
<i>Mitrella</i>	248
<i>Mitrella</i> aff.....	248
<i>Mitrella (Columbellopsis)</i> aff.....	248; pl. 39, tab. 1
<i>ficulneus</i> , <i>Fusus</i>	289
<i>flaminea</i> , <i>Mitrella</i>	246
<i>flavida</i> , <i>Eburna</i>	279
<i>fugax</i> , <i>Anachis</i>	249
(<i>Costoanachis</i>) <i>mira</i>	249; pl. 40, tab. 1
<i>mira</i>	249
<i>fusiformis</i> , <i>Astyrus</i>	248
<i>Columbella</i>	248
<i>Hanetia</i>	257
<i>Polygona</i>	274
<i>Purpura</i>	247
<i>Fusinus</i>	276; tab. 1
<i>Fusinidae</i>	275
<i>Fusinosteira</i>	257
<i>Fusinus</i>	275, 276, 287
<i>closter</i>	276
<i>dupetitthouarsi</i>	276
<i>empicus</i>	276; pl. 43, tab. 1
<i>magdalensis</i>	276
<i>springalensis</i>	276
<i>veatchi</i>	276
<i>Fusinus? sp.</i>	243, 244, 245, 275
<i>Fusus</i>	275
<i>burdigalensis</i>	276
<i>caloosacensis</i>	276
<i>ficulneus</i>	289
"Fusus" <i>turbinelloides</i>	257
<i>Fusus (Latirus)</i> sp. aff. <i>iriae</i>	274

G	
<i>gabbi</i> , <i>Metula</i>	259, 267; pl. 40, tab. 1
<i>galerus</i> , <i>Cymatophos</i>	260
<i>Gastropods</i>	246
<i>Gatun</i> formation.....	241, 242, 245, 246; tab. 1
<i>Gatuncillo</i> formation.....	241, 242
<i>gatumensis</i> , <i>Antillophos candei</i>	245, 264, 265, 267
<i>Antillophos? cf. A. candei</i>	241, 243
<i>Antillophos (Antillophos) candei</i>	264;
.....	pl. 42, tab. 1
<i>Antillophos? (Antillophos?) cf. A. candei</i>	244
<i>Columbella (Strombina)</i>	253
<i>Coralliophila</i>	256, 257
<i>Oliva</i>	276, 277
<i>reticularis</i>	277
(<i>Neocylinidrus</i>).....	277
(<i>Oliva</i>).....	276; pl. 45, tab. 1
<i>Phos</i>	264, 265
(<i>Antillophos</i>).....	264
<i>Strombina</i>	253
<i>gaudens</i> , <i>Phos</i>	265
<i>gibberula</i> , <i>Strombina</i>	254
<i>gibbulus</i> , <i>Murex</i>	274
<i>gigantea</i> , <i>Mitra</i>	283
<i>glabrata</i> , <i>Ancilla</i>	279
<i>speciosa</i> , <i>Ancilla</i>	279
<i>glabratum</i> , <i>Buccinum</i>	279
<i>globularis</i> , <i>Cantharus</i>	258
<i>glypta</i> , <i>Mangilia?</i>	250
<i>Zanassarina</i>	251
<i>Glyptostylia</i>	243, 289
<i>lagunitensis</i>	290
<i>charanensis</i>	290
<i>lagunitensis</i>	290
<i>olsoni</i>	290
<i>panamensis</i>	241, 243, 289; pl. 39
<i>golfoyaquensis</i> , <i>Tritia</i>	263
<i>goliath</i> , <i>Olivella</i>	280, 281
<i>Olivella (Toroliva)</i>	281; pl. 45, tab. 1
<i>gorgasiana</i> , <i>Fasciolaria</i>	275; pl. 43, tab. 1
<i>subsp.</i> , <i>Fasciolaria</i>	275; pl. 45, tab. 1
<i>Fasciolaria (Pleuroploca)</i> cf.....	275
<i>gorgon</i> , <i>Alectrion</i>	270

	Page
<i>gracilis</i> , <i>Columbella</i>	248, 249
(<i>Atilia</i>).....	248
<i>gradata</i> <i>crassa</i> , <i>Columbella</i>	252
<i>Strombina</i>	252
<i>guadelupensis</i> , " <i>Nassa</i> ".....	269
<i>Pallacera</i>	270
<i>Pallacera</i> aff. <i>P</i>	269, 270; pl. 43, tab. 1
<i>guldinigi</i> , <i>Enaeta</i>	289
<i>guttifera</i> , <i>Nicema</i>	268
" <i>Struthiolaria</i> ".....	268

H

<i>habra</i> , <i>Zanassarina</i>	250; pl. 39, tab. 1
<i>hadra</i> , <i>Agaronia testacea</i>	282; pl. 47, tab. 1
<i>Halia</i>	290
<i>americana</i>	290
<i>haneti</i> , <i>Hanetia</i>	256
<i>Murex</i>	256
<i>Ocenebra</i>	256
<i>Tritonalia</i>	256
<i>Hanetia</i>	245, 256, 257, 258
<i>acilimensis</i>	258
<i>alternata</i>	257
<i>chiriquiensis</i>	257
<i>dalli</i>	256, 257, 258
<i>dalli</i>	256, 258, 267; pl. 41, tab. 1
<i>medioamericana</i>	257; pl. 42, tab. 1
<i>protera</i>	256, 257, 258; pl. 42, tab. 1
subsp.	246, 258; pl. 47
<i>fusiiformis</i>	257
<i>haneti</i>	256
<i>hasletti</i>	258
" <i>turbinelloides</i> ".....	257
<i>vaughani</i>	258
<i>Hanetia?</i> sp.....	256
<i>harpa</i> , <i>Voluta</i>	289
<i>hasletti</i> , <i>Hanetia</i>	258
<i>Heilprinia</i>	276
<i>hiatula</i> , <i>Agaronia</i>	281
<i>Voluta</i>	281
<i>Hindsii</i>	259
<i>hindsii</i> <i>Metula</i>	258
<i>hodsoni</i> , <i>Cymatophos</i>	261
<i>holmesii</i> , <i>Uromitra</i>	285

I

<i>immortua</i> , <i>Oliva sayana</i>	277
<i>incerta</i> , <i>Coralliophila</i>	256, 257
<i>infundibulum</i> , <i>Murex</i>	274
<i>inornata</i> , <i>Phos</i>	262
<i>inornatus</i> , <i>Calophos</i>	262, 263
Introduction.....	241
<i>iriae</i> , <i>Fusus</i> (<i>Latirus</i>) sp. aff.....	274
<i>isabella</i> , <i>Mitra</i>	283
<i>Tiara</i>	283
<i>isabellae</i> , <i>Caricella</i>	291

K

<i>kempi</i> , <i>Fasciolaria</i>	275
-----------------------------------------	-----

L

La Boca formation.....	241, 244, 245
<i>laevigatus</i> , <i>Xancus</i>	287
<i>lagunitensis</i> , <i>Glyptostyla</i>	290
<i>lagunitensis</i>	290
<i>lagunitensis</i> , <i>Glyptostyla</i>	290
<i>Peruficus</i>	289
<i>Lamprodoma</i> (<i>Strephonella</i>) <i>undatella</i>	278
<i>lanceolata</i> , <i>Columbella</i>	252
<i>Latirus</i>	274
<i>aurantiacus</i>	274
<i>mcgintyi</i>	275
<i>taurus</i>	275
<i>Latirus?</i> sp.....	243
<i>Latirus</i> (<i>Polygona</i>) <i>anapetes</i>	246, 274; pl. 47
<i>Lepidocyclina</i>	244
<i>Leptarius</i>	241, 242, 245, 272, 279
<i>leptus</i>	242, 246, 272; pl. 44, tab. 1
<i>leptus</i> , <i>Leptarius</i>	242, 246, 272; pl. 44, tab. 1
<i>lessepsiana</i> , <i>Strombina</i>	252, 253, 254
<i>Strombina</i> (<i>Strombina</i>).....	252; pl. 40, tab. 1

<i>limonensis</i> , <i>Metula</i>	259
<i>Mitra</i>	245, 283
<i>Mitra</i> cf.....	288
<i>Mitra swainsonii</i>	282
cf. <i>M. swainsonii</i>	283
(<i>Pleioptygma?</i>).....	282; pl. 46, tab. 1
<i>Mitrella</i>	247; pl. 39, tab. 1
<i>Strombina</i>	247
<i>liodes</i> , <i>Oliva</i>	276
<i>lissa</i> , <i>Strombina</i>	254
<i>Strombina</i> cf.....	254
<i>Strombina</i> (<i>Strombina?</i>) cf. <i>S</i>	254; tab. 1
<i>Littorina</i> aff. <i>L. angulifera</i>	244
<i>longa</i> , <i>Mitra</i>	283, 284
<i>Mitra longa</i>	283, 284
(<i>Tiara</i>) <i>longa</i>	283; pl. 47, tab. 1
<i>couensis</i> , <i>Mitra</i>	283
<i>longa</i> , <i>Mitra</i>	283, 284
<i>Mitra</i> (<i>Tiara</i>).....	283; pl. 47, tab. 1
<i>rhadina</i> , <i>Mitra</i>	283
<i>loripanus</i> , <i>Strombinophos</i>	251
<i>Lyria</i>	288
<i>Lyria?</i> sp.....	245
<i>Lyriinae</i>	288

M

<i>macdonaldi</i> , <i>Fasciolaria</i>	275
<i>magdalenensis</i> , <i>Fusinus</i>	276
<i>mancinella</i> , <i>Agaronia testacea</i>	281; pl. 45, tab. 1
<i>Oliva</i>	281
<i>Mangilia?</i> <i>glypta</i>	250
<i>Mansfieldella</i>	280
Marine member of Bohio(?) formation.....	241, 243
<i>mazwelli</i> , <i>Strombinophos</i>	251
<i>Mazatlanella</i>	246
<i>aciculata</i>	246
<i>mcgintyi</i> , <i>Latirus</i>	275
<i>medioamericana</i> , <i>Hanetia dalli</i>	pl. 42, tab. 1
<i>Solenosteira vaughani</i>	257
<i>Melongena</i>	273, 274
<i>colombiana</i>	273, 274
<i>consors</i>	273
<i>corona</i>	274
<i>fasciata</i>	273
<i>melongena</i>	273, 274
<i>consors</i>	273; pl. 44, tab. 1
<i>melongena</i>	274
<i>orthacantha</i>	274
<i>patula</i>	274
<i>proptulus</i>	274
sp.....	244, 245
(<i>Pugilina</i>) <i>mengana</i>	258
<i>melongena</i> , <i>Melongena</i>	273, 274
<i>Melongena melongena</i>	274
<i>consors</i> , <i>Melongena</i>	273; pl. 44, tab. 1
<i>melongena</i> , <i>Melongena</i>	274
<i>Murex</i>	273
<i>Pyrula</i>	273
<i>Melongenidae</i>	273
<i>mengana</i> , <i>Melongena</i> (<i>Pugilina</i>).....	258
<i>Metula</i>	245, 258, 266
<i>amosi</i>	259
<i>cancellata</i>	259
<i>clathrata</i>	259
<i>gabbi</i>	259, 267; pl. 40, tab. 1
<i>hindsii</i>	258
<i>limonensis</i>	259
sp.....	244, 259
<i>metula</i> , <i>Buccinum</i>	258
<i>metuloides</i> , <i>Antillophos</i>	267
<i>Antillophos</i> (<i>Rhipophos</i>).....	266; pl. 40, tab. 1
<i>Phos</i>	242, 266, 267
<i>mexicana</i> , <i>Tritiaria</i> (<i>Antillophos</i>).....	265
<i>mexicanus</i> , <i>Antillophos</i>	248, 265, 266
<i>Antillophos</i> (<i>Antillophos</i>).....	265; pl. 41, tab. 1
<i>bendradi</i> , <i>Antillophos</i>	266
<i>Phos</i>	265
(<i>Antillophos</i>).....	265

<i>miga</i> , <i>Nassa</i>	270
<i>migum</i> , <i>Buccinum</i>	270
<i>mikra</i> , <i>Mitrella</i>	247
<i>mimicus</i> , <i>Strombinophos</i>	251; pls. 39, 40, tab. 1
<i>minor</i> , <i>Columbella</i>	248
<i>minuta</i> , <i>Olivella</i>	280
<i>Porphyria</i>	280
Miocene series.....	243
<i>miocenica</i> , <i>Northia</i>	269
<i>Miogypsina</i>	244
<i>mira</i> , <i>Anachis</i>	249
<i>Anachis mira</i>	249
(<i>Costoanachis</i>) <i>mira</i>	248; pl. 39, tab. 1
<i>fugax</i> , <i>Anachis</i> (<i>Costoanachis</i>).....	249; pl. 40, tab. 1
<i>Anachis</i>	249
<i>mira</i> , <i>Anachis</i>	249
<i>Anachis</i> (<i>Costoanachis</i>).....	248; pl. 39, tab. 1
<i>Strombina</i>	248
<i>miran</i> , <i>Buccinum</i>	263
<i>mississippiensis</i> , <i>Buccinum</i>	259
<i>Mitra</i>	282, 283, 284
<i>colombiana</i>	284
<i>dalli</i>	284
<i>dariensis</i>	284
<i>venezuelana</i>	284
<i>desmia</i>	284
<i>episcopalis</i>	282
<i>gigantea</i>	283
<i>isabella</i>	283
<i>limonensis</i>	245, 283
cf. <i>M. limonensis</i>	283
<i>longa</i>	283, 284
<i>couensis</i>	283
<i>longa</i>	283, 284
<i>rhadina</i>	283
<i>mitra</i>	282
<i>rhadina</i>	283
<i>sulcata</i>	283, 284
<i>swainsonii</i>	282, 283
<i>antillensis</i>	245, 282
<i>limonensis</i>	282
cf. <i>M. swainsonii</i> <i>limonensis</i>	283
<i>swainsonii</i> <i>swainsonii</i>	245, 282
<i>zaca</i>	282
(<i>Pleioptygma?</i>) <i>limonensis</i>	282; pl. 46, tab. 1
(<i>Strigatella?</i>) <i>perturbatrix</i>	289
(<i>Tiara</i>) <i>dariensis</i>	284; pl. 42, tab. 1
<i>longa longa</i>	283; pl. 47, tab. 1
sp.....	243, 244
<i>mitra</i> , <i>Mitra</i>	282
<i>Voluta</i>	282
<i>Mitrella</i>	243, 246, 248
<i>acanthodes</i>	247
<i>asema</i>	248
<i>debooyi</i>	247
<i>epacta</i>	241, 243, 247; pl. 39
<i>fenestrata</i>	248
aff. <i>M. fenestrata</i>	248
<i>flaminea</i>	246
<i>limonensis</i>	247; pl. 39, tab. 1
<i>mikra</i>	247
<i>nanna</i>	247
<i>oryzoides</i>	247
<i>ozia</i>	247
<i>parva</i>	246, 247
<i>pedana</i>	247
<i>sima</i>	247
sp.....	243, 246; pl. 39
<i>Mitrella?</i> sp.....	245, 246
<i>Mitrella</i> (<i>Columbellopsis</i>) aff. <i>M. fenestrata</i>	248; pl. 39, tab. 1
Mitridae.....	282
Mitriinae.....	282
<i>monachus</i> , <i>Antillophos</i>	266
<i>Antillophos</i> (<i>Antillophos</i>).....	266; pl. 40, tab. 1
<i>moorei</i> , <i>Antillophos</i>	266
<i>Muracyprea</i>	245, 285

	Page
<i>Murex colus</i>	275
<i>gibbulus</i>	274
<i>haneti</i>	256
<i>infundibulum</i>	274
<i>melongena</i>	273
<i>scriptus</i>	246
<i>tulipa</i>	275
<i>musica</i> , <i>Voluta</i>	287, 288
<i>musicus</i> , <i>Voluta</i>	287
<i>mutabile</i> , <i>Buccinum</i>	270
<i>muticoides</i> , <i>Olivella</i>	280
<i>myristicata</i> , <i>Nassa</i>	242, 269
" <i>Nassa</i> ".....	269, 270

N

<i>Nanarius</i>	241, 242, 245, 271
<i>namna</i> , <i>Mitrella</i>	247
<i>Nassa</i>	269, 270
" <i>Nassa</i> " <i>guadelupensis</i>	269
<i>Nassa miga</i>	270
<i>myristicata</i>	242, 269
" <i>Nassa</i> " <i>myristicata</i>	269, 270
<i>Nassa northiae</i>	268
" <i>Nassa</i> " <i>solidula</i>	269
<i>Nassa uncinata</i>	269
(<i>Hima</i>) <i>praeambigua</i>	270
<i>Nassarid?</i>	243
<i>Nassaridae</i>	242, 269
<i>Nassarina</i>	250
<i>bushii</i>	250
<i>poecila</i>	250
<i>Nassarius</i>	241, 242, 245, 270, 271, 272
<i>acutus</i>	272
<i>albus</i>	271
<i>ambiguus</i>	271
<i>brassoensis</i>	271
<i>cercadensis</i>	271
<i>cinclis</i>	271
<i>dasyneuma</i>	271
<i>cestus</i>	271
<i>parapristus</i>	272
<i>aculus</i>	272
<i>conarus</i>	272
<i>parapristus</i>	271, 272
<i>praeambiguus</i>	241, 244, 270, 271, 272
<i>pristus</i>	271, 272
<i>sp.</i>	tab. 1
(<i>Nanarius</i>) <i>parapristus aculus</i>	271; pl. 40, tab. 1
<i>parapristus conarus</i>	272; pl. 43, tab. 1
(<i>Uzita</i>) <i>cercadensis</i>	271; tab. 1
(<i>Uzita</i>)? <i>praeambiguus</i>	245, 270; pl. 43, tab. 1
<i>Naticarius</i>	270
<i>Neritina</i> <i>sp.</i>	244
<i>Nicema</i>	241, 242, 245, 270
<i>amara</i>	242, 246, 268; pl. 42, tab. 1
<i>guttifera</i>	268
<i>Niteolia</i>	280
<i>nitidula</i> , <i>Olivella</i>	280
<i>Northia</i>	243, 268, 269
<i>Northia?</i>	245, 268
<i>Northia miocenica</i>	269
<i>northiae</i>	268, 269
<i>Northia?</i> cf. <i>N. northiae</i>	241, 243, 244, 268; pl. 39
<i>Northia pristis</i>	268
<i>Northia?</i> <i>sp.</i>	269; pl. 43, tab. 1
<i>northiae</i> , <i>Nassa</i>	268
<i>Northia</i>	268, 269
<i>Northia?</i> cf.	241, 243, 244, 268; pl. 39
<i>nucleus</i> , <i>Voluta</i>	288

O

<i>ochyra</i> , <i>Strombina</i>	254
(<i>Strombina</i>).....	253; pl. 39, tab. 1
<i>Ocenebra haneti</i>	256
Oligocene series.....	243
<i>Oliva</i>	241, 243, 245, 276, 277, 278, 280
<i>caribaensis</i>	277
<i>cowanana</i>	278

Oliva—Continued

<i>cristobalcoloni</i>	278
<i>cristobalcoloni</i>	278
<i>dimidiata</i>	278, 279
<i>gatunensis</i>	276, 277
<i>hodes</i>	276
<i>mancinella</i>	281
<i>plicata</i>	278, 279
<i>proaria</i>	278
<i>purpurata</i>	280
<i>reticularis</i>	277, 278
<i>gatunensis</i>	277
<i>trochala</i>	277
<i>sayana immortua</i>	277
<i>tuberaensis</i>	278
<i>undatella</i>	278, 279
<i>sp.</i>	276
(<i>Neocylindrus</i>) <i>gatunensis</i>	277
(<i>Oliva</i>) <i>cristobalcoloni cristobalcoloni?</i>	278; tab. 1
<i>gatunensis</i>	276; pl. 45, tab. 1
<i>plicata</i>	278
<i>reticularis</i> , subsp.	277; pl. 45, tab. 1
<i>sp.</i>	243, 245
(<i>Strephonella</i>) <i>plicata</i>	278; pl. 45, tab. 1
<i>oliva</i> , <i>Voluta</i>	276
<i>Olivella</i>	241, 243, 278, 280
<i>colpus</i>	280
<i>goliath</i>	280, 281
<i>minuta</i>	280
<i>muticoides</i>	280
<i>nitidula</i>	280
<i>terryi</i>	280
<i>sp.</i>	243, 244, 280
<i>Olivella?</i> <i>sp.</i>	245
(<i>Niteolia</i>) <i>terryi</i>	280; pl. 45, tab. 1
(<i>Toroliva</i>) <i>goliath</i>	281; pl. 45, tab. 1
<i>Olivellinae</i>	280
<i>Olivid</i>	242, 243
<i>Olividae</i>	243, 276
<i>Olivinae</i>	276
<i>olssoni</i> , <i>Glyptostyla</i>	290
<i>Strombina</i>	246, 255, 273; pl. 39, tab. 1
<i>orthacantha</i> , <i>Melongena</i>	274
<i>oryzoides</i> , <i>Mitrella</i>	247
<i>ovoideus</i> , <i>Xancus</i>	287
<i>ozia</i> , <i>Mitrella</i>	247

P

<i>Pallacera</i>	242, 269
<i>guadelupensis</i>	270
aff. <i>P. guadelupensis</i>	269, 270; pl. 43, tab. 1
Panamá formation.....	241, 244
<i>panamensis</i> , <i>Glyptostyla</i>	241, 243, 289; pl. 39
<i>paraguanensis</i> , <i>Cymatophos</i>	261
<i>paraprista</i> , <i>Uzita</i>	242, 271
<i>parapristus</i> , <i>Nassarius</i>	272
<i>Nassarius parapristus</i>	271, 272
<i>aculus</i> , <i>Nassarius</i>	272
<i>conarus</i> , <i>Nassarius</i>	272
<i>parapristus</i> , <i>Nassarius</i>	271, 272
<i>aculus</i> , <i>Nassarius</i> (<i>Nanarius</i>).....	271; pl. 40, tab. 1
<i>conarus</i> , <i>Nassarius</i> (<i>Nanarius</i>).....	272; pl. 43, tab. 1
<i>parva</i> , <i>Mitrella</i>	246, 247
<i>patula</i> , <i>Melongena</i>	274
<i>pavonina</i> , <i>Strombina</i>	254
<i>paytensis</i> , <i>Xancus</i>	286
<i>pedana</i> , <i>Mitrella</i>	247
<i>pedanus</i> , " <i>Phos</i> ".....	269
<i>perturbatrix</i> , <i>Mitra</i> (<i>Strigatella</i>)?.....	289
<i>Peruficus</i>	243, 289, 290
<i>lagunitensis</i>	289
<i>Perumassa</i>	263
<i>peruvianus</i> , <i>Xancus</i>	286
<i>Xancus</i> cf.	241, 242, 286; pl. 39
<i>colombianus</i> , <i>Xancus</i>	286
<i>Phos</i>	241, 246, 260, 264, 267, 269
<i>baranoanus</i>	262

" <i>Phos</i> " <i>chipolanus</i>	269
<i>costatus</i>	269
<i>Phos</i> aff. <i>elegans</i>	263
<i>erectus</i>	269
" <i>Phos</i> " <i>fasciolatus</i>	269
<i>Phos gatunensis</i>	264, 265
<i>gaudens</i>	265
<i>inornata</i>	262
<i>metuloides</i>	242, 266, 267
<i>mericanus</i>	265
" <i>Phos</i> " <i>pedanus</i>	269
<i>Phos?</i> <i>rohri</i>	262
<i>Phos semilineatum</i>	249
<i>subsemicostatus</i>	261
" <i>Phos</i> " <i>tribakus</i>	269
<i>Phos veatchi</i>	260
(<i>Antillophos</i>) <i>gatunensis</i>	264
<i>mericanus</i>	265
(<i>Phos</i>) <i>buchivacoensis</i>	260
<i>pinguis</i> , <i>Ancilla</i>	279
(<i>Eburna</i>).....	279; pl. 45, tab. 1
<i>Ancillaria</i>	279
<i>Pleioptygma</i>	282
(<i>Mitra</i>) <i>carolinensis</i>	282
<i>pleurica</i> , <i>Strombina</i> (<i>Strombina</i>)?.....	254; pl. 40, tab. 1
<i>plicaria</i> , <i>Voluta</i>	284
<i>plicata</i> , <i>Oliva</i>	278, 279
(<i>Oliva</i>).....	278
(<i>Strephonella</i>).....	278; pl. 45, tab. 1
<i>plicatilis</i> , <i>Dorsanum?</i>	262
<i>plicatilis</i> , <i>Calophos</i>	262
<i>Cominella</i>	262
<i>plicatulum</i> , <i>Dorsanum?</i>	262, 263
<i>plicatum</i> , <i>Vexillum</i>	284
<i>Pliocene</i> series.....	246
<i>poecila</i> , <i>Nassarina</i>	250
<i>poliutum</i> , <i>Buccinum</i>	263
<i>Polygona fusiformis</i>	274
<i>Porphyria minuta</i>	280
<i>Potamides suprasulcatus</i>	244
<i>praeambigua</i> , <i>Nassa</i> (<i>Hima</i>).....	270
<i>praeambiguus</i> , <i>Nassarius</i>	241, 244, 270, 271, 272
(<i>Uzita</i>)?.....	245, 270; pl. 43, tab. 1
<i>praeovoidea</i> , <i>Turbinella</i>	286
<i>praeovoideus</i> , <i>Xancus</i>	286, 287
<i>riosecanus</i> , <i>Xancus</i>	287
<i>praeovoideus</i> , <i>Xancus</i>	286, 287
<i>predistortus</i> , <i>Cantharus</i> (<i>Triumphus</i>).....	268
<i>priamus</i> , <i>Ampulla</i>	290
<i>Bulimus</i>	290
<i>prisma</i> , <i>Strombina</i>	253
<i>pristis</i> , <i>Northia</i>	268
<i>pristus</i> , <i>Nassarius</i>	271, 272
<i>proaria</i> , <i>Oliva</i>	278
<i>propatulus</i> , <i>Melongena</i>	274
<i>protera</i> , <i>Hanetia dalli</i>	256, 257, 258; pl. 42, tab. 1
<i>Pseudolyria</i>	288
<i>ventricosa</i>	288
<i>Ptychosalpinx?</i> <i>dentalis</i>	267
<i>pumilio</i> , <i>Strombina</i>	252
<i>Purpura fusiformis</i>	257
<i>purpurata</i> , <i>Oliva</i>	280
<i>Pyrene</i> (<i>Strombina</i>) <i>chiriquiensis</i>	255
<i>Pyruia anomala</i>	256
" <i>Pyruia</i> " <i>anomala</i>	256
<i>Pyruia consors</i>	273
<i>melongena</i>	273
<i>pyrum</i> , <i>Voluta</i>	285
<i>Xancus</i>	285

Q

<i>quirosana</i> , <i>Strombina</i>	252
<i>Strombina</i> cf.	241, 243, 244, 252

R

<i>recurva</i> , <i>Columbella</i>	252
<i>reticularis</i> , <i>Oliva</i>	277, 278
<i>gatunensis</i> , <i>Oliva</i>	277
<i>trochala</i> , <i>Oliva</i>	277
subsp., <i>Oliva</i> (<i>Oliva</i>).....	277; pl. 45, tab. 1

	Page
<i>Retipirula</i>	289
<i>crassitesta</i>	289
<i>rez</i> , <i>Xancus</i>	286
<i>Xancus</i> cf.....	244, 286
<i>rhadina</i> , <i>Mitra</i>	283
<i>Mitra longa</i>	283
<i>Rhipophos</i>	241, 242, 245, 260, 266, 267
<i>riosecanus</i> , <i>Xancus praeovoides</i>	287
<i>rohri</i> , <i>Calophos</i>	262, 263
<i>Phos</i> ?.....	262
<i>rutschi</i> , <i>Antillophos</i>	266

S

<i>sayana immortua</i> , <i>Oliva</i>	277
<i>scalarina</i> , <i>Columbella</i>	248
<i>sclera</i> , <i>Trachypollia</i>	258
<i>Sconsia</i>	245, 285
<i>scotti</i> , <i>Bittum</i>	270
<i>scriptus</i> , <i>Murex</i>	246
<i>semicostatus</i> , <i>Cymatophos</i>	261
<i>semilineatum</i> , <i>Phos</i>	249
<i>sima</i> , <i>Mitrella</i>	247
<i>Sincola</i>	241, 245, 254
<i>sincola</i> , <i>Strombina</i>	254, 255
<i>Siphogenerina</i>	244
<i>Solenosteira</i>	256, 257
<i>dalli</i>	256
<i>vaughani medioamericana</i>	257
<i>solidula</i> , "Nassa".....	269
<i>speciosa</i> , <i>Ancilla glabrata</i>	279
<i>springvalensis</i> , <i>Fusinus</i>	276
<i>stevensoni</i> , <i>Anachis</i>	249
<i>stibara</i> , <i>Anachis (Costoanachis)</i>	250; pl. 40, tab. 1
<i>Strephonella</i>	241, 245, 278, 279
<i>Strepsidura</i>	289
<i>Strigatella americana</i>	289
<i>Strioterebrum</i>	241, 245, 255
<i>Strombina</i>	241, 243, 245, 252, 254
<i>amphidyma</i>	255
<i>bassi</i>	254
<i>chiriquiensis</i>	255
<i>coromandelana</i>	252
<i>costaricensis</i>	254
<i>gatunensis</i>	253
<i>gibberula</i>	254
<i>gradata</i>	252
<i>lessepsiana</i>	252, 253, 254
<i>limonensis</i>	247
<i>lissa</i>	254
cf. <i>S. lissa</i>	254
<i>mira</i>	248
<i>ochyra</i>	254
<i>pavonina</i>	254
<i>prisma</i>	253
<i>pumilio</i>	252
<i>quirosana</i>	252
cf. <i>S. quirosana</i>	241, 243, 244, 252
<i>sincola</i>	254, 255
<i>walli</i>	255
<i>waltonia</i>	253
(<i>Sincola</i>) <i>amphidyma</i>	255; pl. 40, tab. 1
<i>chiriquiensis</i>	255; pl. 40, tab. 1
(<i>Strombina</i>) <i>lessepsiana</i>	252; pl. 40, tab. 1
(<i>Strombina</i>)? cf. <i>S. lissa</i>	254; tab. 1
(<i>Strombina</i>) <i>ochyra</i>	253; pl. 39, tab. 1
(<i>Strombina</i>)? <i>pleurica</i>	254; pl. 40, tab. 1
<i>Strombinella</i>	241, 245, 246, 255, 279
<i>acutiformis</i>	254
<i>olssoni</i>	246, 255, 273; pl. 39, tab. 1
<i>Strombinophos</i>	241, 245, 246, 251, 252
<i>estrellensis</i>	252
cf. <i>S. estrellensis</i>	252; tab. 1
<i>loripanus</i>	251
<i>maxwelli</i>	251
<i>mimicus</i>	251; pls. 39, 40, tab. 1
<i>Strombocolumbus</i>	252
<i>Strongylocera</i>	269
" <i>Struthiolaria</i> " <i>guttifera</i>	268
<i>Subancilla</i>	283

Page

<i>subrostrata</i> , <i>Cominella</i>	268
<i>subsemicostatus</i> , <i>Cymatophos</i>	261; pl. 41, tab. 1
<i>Phos</i>	261
<i>sulcata</i> , <i>Mitra</i>	283, 284
<i>suprasulcatus</i> , <i>Potamides</i>	244
<i>swainsonii</i> , <i>Mitra</i>	282, 283
<i>Mitra swainsonii</i>	245, 282
<i>antillensis</i> , <i>Mitra</i>	245, 282
<i>limonensis</i> , <i>Mitra</i>	282
<i>Mitra</i> cf. <i>M.</i>	283
<i>swainsonii</i> , <i>Mitra</i>	245, 282

T

<i>talarensis</i> , <i>Xancus</i>	286
<i>taurus</i> , <i>Latirus</i>	275
<i>Terebralia dentilabris</i> ?.....	244
<i>terryi</i> , <i>Olivella</i>	280
<i>Olivella (Niteolina)</i>	280; pl. 45, tab. 1
Tertiary mollusks, description.....	248
<i>testacea</i> , <i>Agaronia</i>	281, 282
<i>testacea</i>	281, 282
<i>costaricensis</i> , <i>Agaronia</i>	282
<i>hadra</i> , <i>Agaronia</i>	282; pl. 47, tab. 1
<i>manicella</i> , <i>Agaronia</i>	281; pl. 45, tab. 1
<i>testacea</i> , <i>Agaronia</i>	281, 282
<i>texilis</i> , <i>Xancus</i>	286
<i>Tiara</i>	283
<i>isabella</i>	283
<i>Torolia</i>	280
<i>tortuosellum</i> , <i>Vezillum</i>	285
<i>Trachypollia</i>	258
<i>aneurela</i>	258; pl. 42, tab. 1
<i>sclera</i>	258
<i>ranquebaricus</i> , <i>Buccinum</i>	258
<i>Cantharus</i>	258
<i>tribakus</i> , "Phos".....	269
<i>trinitatis</i> , <i>Xancus</i>	287
<i>Tritia golfoyaquensis</i>	263
<i>Tritiaria</i>	259, 263, 264
<i>Tritiaria</i> ?.....	259
<i>Tritiaria</i> sp.....	264
<i>Tritiaria</i> ? sp.....	243, 259-260
<i>Tritiaria (Antillophos) mexicana</i>	265
<i>Tritonalia haneti</i>	256
<i>Triumphis</i>	268
<i>distorta</i>	268
<i>trochala</i> , <i>Oliva reticularis</i>	277
<i>tuberaensis</i> , <i>Cymatophos</i>	260
<i>Oliva</i>	278
<i>tulpa</i> , <i>Murex</i>	275
<i>turbacoensis</i> , <i>Cymatophos</i>	261
<i>Turbinella</i>	285
<i>crassitesta</i>	289
<i>praeovoides</i>	286
<i>turbinelloides</i> , "Fusus".....	257
"Hanetia".....	257
<i>Turricula bristoli</i>	285
<i>turrita</i> , <i>Columbella (Anachis)</i>	248
<i>Undatella</i> , <i>Lamprodoma (Strephonella)</i>	278
<i>Oliva</i>	278, 279
<i>unicincta</i> , <i>Nassa</i>	269
<i>Uromitra</i>	284, 285
<i>antegressa</i>	284
<i>callipicta</i>	285
<i>ctenota</i>	285
<i>cucurrupeensis</i>	284
aff. <i>U. cucurrupeensis</i>	284; pl. 44, tab. 1
<i>elachista</i>	285; pl. 44, tab. 1
<i>holmesii</i>	285
<i>Uzita</i>	270, 271
<i>paraprista</i>	242, 271

V

<i>vadosus</i> , <i>Engoniophos</i>	251
<i>validus</i> , <i>Xancus</i>	286
<i>validus</i>	286
<i>validus</i> ?, <i>Xancus validus</i>	286; pl. 47, tab. 1
<i>Validus falconensis</i> , <i>Xancus</i>	286; pl. 46, tab. 1
<i>validus</i> , <i>Xancus</i>	286
<i>validus</i> ?, <i>Xancus</i>	286; pl. 47, tab. 1

Page

<i>vaughani</i> , <i>Hanetia</i>	258
<i>medioamericana Solenosteira</i>	257
<i>veatchi</i> , <i>Cymatophos</i>	260, 261
<i>Cymatophos</i> ? cf. <i>C.</i>	241, 243, 244, 260
<i>Cymatophos veatchi</i>	245, 260, 261, 263; pl. 41, tab. 1
<i>erymnus</i> , <i>Cymatophos</i>	246, 261; pl. 42, tab. 1
<i>veatchi</i> , <i>Cymatophos</i>	245, 260, 261, 263; pl. 41, tab. 1
<i>Fusinus</i>	276
<i>Phos</i>	260
<i>veneris</i> , <i>Buccinum</i>	263
<i>Dorsanum</i>	263
<i>venezuelana</i> , <i>Mitra dariensis</i>	284
<i>ventricosa</i> , <i>Pseudolyria</i>	288
<i>veraguensis</i> , <i>Antillophos</i>	245, 265
<i>Vexillinae</i>	284
<i>Vezillum</i>	284
<i>plicatum</i>	284
<i>tortuosellum</i>	285
<i>virescens</i> , <i>Voluta</i>	288
<i>Voluta</i>	287, 288
<i>alfaroi</i>	288
<i>alfaroi</i>	288
<i>eurytera</i>	246, 287; pl. 45, tab. 1
<i>barnesi</i>	289
<i>barnesi</i>	289
<i>carolinensis</i>	282
<i>coroni</i>	288
<i>dama</i>	280
<i>episcopalis</i>	282
<i>harpa</i>	289
<i>hiatula</i>	281
<i>mitra</i>	282
<i>musica</i>	287, 288
<i>musicus</i>	287
<i>nucleus</i>	288
<i>oliva</i>	276
<i>plicaria</i>	284
<i>pyrum</i>	285
<i>virescens</i>	288
<i>Volutidae</i>	242, 245, 287; tab. 1
<i>Volutinae</i>	287

W

<i>walli</i> , <i>Strombina</i>	255
<i>waltonia</i> , <i>Strombina</i>	253

X

<i>Xancidae</i>	285
<i>Xancus</i>	241, 245, 285, 286, 287
<i>falconensis</i>	287
<i>laevigatus</i>	287
<i>ovideus</i>	287
<i>paylensis</i>	286
<i>peruvianus</i>	286
cf. <i>X. peruvianus</i>	241, 242, 285; pl. 39
<i>peruvianus colombianus</i>	286
<i>praeovoides</i>	286, 287
<i>riosecanus</i>	287
<i>praeovoides</i>	286, 287
<i>pyrum</i>	285
<i>rez</i>	286
cf. <i>X. rez</i>	244, 286
<i>talarensis</i>	286
<i>texilis</i>	286
<i>trinitatis</i>	287
<i>validus</i>	286
<i>falconensis</i>	286; pl. 46, tab. 1
<i>validus</i>	286
<i>validus</i> ?.....	286; pl. 47, tab. 1
sp.....	243, 286, 287

Z

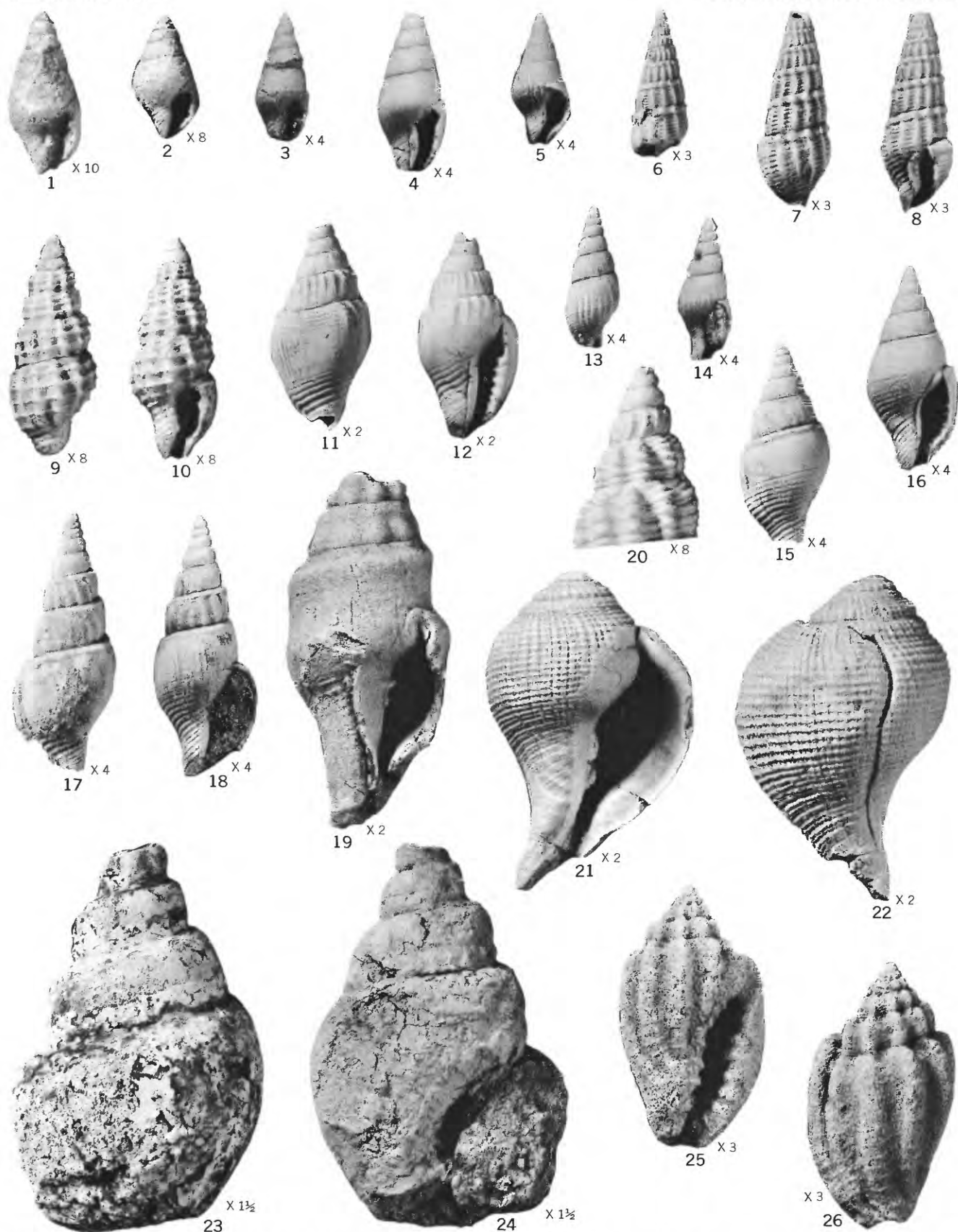
<i>zaca</i> , <i>Mitra</i>	282
<i>Zanassarina</i>	250, 251
<i>glypta</i>	251
<i>habra</i>	250; pl. 39, tab. 1
sp.....	251; tab. 1
<i>zorritense</i> , <i>Argobuccinum</i>	263

PLATES 39–47

PLATE 39

FIGURE 1. *Mitrella* sp. (p. 246).

- Height 2.7 mm, diameter 1.2 mm. Locality 42.
Marine member of Bohio(?) formation. USNM 643623.
2. *Mitrella limonensis* (Gabb), small form (p. 247).
Height 2.6 mm, diameter 1.4 mm. Locality 147b.
Middle part of Gatun formation. USNM 643627.
- 3, 4. *Mitrella epacta* Woodring, n. sp. (p. 247).
Locality 42d. Bohio formation.
3. Paratype. Height 5.7 mm, diameter 2.4 mm. USNM 643625.
4. Type. Height (incomplete) 7.2 mm, diameter 3.1 mm. USNM 643624.
5. *Mitrella (Columbellopsis)* aff. *M. fenestrata* (C. B. Adams) (p. 248).
Height 6.2 mm, diameter 2.7 mm. Locality 138.
Lower part of Gatun formation. USNM 643628.
- 6-8. *Strombinella olssoni* Woodring, n. sp. (p. 255).
Locality 161c. Middle part of Gatun formation.
6. Paratype. Height (incomplete) 9 mm, diameter 3.5 mm. USNM 643646.
7, 8. Type. Height (incomplete) 11.8 mm, diameter 4.6 mm. USNM 643645.
- 9, 10. *Zanassarina habra* Woodring, n. sp. (p. 250).
Type. Height 5 mm, diameter 1.9 mm.
Locality 147b. Middle part of Gatun formation. USNM 643635.
- 11, 12. *Strombina (Strombina) ochyra* Woodring, n. sp. (p. 253).
Type. Height (incomplete) 19 mm, diameter 9 mm.
Locality 157. Middle part of Gatun formation. USNM 643640.
- 13-18. *Anachis (Costoanachis) mira mira* (Dall) (p. 248).
13, 14. Height 6.4 mm, diameter 2.4 mm. Locality 155c.
Middle part of Gatun formation. USNM 643629.
15, 16. Type. Height 9.3 mm, diameter 4 mm. Locality 177. Upper part of Gatun formation, eastern area. USNM 113713.
17, 18. Height 11.8 mm, diameter 4.5 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 643630.
19. *Xancus* cf. *X. peruvianus* Olsson (p. 285).
Height (incomplete) 32.5 mm, diameter 15.3 mm.
Locality 38. Gatuncillo formation. USNM 643621.
20. *Strombinophos mimicus* Woodring, n. sp. (p. 251).
Early whorls. Height 4 mm, diameter 2.6 mm.
Locality 155c. Middle part of Gatun formation. USNM 643637.
- 21, 22. *Glyptostyla panamensis* Dall (p. 289).
Type. Height (almost complete) 29 mm, diameter 18.7 mm.
Locality 40. Marine member of Bohio(?) formation. USNM 112263.
- 23, 24. *Northia*? cf. *N. northiae* (Gray) (p. 268).
Height (incomplete) 48 mm, diameter (increased by crushing) 30.5 mm. Locality 115a. Culebra formation USNM 643626.
- 25, 26. *Ctenilyria ctenista* Woodring, n. sp. (p. 288).
Type. Height 16 mm, diameter 9 mm. Locality 38.
Gatuncillo formation. USNM 643622.

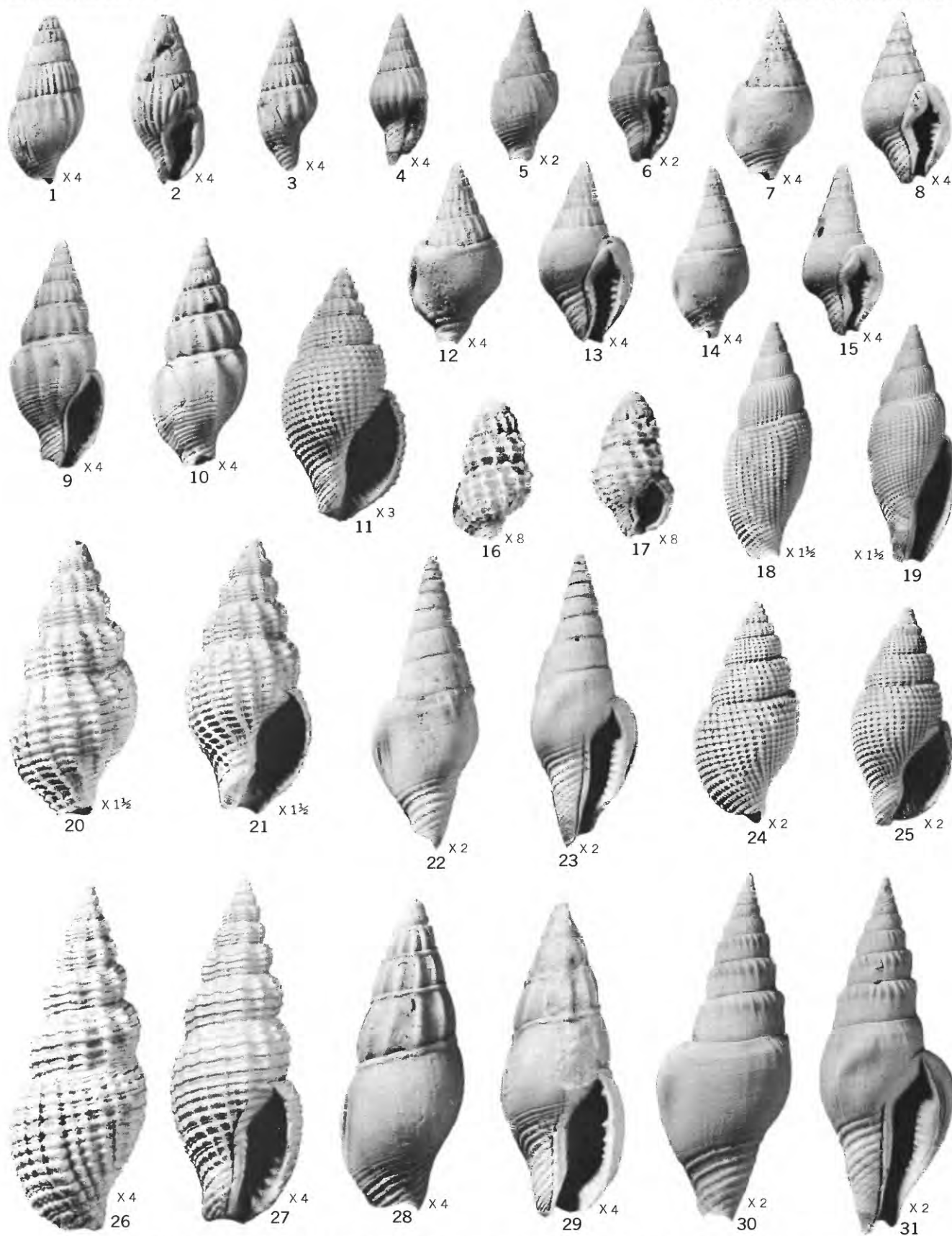


MIDDLE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION, LATE EOCENE OR EARLY OLIGOCENE MOLLUSKS FROM MARINE MEMBER OF BOHIO (?) FORMATION, LATE OLIGOCENE MOLLUSKS FROM BOHIO FORMATION, EARLY MIOCENE MOLLUSK FROM CULEBRA FORMATION, AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 40

FIGURE 1-4, 9, 10. *Anachis* (*Costoanachis*) *mira fugax* Brown and Pilsbry (p. 249).

- 1, 2. Height (incomplete) 7.8 mm, diameter 3.5 mm. Locality 138a. Lower part of Gatun formation, middle Miocene. USNM 643631.
- 3, 4. Height 7 mm, diameter (outer lip broken) 3 mm. Locality 177. Upper part of Gatun formation, eastern area, middle Miocene. USNM 643633.
- 9, 10. Height 11.6 mm, diameter 4.5 mm. Locality 161b. Middle part of Gatun formation, middle Miocene. USNM 643632.
- 5, 6. *Strombina* (*Strombina*?) *pleurica* Woodring, n. sp. (p. 254).
Type. Height 14 mm, diameter 6.4 mm. Locality 138d. Lower part of Gatun formation, middle Miocene. USNM 643641.
- 7, 8, 14, 15. *Strombina* (*Sincola*) *amphidyma* Woodring, n. sp. (p. 255).
Locality 138c. Lower part of Gatun formation, middle Miocene.
7, 8. Type. Height 7.7 mm, diameter 4.1 mm. USNM 643642.
14, 15. Height 7.7 mm, diameter 3.6 mm. USNM 643643.
- 11, 24, 25. *Antillophos* (*Rhipophos*) *metuloides* (Dall) (p. 266).
Upper part of Gatun formation, eastern area, middle Miocene.
11. Immature specimen. Height (almost complete) 15.9 mm, diameter 7.7 mm. Locality 175. USNM 643663.
24, 25. Type. Height (almost complete) 20.2 mm, diameter 9.7 mm. Mount Hope, Canal Zone. USNM 113665.
- 12, 13. *Strombina* (*Sincola*) *chiriquiensis* Olsson (p. 255).
Height 8.3 mm, diameter 4.4 mm. Locality 157. Middle part of Gatun formation, middle Miocene. USNM 643644.
- 16, 17. *Nassarius* (*Nanarius*) *parapristus acolus* Woodring, n. subsp. (p. 271).
Type. Height 3.3 mm, diameter 1.8 mm. Locality 147b. Middle part of Gatun formation, middle Miocene. USNM 643668.
- 18, 19. *Metula gabbi* Brown and Pilsbry (p. 259).
Height (practically complete) 29 mm, diameter 10.5 mm. Locality 155. Middle part of Gatun formation, middle Miocene. USNM 643652.
- 20, 21. *Antillophos* (*Antillophos*) *monachus* Woodring, n. sp. (p. 266).
Type. Height (almost complete) 34 mm, diameter 15.5 mm. Locality 183. Upper part of Gatun formation, western area, late Miocene. USNM 643662.
- 22, 23, 30, 31. *Strombina* (*Strombina*) *lessepsiana* Brown and Pilsbry (p. 252).
22, 23. Height 27 mm, diameter 10 mm. Locality 161a. Middle part of Gatun formation, middle Miocene. USNM 643639.
30, 31. Height 32.7 mm, diameter 12 mm. Locality 138a. Lower part of Gatun formation, middle Miocene. USNM 643638.
- 26, 27. *Strombinophos mimicus* Woodring, n. sp. (p. 251).
Type. Height 16 mm, diameter 6 mm. Locality 138c. Lower part of Gatun formation, middle Miocene. USNM 643636.
- 28, 29. *Anachis* (*Costoanachis*) *stibara* Woodring, n. sp. (p. 250).
Type. Height (not quite complete) 14.6 mm, diameter 5.7 mm. Locality 136. Lower part of Gatun formation, middle Miocene. USNM 643634.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 41

FIGURE 1-4. *Cymatophos subsemicostatus* (Brown and Pilsbry) (p. 261).

Middle part of Gatun formation, middle Miocene.

1, 2. Height 46.8 mm, diameter 22 mm. Locality 159. USNM 643657.

3, 4. Height 51 mm, diameter 21.7 mm. Locality 155. USNM 643656.

5, 6, 8, 13. *Cymatophos veatchi veatchi* (Olsson) (p. 260).

Locality 138c. Lower part of Gatun formation, middle Miocene.

5, 6. Height 43.5 mm, diameter 23 mm. USNM 643654.

8, 13. Height 44.5 mm, diameter 22 mm. USNM 643653.

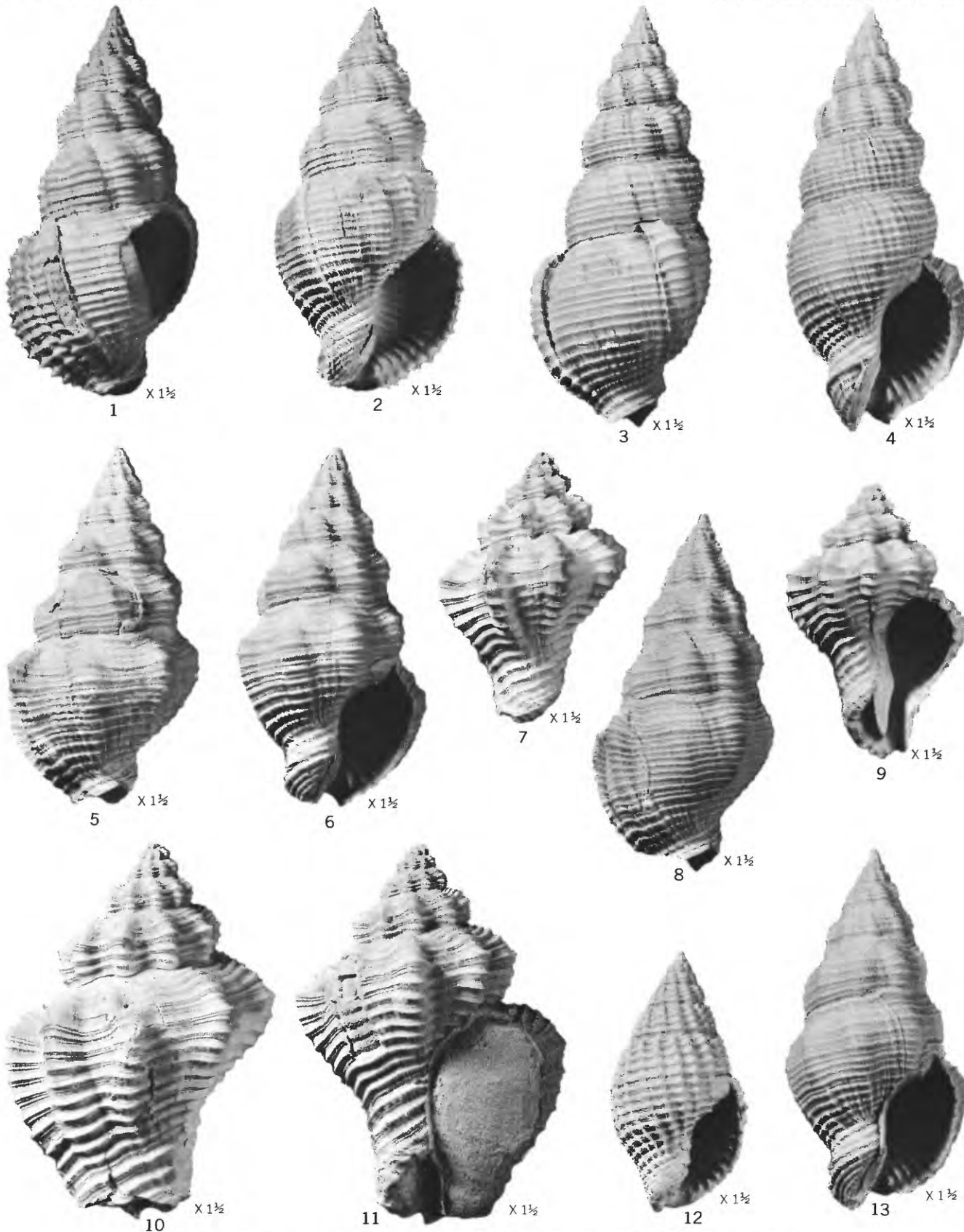
7, 9, 10, 11. *Hanetia dalli dalli* (Brown and Pilsbry) (p. 256).

7, 9. Height (almost complete) 33.3 mm, diameter 23 mm. Locality 155a. Middle part of Gatun formation, middle Miocene. USNM 643648.

10, 11. Height (almost complete) 46 mm, diameter 32 mm. Locality 175. Upper part of Gatun formation, eastern area, middle Miocene. USNM 643649.

12. *Antillophos (Antillophos) mexicanus* (Böse) (p. 265).

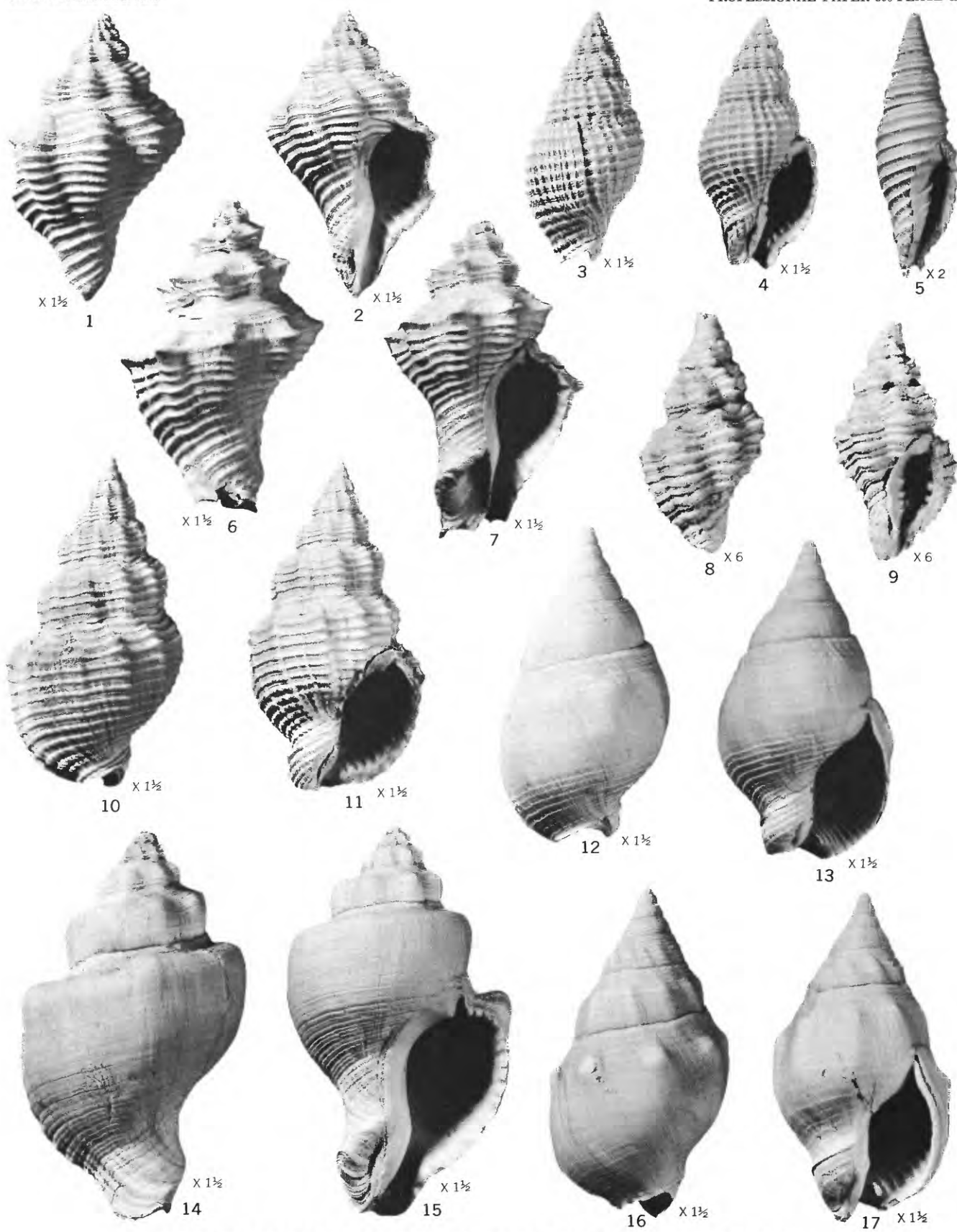
Height (practically complete) 31.9 mm, diameter 16.7 mm. Locality 183. Upper part of Gatun formation, western area, late Miocene. USNM 643661.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 42

- FIGURE 1, 2. *Hanetia dalli medioamericana* (Olsson) (p. 257).
 Height (practically complete) 35.3 mm, diameter (incomplete) 21 mm. Locality 179. Upper part of Gatun formation, western area, late Miocene. USNM 643650.
- 3, 4. *Antillophos (Antillophos) candei gatunensis* (Toula) (p. 264).
 Neotype. Height 30.8 mm, diameter 14.5 mm. Locality 159. Middle part of Gatun formation, middle Miocene. USNM 643660.
5. *Mitra (Tiara) dariensis* Brown and Pilsbry (p. 284).
 Height (not quite complete) 24.3 mm, diameter 7.8 mm. Locality 138c. Lower part of Gatun formation, middle Miocene. USNM 643688.
- 6, 7. *Hanetia dalli protera* Woodring, n. subsp. (p. 257).
 Type. Height (not quite complete) 39 mm, diameter 24.5 mm. Locality 136a. Lower part of Gatun formation, middle Miocene. USNM 643647.
- 8, 9. *Trachypollia aneureta* Woodring, n. sp. (p. 258).
 Type. Height (practically complete) 7.2 mm, diameter 3.8 mm. Locality 138. Lower part of Gatun formation, middle Miocene. USNM 643651.
- 10, 11. *Cymatophos veatchi erymnus* Woodring, n. subsp. (p. 261).
 Type. Height 40 mm, diameter 22 mm. Locality 182a. Upper part of Gatun formation, western area, late Miocene. USNM 643655.
- 12, 13, 16, 17. *Calophos ectyphus* Woodring, n. sp. (p. 263).
 Lower part of Gatun formation, middle Miocene.
 12, 13. Height (almost complete) 39 mm, diameter 21.5 mm. Locality 138c. USNM 643659.
 16, 17. Type. Height (practically complete) 40.7 mm, diameter 22 mm. Locality 138. USNM 643658.
- 14, 15. *Nicema amara* Woodring, n. sp. (p. 268).
 Type. Height (practically complete) 49.2 mm, diameter 27.7 mm. Locality 136a. Lower part of Gatun formation, middle Miocene. USNM 643665.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 43

FIGURE 1, 4. *Nassarius (Uzita?) praeambiguus* (Brown and Pilsbry) (p. 270).

Height 6.5 mm, diameter 3.8 mm. Locality 138.

Lower part of Gatun formation, middle Miocene. USNM 643667.

2, 6. *Pallacera* aff. *P. guadelupensis* (Petit) (p. 270).

Height (almost complete) 15.3 mm, diameter 8.6 mm.

Locality 155. Middle part of Gatun formation, middle Miocene. USNM 643664.

3, 8. *Nassarius (Nanarius) parapristus conarus* Woodring, n. subsp. (p. 272).

Type. Height 4.7 mm, diameter 2.8 mm.

Locality 138c. Lower part of Gatun formation, middle Miocene. USNM 643669.

5, 7, 11. *Fasciolaria gorgasiana* Brown and Pilsbry (p. 275).

Middle part of Gatun formation, middle Miocene.

5, 7. Immature. Height (practically complete) 63.5 mm, diameter 30 mm. Locality 155. USNM 643671.

11. Body-whorl fragment. Height 102 mm. Locality 155b. USNM 643672.

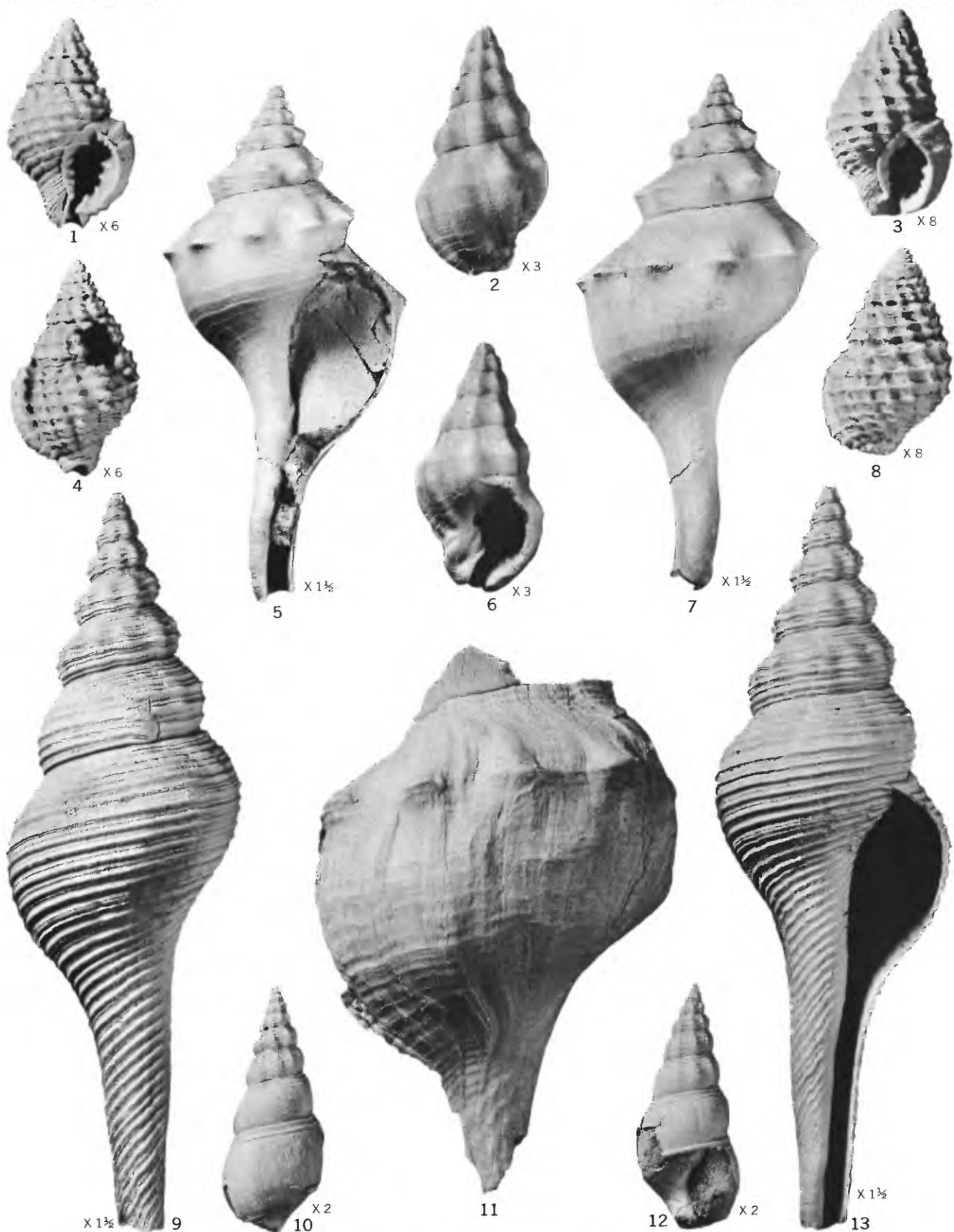
9, 13. *Fusinus empleus* Woodring, n. sp. (p. 276).

Type. Height (incomplete) 90.5 mm, diameter 30 mm. Locality 185. Upper part of Gatun formation, western area, late Miocene. USNM 643674.

10, 12. *Northia?* sp. (p. 269).

Height (incomplete) 22.5 mm, diameter 9 mm.

Locality 136a. Lower part of Gatun formation, middle Miocene. USNM 643666.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 44

FIGURE 1, 5. *Leptarius leptus* Woodring, n. sp. (p. 272).

Type. Height 9 mm, diameter 3.6 mm. Locality 170. Middle part of Gatun formation. USNM 643670.

2, 4, 6, 8. *Melongena melongena consors* (Sowerby) (p. 273).

Lower part of Gatun formation.

2, 8. Immature. Height (almost complete) 53.5 mm, diameter 30.5 mm. Locality 136a. USNM 643700.

4, 6. Height 130 mm, diameter (without spines) 87 mm. Locality 138c. USNM 643699.

3. *Uromitra elachista* Woodring, n. sp. (p. 285).

Type. Height 5 mm, diameter 1.8 mm. Locality 147b. Middle part of Gatun formation. USNM 643690.

7. *Uromitra* aff. *U. cucurruapiensis* (Oinomikado) (p. 284).

Height (almost complete) 16.1 mm, diameter 3.8 mm. Locality 147b. Middle part of Gatun formation. USNM 643689.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 45

FIGURE 1, 2. *Ancilla (Eburna) pinguis* (Guppy) (p. 279).

Height 16.5 mm, diameter 7.8 mm. Locality 139c. Middle part of Gatun formation, middle Miocene. USNM 643680.

3, 10, 11. *Olivella (Niteoliva) terryi* Olsson (p. 280).

3, 11. Locality 138c. Lower part of Gatun formation, middle Miocene. USNM 643681.

3. Height 11.2 mm, diameter 4 mm.

11. Height 8 mm, diameter 4 mm.

10. Height 7.5 mm, diameter 3.2 mm. Locality 170. Middle part of Gatun formation, middle Miocene. USNM 643682.

4-7. *Oliva (Strephonella) plicata* Guppy (p. 278).

Locality 170. Middle part of Gatun formation, middle Miocene. USNM 643679.

4, 5. Height 7.2 mm, diameter 3.6 mm.

6, 7. Height (incomplete) 9.2 mm, diameter 4.5 mm.

8. *Agaronia testacea mancinella* (Olsson) (p. 281).

Height 43.2 mm, diameter 17.8 mm. Locality 138. Lower part of Gatun formation, middle Miocene. USNM 643684.

9. *Olivella (Toroliva) goliath* Olsson (p. 281).

Height 19.7 mm, diameter 8.2 mm. Locality 161c. Middle part of Gatun formation, middle Miocene. USNM 643683.

12, 13, 16. *Oliva (Oliva) gatunensis* Toulou (p. 276).

12. Height 34.6 mm, diameter 16 mm. Locality 138c. Lower part of Gatun formation, middle Miocene. USNM 643675.

13. Topotype. Height 32 mm, diameter 14.5 mm. Locality 159. Middle part of Gatun formation, middle Miocene. USNM 643676.

16. Height 36.3 mm, diameter 14.6 mm. Locality 155b. Middle part of Gatun formation, middle Miocene. USNM 643677.

14, 18, 19. *Voluta alfaroi eurytera* Woodring, n. subsp. (p. 287).

Locality 182. Upper part of Gatun formation, western area, late Miocene.

14. Height (not quite complete) 50 mm, diameter 36 mm. USNM 643692.

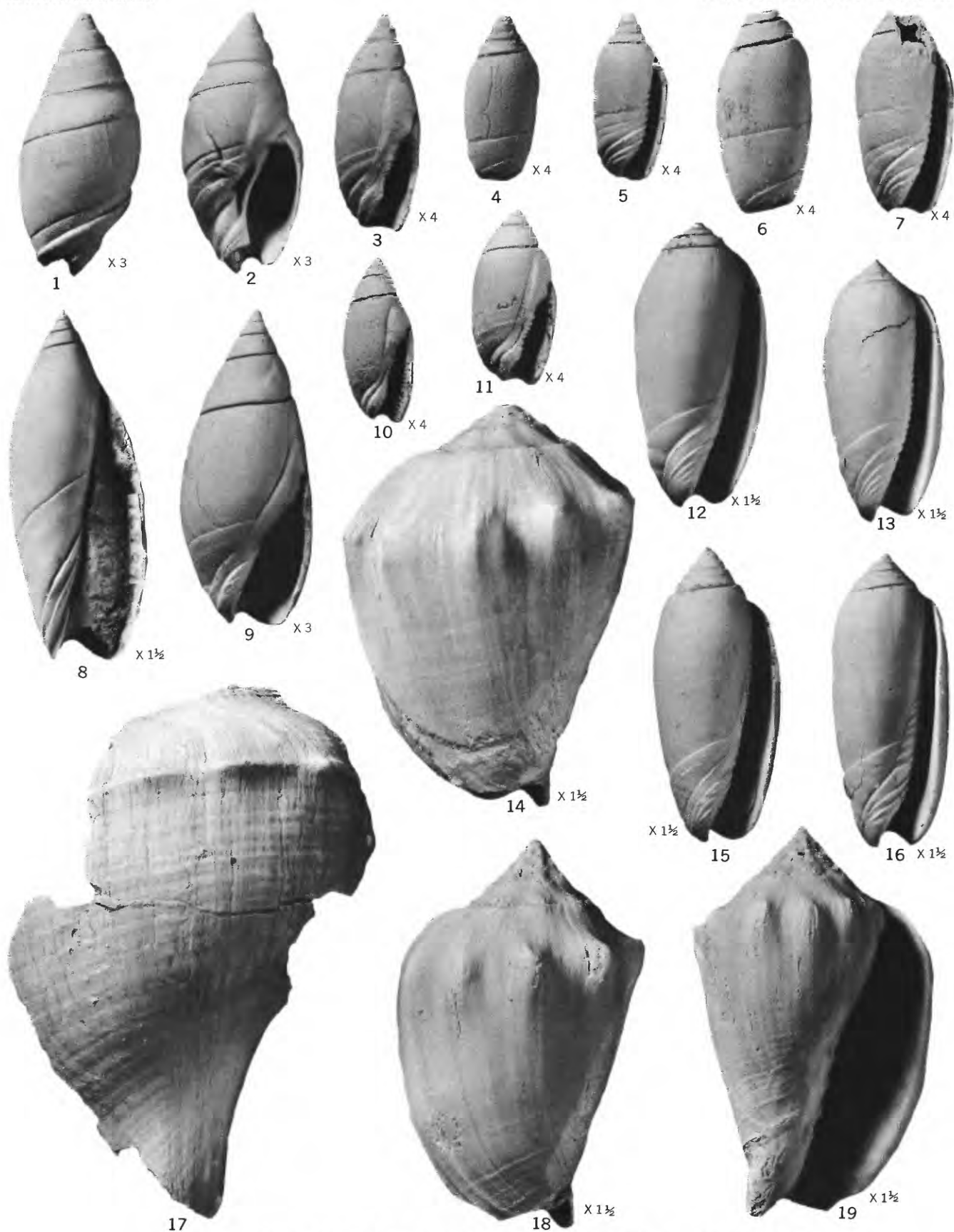
18, 19. Type. Height 48.7 mm, diameter 30.5 mm. USNM 643691.

15. *Oliva (Oliva) reticularis* Lamarck, subsp. (p. 277).

Height 36 mm, diameter 15.3 mm. Locality 182. Upper part of Gatun formation, western area, late Miocene. USNM 643678.

17. *Fasciolaria gorgasiana* Brown and Pilsbry, subsp. (p. 275).

Body-whorl fragment. Height 99.5 mm. Locality 182. Upper part of Gatun formation, western area, late Miocene. USNM 643673.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 46

FIGURE 1. *Mitra* (*Pleioptygma*?) *limonensis* Olsson (p. 282).

Height (incomplete) 77 mm, diameter 24.5 mm. Locality 177b. Upper part of Gatun formation, eastern area. USNM 643686.

2, 3. *Enaeta ecnomia* Woodring, n. sp. (p. 289).

Type. Height 20.2 mm, diameter 11.5 mm. Locality 138a. Lower part of Gatun formation. USNM 643693.

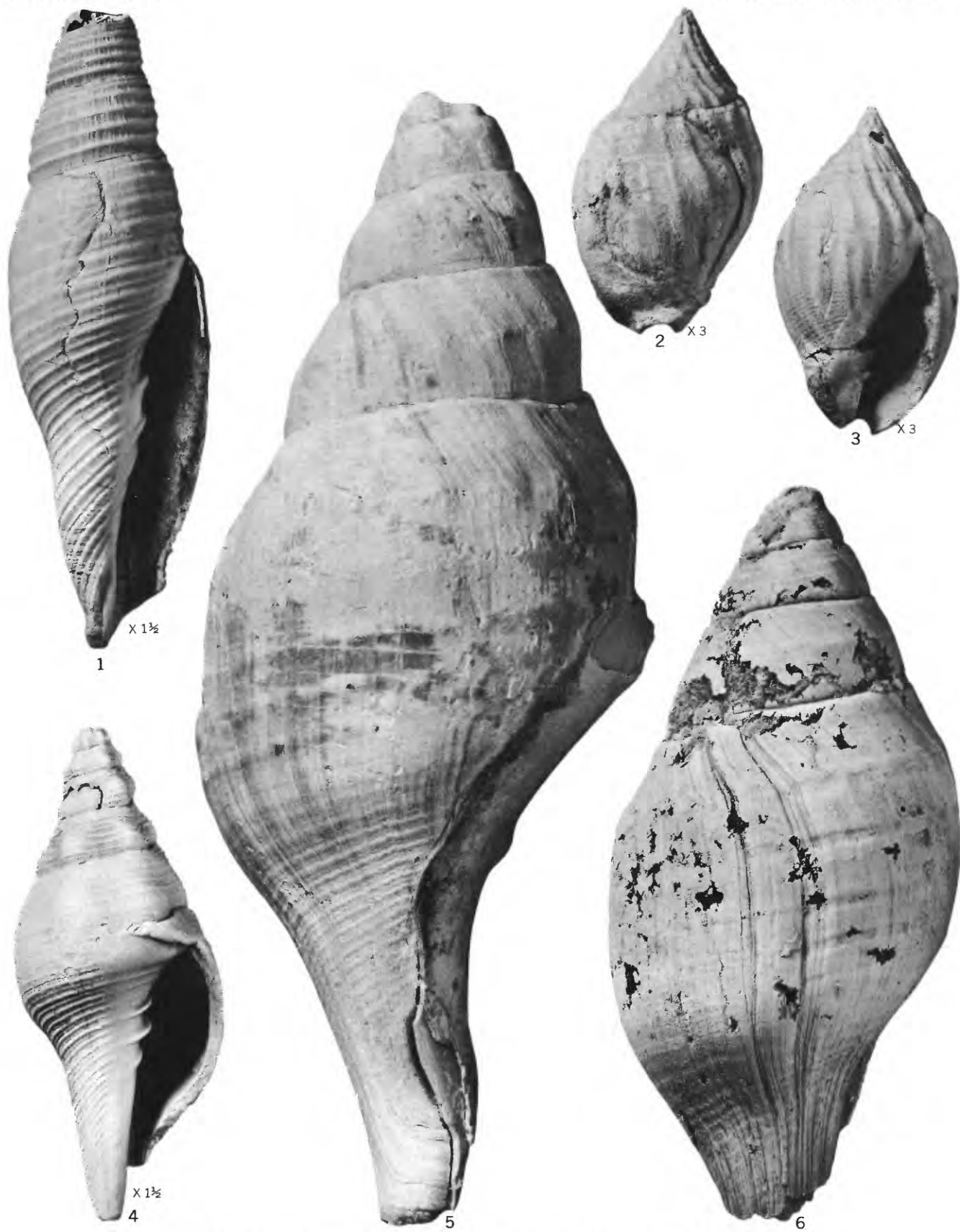
4-6. *Xancus validus falconensis* H. K. Hodson (p. 286).

4, 5. Locality 138e. Lower part of Gatun formation.

4. Immature specimen. Height (incomplete) 60.5 mm, diameter 25 mm. USNM 643703.

5. Height (incomplete) 220 mm, diameter 85 mm. USNM 643702.

6. Immature specimen. Height (incomplete) 140 mm, diameter 67 mm. Locality 144. Middle part of Gatun formation. USNM 643704.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 47

FIGURE 1, 2. *Amarophos bothrus* Woodring, n. sp. (p. 267).

Type. Height (almost complete) 24.7 mm, diameter 13.2 mm. Locality 208. Chagres sandstone. USNM 643697.

3, 4, 7-10. *Cymatophos? acolus* Woodring, n. sp. (p. 261).

Locality 208. Chagres sandstone.

3, 4. Type. Height (incomplete), 26.2 mm, diameter 16 mm. USNM 643695.

7-10. Paratypes. USNM 643696.

7, 8. Height (incomplete) 23 mm, diameter 13 mm.

9, 10. Height (almost complete) 20 mm, diameter 10 mm.

5. *Mitra (Tiara) longa longa* Gabb (p. 283).

Height (not quite complete) 54 mm, diameter 12.6 mm. Locality 155a. Middle part of Gatun formation. USNM 643687.

6. *Agaronia testacea hadra* Woodring, n. subsp. (p. 282).

Type. Height (not quite complete) 42 mm, diameter 19.8 mm. Locality 138a. Lower part of Gatun formation. USNM 643685.

11, 14. *Hanetia dalli* (Brown and Pilsbry), subsp. (p. 258).

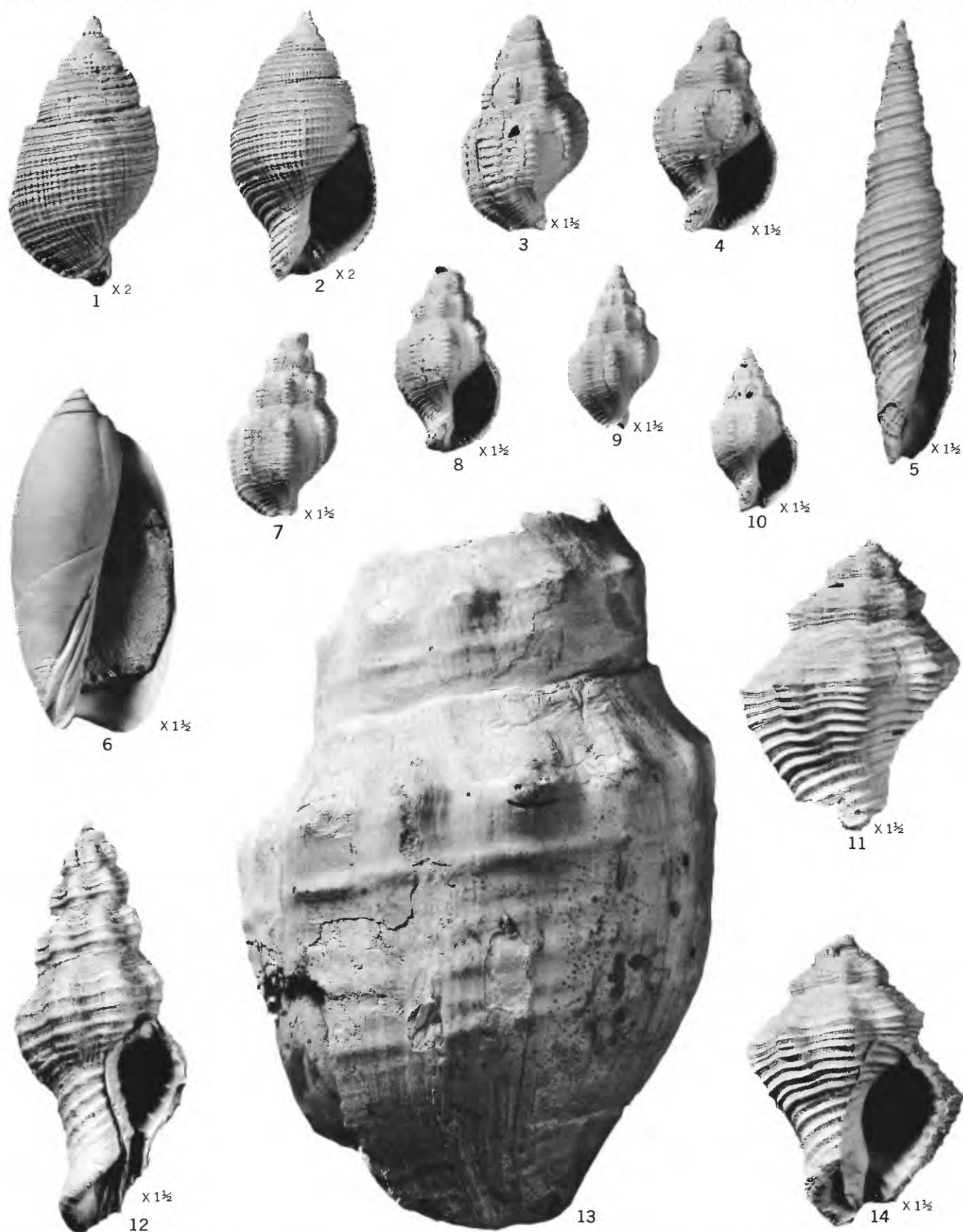
Height (almost complete) 36 mm, diameter 26 mm. Locality 208. Chagres sandstone. USNM 643694.

12. *Latirus (Polygona) anapetes* Woodring, n. sp. (p. 274).

Type. Height (incomplete) 50.7 mm, diameter 21 mm. Locality 208. Chagres sandstone. USNM 643698.

13. *Xancus validus validus* (Sowerby)? (p. 286).

Height (incomplete) 140 mm, diameter 90 mm. Locality 155. Middle part of Gatun formation. USNM. 643701



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY
PLIOCENE MOLLUSKS FROM CHAGRES SANDSTONE