Geology and Paleontology Of Canal Zone and Adjoining Parts of Panama

Description of Tertiary Mollusks (Gastropods: Vermetidae to Thaididae)

GEOLOGICAL SURVEY PROFESSIONAL PAPER 306-B

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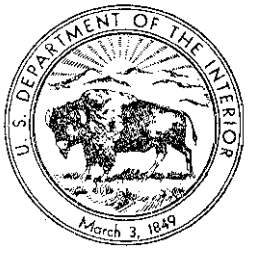
By W. P. WOODRING

GEOLOGICAL SURVEY PROFESSIONAL PAPER 306-B

A contribution to the history of the Panamá land bridge



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GEOLOGY AND PALEONTOLOGY OF CANAL ZONE AND ADJOINING PARTS OF PANAMA

DESCRIPTION OF TERTIARY MOLLUSKS (GASTROPODS: VERMETIDAE TO THAIDIDAE)

By W. P. Woodring

ABSTRACT

The description of the mollusks found in the Tertiary deposits of the Canal Zone and adjoining parts of Panamá—ranging in age from middle and late Eocene to early Pliocene—started in chapter A, is continued in the present chapter. A total of 104 species and subspecies in 17 families of gastropods (and seven additional species in four families already covered in chapter A) is considered. Ninety-three are formally described under separate headings; the other 18, all represented by inadequate material, are briefly described or merely mentioned.

Notable fossils from the Gatuncillo formation, of middle and late Eocene age, include *Dirocerithium ame* (a species of a new genus, evidently of Tethyan affinities, that reached southeastern United States during middle Eocene time), *Oostrombus* aff. *O. chiracnsis*, *Terebellum* (*Terebellum*) *procerum?*, *T.* (*Seraphs*) *belemnitum?*, *Ectinochilus* cf. *E. gaudichaudi*, *Morum* (*"Oniscidia"*) sp. (the earliest known American species of *"Oniscidia"*), and *Yasila* aff. *Y. paytensis*.

The late Eocene or early Oligocene marine member of the Bohio(?) formation has both Eocene and Oligocene faunal affinities, as shown by *Architectonica* aff. *A. alvcata*, *A.* cf. *A. fungina*, *Morum* cf. *M. antiquum*, and *Typhis* aff. *T. curvirostratus*.

The Bohio formation of Barro Colorado Island, where only the upper part of the formation is exposed, yielded fossils of late Oligocene age, including *Hemisinus oeciscus*, *Turritella listrota* (which seems to be the earliest known species of the *T. ocoyana* group), *Orthaulax* cf. *O. pugnax*, and *Gonosycon epomis* (the type of a new ficid genus). *Orthaulax* is an extinct endemic American genus that has an age range of late Oligocene to early Miocene. *Orthaulax* cf. *O. pugnax* also occurs in deposits of late Oligocene age in the Caimito formation of the Gatun Lake area and in the late Oligocene part of the Caimito formation of Madden basin, as well as in the upper part of the Bohio. *Orthaulax* cf. *O. aguadillensis* is found in the Culebra formation proper and in its Emperador limestone member, both of early Miocene age.

The upper Oligocene Caimito formation of the Gatun Lake area contains *Ampullinopsis spenceri*. *Ampullinopsis* is widely distributed in the Oligocene of western Europe, southeastern United States, the Caribbean region, Central America, and northern South America, but recently has been found in the middle or upper Eocene of Florida.

Potamides suprasulcatus, which occurs in the lower Miocene Culebra formation, is found in the Dominican Republic, along the south border of the Caribbean Sea from Trinidad to Colombia, and also in Ecuador and Perú. Its age range is late Oligocene to middle Miocene.

A new locality in the lower Miocene Cucaracha formation yielded fresh-water snails (*Hemisinus* aff. *H. Occiscus*), a crocodile tooth, turtle fragments, an incomplete mammal femur, and minute oögonia of a charophyte (*Tectochara* aff. *T. escheri*).

Almost half of the fossils described in the present chapter (44 species and subspecies) are from the richly fossiliferous middle and upper Miocene Gatun formation. They include two species now living in both the Caribbean Sea and the eastern Pacific Ocean (*Architectonica nobilis* and *Murex recurvirostris*); genera, subgenera and an unnamed species group that are no longer in the Caribbean Sea but survive in the eastern Pacific Ocean (*Astronacus*, *Ochetoclava*, *Malea*, group of *Ficus ventricosa* and *Cymia*); and a genus (*Sconsia*) that formerly lived in both the eastern and the western Pacific Ocean but survives in the Caribbean Sea. *Euplcura thompsoni* is the first Caribbean species of the genus to be described.

The Chagres sandstone proper, of early Pliocene age, is noteworthy for its relatively large number of epitonids: species of *Epitonium*, *Sthenorytis* and *Scalina*. The fossils of the Chagres also include *Bathygalea hadra*, a species of a recently described moderately deepwater and deepwater cassid genus.

The 202 forms covered in chapters A and B are estimated to be less than a third of the total available molluscan fauna to be described.

INTRODUCTION

The description of the mollusks found in the Tertiary deposits of the Canal Zone and adjoining parts of Panamá—ranging in age from middle and late Eocene to early Pliocene—started in chapter A, is continued in the present chapter. One hundred and eleven species and subspecies, including seven species in families covered in chapter A, are considered. Ninety-three are formally described and the other 18, represented by inadequate material, are briefly described or merely mentioned. The 202 forms so far covered in chapters A and B are estimated to be less than a third of the total available molluscan fauna to be described.

The arrangement of gastropod families adopted in chapter A, based on a combination of Pelseneer's classification and Pilsbry's arrangement for "Biological Abstracts," differs considerably from the arrangement in the Thiele-Wenz classification. The arrangement in the present chapter more closely follows the Thiele-Wenz classification. Though that classification is widely used, it has some unsatisfactory features. At all events, the present chapter completes the Archaeogastropoda of the Thiele-Wenz classification and includes two families of their Mesogastropoda: Muricidae and Thaididae.

The following new generic and subgeneric names are proposed:

Astronacus, subgenus of *Heliacus*, Heliacidae.
Type: *Heliacus planispira* Pilsbry and Lowe, Recent, Mazatlán, México, p. 168. Gender masculine.

Dirocerithium Woodring and Stenzel, Cerithiidae, Cerithiinae.
Type: *Dirocerithium wechesense* Stenzel, n. sp., middle Eocene, Texas, p. 172. Gender neuter.

Gonysycon, Ficidae.
Type: *Gonysycon eponis* Woodring, n. sp., Bohio formation, Oligocene, p. 213. Gender neuter.

Panamurex, subgenus of *Paziella*, Muricidae, Muricinae.
Type: *Murex* (*Phyllonotus*) *gatunensis* Brown and Pilsbry, Gatun formation, Miocene, p. 217. Gender masculine.

Pilsbrytyphis, subgenus of *Typhis*, Muricidae, Typhinae.
Type: *Typhis gabbi* Brown and Pilsbry, Gatun formation, p. 220. Gender masculine.

ADDITIONS TO ANNOTATED BIBLIOGRAPHY

The following items should be added to the annotated bibliography on pages 5–10 of chapter A.

1958. Woodring, W. P., and Olsson, A. A., *Bathygalea*, a genus of moderately deep-water and deep-water Miocene to Recent cassids: U. S. Geol. Survey Prof. Paper 314–B, p. 21–26, pls. 7–10, fig. 1, 1957 [1958]. Includes description of *Bathygalea hadra* from the Chagres sandstone.

1958. Woodring, W. P., Geology of Barro Colorado Island, Canal Zone: Smithsonian Misc. Coll., v. 135, no. 3, 39 p., 3 pls., 3 figs. Account of geology and paleontology of Barro Colorado Island written primarily for visitors to the island.

ADDITIONS TO LOCALITIES AT WHICH FOSSILS WERE COLLECTED

The following new localities at which fossils were collected should be added to those listed on pages 113–130 of chapter A.

Additions to localities at which fossils were collected

No. used in this report	USGS Cenozoic No.	Field No.	Description of locality
			Bohio formation, Pacific coastal area, Panamá
43a	----------	RPP19	Río Lajas, 3.1 kilometers east-northeast of locality 43. Calcareous sandstone at base of Bohio formation. R. H. Stewart, 1956.

Additions to localities at which fossils were collected—Con.

No. used in this report	USGS Cenozoic No.	Field No.	Description of locality
			Cucaracha formation, Canal Zone
122a	19966	----------	Contractors Hill, west side of Gaillard Cut at continental divide, 10-centimeter fossiliferous layer in bentonitic clay, 7 to 9 meters above top of welded tuff. R. H. Stewart, 1956.
122b	----------	----------	Same locality, bentonitic clay about 10 meters above top of welded tuff. R. H. Stewart, 1956.
			Lower part of Gatun formation
138b	19853	----------	Transisthmian Highway, south edge of village of Cativa, Panamá. Practically a duplicate of localities 138 and 138a. R. H. Stewart, 1955.

FAUNAL SUMMARIES OF SPECIES

Aside from data covering larger Foraminifera from the Bohio formation at a new locality, faunal summaries and brief comments are presented only for the species covered in this report. As explained in chapter A (p. 4), a full discussion of the faunas, the age and correlation of the formations and the paleoecologic implications of the fossils is reserved for the final chapter.

Contrary to what was done in chapter A, 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

Most of the species from the Gatuncillo formation—and all those that are well preserved—are silicified fossils from locality 38 in the Río Casaya area. *Dirocerithium ame* is a representative of a genus that is widely distributed in the middle Eocene of the Caribbean region and appeared in the middle Eocene of the Gulf coast of the United States. As the genus appeared earlier in the Caribbean region than in continental North America, it evidently was a migrant—a migrant of Tethyan affinities—from the Caribbean region. *Oostrombus* aff. *O. chiraensis*, *Ectinochilus* cf. *E. gaudichaudi*, and *Yasila* aff. *Y. paytensis* show Peruvian affinities. *Morum* ("*Oniscidia*") sp. is the earliest known American species of the subgenus "*Oniscidia*".

Mollusks from Gatuncillo formation (Vermetidae to Muricidae)

[R, rare; F, few; C, common; A, abundant; ?sp., genus doubtful, species unidentified]

	Localities						
	Madden basin				Río Agua Sucia area	Río Frijol area	Río Casaya area
	6	9	11	12	27	34	38
Vermetid?, genus?			R				
Large cerithid, possibly *Campanile*			R	R			
Cerithium sp. a	R						F
sp. b							R
Diroceriskium ame Woodring, n. sp.							A
Oostrombus aff. *O. chiracnsis* Olsson			?sp.	?sp.			A
Terebellum (*Terebellum*) procerum Merian?				C			
(*Seraphs*) *bdemnitum* Palmer?							R
Ectinochilus cf. *E. gaudichaudi* (d'Orbigny)		C	R	A		R	
Cypraea sp.			F	R			
Cypraedia aff. *C. subelegans* (Trechmann)			R	C			
Galeodea? cf. *G. nodosa* (Solander)					R		
Morum ("*Oniscidia*") sp.							R
Yasila aff. *Y. paytensis* Olsson							R

EOCENE OR OLIGOCENE SERIES

MARINE MEMBER OF BOHIO(?) FORMATION

The mollusks of the marine member of the Bohio(?) formation have both Eocene and Oligocene affinities. *Architectonica* aff. *A. alveata* is closely related to an Eocene species from southeastern United States; *Architectonica* cf. *A. fungina* seems to be related to an Eocene species from the same region; and *Morum* cf. *M. antiquum* is similar to an Eocene European species. *Typhis* aff. *T. curvirostratus*, however, is closely allied to an Oligocene species of southeastern United States.

Mollusks from marine member of Bohio(?) formation (Vermetidae to Muricidae)

[R, rare; F, Few]

	Localities				
	Vamos Vamos		Palenquilla Point		Trinidad Island
	40a	40d	41	41b	42
Vermetid?, genus?		R			
Caecum? sp.		R			
Architectonica (*Stellaris*) aff. *A. alveata* (Conrad)	R		R		
sp.	R				
cf. *A. fungina* (Conrad)	R				
Cerithium sp.		F		R	R
Scalina? sp.	R	R			
Morum ("*Oniscidia*") cf. *M. antiquum* (Bayan)	R				
Ficus cf. *F. mississippiensis* Conrad	R				
Typhis (*Lacrityphis*) aff. *T. curvirostratus* Conrad		R			

OLIGOCENE SERIES

BOHIO FORMATION

During the course of field work at the site of a proposed dam on Río Lajas (the unnamed stream of plate 1 located 3.5 kilometers east of Las Cumbres, on the Transisthmian Highway), R. H. Stewart found foraminiferal calcareous sandstone at the base of the Bohio formation (locality 43a). W. S. Cole identified the following larger Foraminifera in a sample from this locality.

Larger Foraminifera from basal part of Bohio formation in Pacific coastal area at locality 43a

[Identifications by W. S. Cole]

Heterostegina panamensis Gravell
Lepidocyclina (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé
parvula Cushman
waylandvaughani Cole
(*Nephrolepidina*) *vaughani* Cushman

Stewart forwarded other samples from the Río Lajas area, one of which consists of a dense mat of large eulepidine *Lepidocyclina*.

In the Río Lajas area the Bohio formation overlaps part of the Gatuncillo and a short distance farther east (as shown on plate 1) completely overlaps the Gatuncillo and rests on the Cretaceous(?) basement. According to these new collections, the overlapping strata of the Bohio are of late Oligocene age, whereas in the Quebrancha syncline, the basal part of the Bohio is early Oligocene. Moreover, the upper part of the Bohio of the Pacific coastal area contains late Oligocene larger Foraminifera at localities 43 and 45.

The only molluscan faunas of considerable size from the Bohio formation—and the only faunas containing species described in the present chapter—were found in the upper part of the formation on Barro Colorado Island. The collections from Barro Colorado were received too late to be included in chapter A. The species in the families covered by chapter A, however, were listed on page 27. Five of those species (the first five of the following table) are described in the present chapter. These fossils from Barro Colorado are of late Oligocene age. *Turritella listrota* evidently is the earliest species of the *T. ocoyana* group to be described. *Orthaulax* cf. *O. pugnax*, which also occurs in the Caimito formation of the Gatun Lake area and in the late Oligocene part of the Caimito formation of Madden basin, is a species of an extinct endemic American genus that has an age range of late Oligocene to early Miocene. *Gonysycon epomis* is the type of a new ficid genus.

Mollusks from upper part of Bohio formation on Barro Colorado Island (Trochidae to Muricidae)

[R, rare; F, few; C, common; A, abundant; cf., comparable species; ?sp., genus doubtful, species unidentified]

	Localities		
	42d	42f	42g
Solariella ephnidia Woodring, n. sp.	R		
Hemisinus (*Longivcrena*) *occiscus* Woodring, n. sp.		C	
Globularia (*Globularia*) aff. *G. fischeri* (Dall)	A		?F
Pachycrommium aff. *P. guppyi* (Gabb)	R		
Turritella listrota Woodring, n. sp.	A		?F
Cerithium (*Thericium*) *minneticum* Woodring, n. sp.	A		?sp. R
Orthaulax cf. *O. pugnax* (Heilprin)	R		
Conusycon epomis Woodring, n. sp.	R		cf. R
Muricid?, genus?	R		

CAIMITO FORMATION, EXCLUSIVE OF MADDEN BASIN

The species in the following table occur in the middle member of the Caimito formation in the Gatun Lake area, in the undifferentiated Caimito of the Río Mandinga area, and in the Quebrancha limestone member of the Caimito in the Quebrancha syncline. In these three areas the fossiliferous strata are of late Oligocene age.

Though *Ampullinopsis spenceri* was listed on page 31 of chapter A, it is described in the present chapter. The genus *Ampullinopsis* is widely distributed in the upper Oligocene deposits of the Caribbean region but in the area covered by the present report was found only on Pato Horqueto Island (locality 55b). The shallow-water deposits of the Caimito, like the upper part of the Bohio formation on Barro Colorado Island, contain *Orthaulax* cf. *O pugnax.*

Mollusks from Caimito formation of Gatun Lake area, Río Mandinga area and Quebrancha syncline (Naticidae to Ficidae)

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

	Localities									
	Gatun Lake Area								Río Mandinga area	Quebrancha syncline
	54h	54j	54k	54l	55b	56	57	57a	60	62
Ampullinopsis spenceri (Cooke)					C					
Architectonica (*Architectonica*) *rhicna* Woodring, n. sp						F				
sp	R		R							
Epitonium sp							R			
Orthaulax cf. *O. pugnax* (Heilprin)							R			
Cypraea cf. *C. chilona* Dall						R				R
Semicassis (*Echinophoria*) *apenes* Woodring, n. sp						F				
sp	R	R		R						
Cymatium (*Septa*) *oggium* Woodring, n. sp					R					
Ficus cf. *F. pilsbryi* (B. Smith)	R			R						
sp., group of *F. ventricosa* (Sowerby)						R			R	

OLIGOCENE AND MIOCENE SERIES

CAIMITO FORMATION OF MADDEN BASIN

Limestone in the pyroclastic-clay member of the Caimito formation of Madden basin, of late Oligocene age, yielded the following species:

Mollusks from limestone in pyroclastic-clay member of Caimito formation of Madden basin (Strombidae to Ficidae)

[R, rare]

	Localities	
	71	73
Strombus sp		R
Orthaulax cf. *O. pugnax* (Heilprin)	R	
Cypraea cf. *C. chilona* Dall	R	
Ficus cf. *F. carbasea micronematica* (Brown and Pilsbry)	R	R

A few species in the families covered by this report were found in the early Miocene upper part of the Caimito formation in Madden basin. Locality 82a and probably localities 77 and 79 represent the calcareous sandstone member; the other localities represent the Alhajuela sandstone member, the youngest Tertiary strata in Madden basin.

Mollusks from upper part of Caimito formation of Madden basin (Vermetidae to Ficidae)

[R, rare; C, common; sp., unidentified species]

	Localities					
	77	79	82a	85	85a	88
Vermetid, genus?				C		
Malea sp		R	?R		?R	
Ficus carbasea carbasea (Guppy)	sp.R					R

MIOCENE SERIES

CULEBRA FORMATION, INCLUDING EMPERADOR LIMESTONE MEMBER

Potamides suprasulcatus, a species widely distributed in brackish-water deposits of late Oligocene and early and middle Miocene age in the Caribbean region—and in deposits that contain marine and brackish-water fossils—occurs in the Culebra formation proper. The formation, including the Emperador limestone member, contains *Orthaulax* cf. *O. aguadillensis.*

Mollusks from Emperador limestone member of Culebra formation (Strombidae to Muricidae)

[R, rare; ?sp., genus doubtful, species unidentified]

	Localities					
	118	119	119a	120	121	Other collections
Strombus sp			R	R		
Orthaulax cf. *O. aguadillensis* Maury	?sp R	R		R		
Cypraea cf. *C. chilona* Dall		R			R	
Ficus carbasea micronematica (Brown and Pilsbry)				R		
Paziella (*Panamurex*) *gatunensis* (Brown and Pilsbry)						R

CUCARACHA FORMATION

In addition to the mammal femur mentioned on page 39, R. H. Stewart found a crocodile tooth and turtle fragments in the Cucaracha formation at locality 122b. At locality 122a he collected many crushed specimens of a fresh-water snail (*Hemisinus* aff. *H. oeciscus*), minute oögonia of a charophyte, (identified by R. E. Peck as *Tectochara* aff. *T. escheri*), and carbonized plant fragments. These fossils support the inference that much of the Cucaracha is nonmarine.

Mollusks from Culebra formation, exclusive of Emperador limestone member (Vermetidae to Muricidae)

[R, rare; F, few; C, common; A, abundant; ?sp., genus doubtful, species unidentified]

	Localities																								
	99a	99b	99c	99d	99e	99f	99g	99h	100	100a	100b	101	102	103	104a	106	108a	110	110a	111	111b	112	114	115a	115b	116
Vermetid, genus?				F			?R																	?F		
Architectonica (*Pseudotorinia?*) sp																							R			
Architectonica (*Architectonica*) cf. *A. nobilis* Röding		R	R						R																	R
Large cerithid, genus?											R															
Potamides suprasulcatus (Gabb)														R	R	R	C	F					F	F	C	
Terebralia dentilabris (Gabb)?																		R								
Bittium scotti Brown and Pilsbry		C			R				C	A		A														
Epitonium sp																										
Strombus sp			R	C		R	F	F								R			?sp			R	R	F	F	R
Orthaulax cf. *O. aguadillensis* Maury				?sp R			R												R					R		
Cypraea cf. *C. chilona* (Dall)	?sp. R						R				R							R								
Semicassis? (*Tylocassis?*) cf. *S. aldrichi* (Dall)																		R		R	R					
Morum ("*Oniscidia*") cf. *M. chipolanum* Maury																							R			
Ficus carbasea micronematica (Brown and Pilsbry)			R	R		R	F	R					R								R		R	R		
Murex (*Murex?*) cf. *M. polynematicus* Brown and Pilsbry																		R					R			

Mollusks from Gatun formation (Vermetidae to Thaididae)

[R, rare; F, few; C, common; A, abundant; sp., species unidentified; ?sp., genus doubtful, species unidentified]

	LOCALITIES																									
	Lower part								Middle part																	
									Eastern area																	
	136	136a	137	137a	138	138a	138b	139	141	142	143	146	147	147a	147b	147f	147g	147h	147i	150	150a	151	153	153a
Vermetid?																								
Serpulorbis papulosus (Guppy)																								
Petaloconchus aff. *P. floridanus* Olsson and Harbison																								
Caecum cf. *C. regulare* Carpenter						R																		
Caecum cf. *C. anellifer* Pilsbry																			R					
Metoceras umbliyoceras Woodring, n. sp.																								
Architectonica (*Architectonica*) *nobilis nobilis* Röding		C	R	C	C	R	sp. F	R		R		R			A	?R	F	F	?R		R	F	?R	R
Heliacus (*Astronacus*) *stonemanae* (Maury)				R	R	R																		
Heliacus (*Astronacus*) *anaglyptus* Woodring, n. sp.																								
Rhinoclavis (*Ochetoclava*) *costaricana canabina* Woodring, n. sp.																								
Bittium nugatorium Brown and Pilsbry		C			R	C													F					
Bittium pericallum Woodring, n. sp.																								
Alabina asperoides asperoides (Gabb)		R			R	C	R																	
Alabina asperoides canaliculata (Gabb)					R	C									C				C					
Epitonium (*E.*) cf. *E. foliaccicostum* (d'Orbigny)						?R									R									
Epitonium (*Asperiscala*) cf. *E. gabbi* (de Boury)																	R							
Epitonium (*Asperiscala*) cf. *E. rushii* (Dall)																								
Epitonium (*Asperiscala*) *sp.*						R																		
Cirsotrema (*Cirsotremopsis*) cf. *C. arcella* Rehder																							R	
Scalina pseudoleroyi (Maury)																	R							
Scalina cf. *S. brunneopicta* (Dall)																								
Strombus gatunensis Toula		R				R			?R															
Strombus sp.																								
Cypraca (*Muracypraea*) *henekeni* Sowerby		R			F	F																		
Eocypraea (*Apiocypraea*) *kennae* Woodring, n. sp.																								
Protatlanta (*Atlantidea*) *lissa* (Woodring)																								
Semicassis (*Tylocassis*) *reclusa* (Guppy)		R			?R													R						
Sconsia laevigata sublaevigata (Guppy)										R														
Cymatium (*Septa*) *pileare henicum* Woodring, n. subsp.		R																						
Cymatium? (*Ranularia?*) sp.																								
Distorsio (*Rhysema*) *decussata gatunensis* Toula		R			R	R				R							?R							
Bursa (*Colubrellina*) *caelata amphitrites* Maury					F																			
Malea camura Guppy	?sp. R	R			R				?R		?F	?sp. R	?R					?sp. R		?R			?F	
Malea? cf. *M. elliptica* Pilsbry and Johnson																								
Ficus cf. *F. pilsbryi* (B. Smith)																								
Ficus carbasea carbasea (Guppy)												?R		F										
Murex (*Murex*) *recurvirostris recurvirostris* Broderip					R	R																		
Murex (*Murex?*) *polynematicus* Brown and Pilsbry	R	R			C	R																		
Murex (*Chicoreus*) *brevifrons* Lamarck																								
Paziella (*Panamurex*) *gatunensis* (Brown and Pilsbry)																								
Eupleura thompsoni Woodring, n. sp.	C	C	C	R		R	R																	
Typhis (*Pilsbrityphis*) *gabbi* Brown and Pilsbry																	R							
Typhis (*Talityphis*) *alatus obesus* Gabb	R																							
Thais (*Stramonita*) aff. *T. haemastoma* (Linné)																								
Cymia (*Cymia*) *cheloma* Woodring, n. sp.	R	F																						

| LOCALITIES | | |

LA BOCA MARINE MEMBER OF PANAMÁ FORMATION

Strombus sp. (locality 129a), *Ficus?* sp. (locality 131a), and *Thais* aff. *T. melones* (locality 123) are the ony mollusks from the La Boca marine member of the Panamá formation in the families covered by this report.

GATUN FORMATION

Almost half (44 species and subspecies) of the fossils described in the present chapter were found in the richly fossiliferous Gatun formation. *Heliacus stonemanae* is an example of the faunal similarity between the lower part of the Gatun formation and the Cercado formation of the Dominican Republic. *Eupleura thompsoni* is the first Caribbean species of the genus to be described. The Gatun fossils include two species now living in both the Caribbean Sea and the eastern Pacific Ocean (*Architectonica nobilis* and *Murex recurvirostris*); genera, subgenera and an unnamed species group that are no longer in the Caribbean Sea but survive in the eastern Pacific Ocean (*Astronacus*, *Ochetoclava*, *Malea*, group of *Ficus ventricosa* and *Cymia*); and a genus (*Scensia*) that formerly lived in both the eastern and the western Pacific Ocean but survives in the Caribbean Sea.

PLIOCENE SERIES

CHAGRES SANDSTONE, INCLUDING TORO LIMESTONE MEMBER

The Chagres sandstone, including the Toro limestone member, is notable for its relatively large number of epitonids. The fossils of the Chagres proper include *Bathygalea hadra*, a species of a recently described moderately deepwater and deepwater cassid genus.

Mollusks from Toro limestone member of Chagres sandstone (Epitoniidae to Strombidae)

[R, rare; C, common]

	Localities			
	186	186a	186b	Other collections
Sthenorytis pernobilis (Fischer and Bernardi)?	R			
Sthenorytis toroensis toroensis (Dall)	C	R	C	
Strombus gatunensis Toula?				R

Mollusks from Chagres sandstone, exclusive of Toro limestone member (Epitoniidae to Ficidae)

[R, rare; F, few; C, common; A, abundant; sp., species unidentified]

	Localities							
	199	201	203	205	206	206a	206b	208
Architectonica (Architectonica) nobilis karsteni Rutsch		R	sp A					F
Epitonium ("Depressiscala") cuetaanum Woodring, n. sp.							R	
"Epitonium" sp.					R			
Sthenorytis toroensis euthynia Woodring, n. subsp.				R				
Scalina i eigandi (Böse)					R	R		?R
Strombus gatunensis Toula								?R
Bathygalea (Miogalea) hadra Woodring and Olsson								R
Distorsio decussata gatunensis Toula								?R
Ficus carbasea carbasea (Guppy)	R	R						

DESCRIPTION OF TERTIARY MOLLUSKS—CONTINUED FROM CHAPTER A

GASTROPODS—CONTINUED FROM CHAPTER A

TYPES AND OTHER SPECIMENS OF TOULA'S GASTROPODS FROM GATUN FORMATION

The fossils from the Gatun formation described by Franz Toula in 1909 and 1911 (in the publications listed on pages 6, 7, and 134 of chapter A of the present report) were deposited in the Technische Hochschule in Vienna. In the late 1920's the gastropods were borrowed by Dr. R. F. Rutsch, when he was on the staff of the Basel Naturhistorisches Museum and was working on Tertiary Caribbean faunas. Owing to the outbreak of World War II, the specimens were kept in Switzerland. When Dr. Rutsch moved to the University of Bern, the collection was transferred to that institution, but later was returned to Basel. At the suggestion of Dr. Rutsch in April 1957, I wrote to Dr. E. Gasche, Curator of the Geology Department of the Basel Museum, inquiring whether I could borrow the specimens. When Prof. A. Kieslinger, Director of the Geological Department of the Technische Hochschule, kindly gave his approval, they were forwarded to Washington, D. C., with the understanding that they are to be returned to the Technische Hochschule. They have been forwarded recently to that institution. The specimens have no catalog numbers, but the year when they were collected is entered on the labels. Three types and nine other figured specimens are missing. According to a communication from Prof. Kieslinger, the missing specimens are no longer in the collections of the Technische Hochschule, and he has been unsuccessful in attempting to locate them elsewhere.

As outlined by Toula (1909, p. 673–675; 1911, p. 487), the fossils were forwarded by W. Rowland, a former student of Prof. Toula and an engineer of the Isthmian Canal Commission. Rowland collected one lot in 1908 and a second in 1910. "Most" of them were collected at the Gatun Locks site or at the Gatun Dam Spillway. The locality for the remainder was not specified, but all the fossils evidently were found in the middle part of the Gatun formation. Toula (1909, p. 749–758) also examined fossils from the Gatun formation and Pleistocene deposits near Limon Bay in the collections of the Staatsmuseum in Munich. The Gatun fossils in the Munich Museum also evidently were found in the middle part of the Gatun formation.

The following comments cover Toula's species in the families of gastropods described in chapter A of the present report. The page notation in parenthesis, following the name used by Toula, refers to chapter A. His remaining gastropods are to be taken up in systematic order in the present and later chapters.

Teinostoma cf. carinatum d'Orbigny (p. 69)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 497, pl. 31, figs. 10a–c, 1911.

This minute vitrinellid is missing. Principally on account of the fairly wide distribution of *Teinostoma spermatia* Woodring near Gatun (but not at the Gatun Locks or the Gatun Dam Spillway), Toula's vitrinellid was referred doubtfully to that species. It was pointed out, however, that his illustrations show an exposed spire and a peripheral carina, and that Pilsbry thought Toula's species is very similar to—perhaps identical with—d'Orbigny's Recent Caribbean species. For other species Toula's illustrations are trustworthy. Therefore *Teinostoma* aff. *T. carinatum* (d'Orbigny) presumably is to be added to the list of species from the middle part of the Gatun formation.

Cyclostrema quadrilineatum Toula (p. 73)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 497, pl. 31, figs. 11a–c, 1911.

This species also is missing. The identification as *Cyclostremiscus pentagonus* (Gabb) is based on Toula's illustrations.

Crepidula gatunensis Toula (p. 79)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 498, pl. 31, figs. 12a, b, 1911.

Crepidula gatunensis is the third missing species. Toula's illustrations of the type, an immature specimen (length 2.8 mm, width 1.8 mm) suggest the species identified in the present report as *Crepidula* cf. *C. maculosa* Conrad. As pointed out on page 79, should additional material show that the slipper-shell from the Gatun formation needs a name, *C. gatunensis* is available.

Capulus? gatunensis Toula (p. 83)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 692, pl. 25, fig. 1 (not fig. 2; see explanation of pl.), 1909.

The only specimen Toula had is the type, illustrated in lateral view. It is immature (length 11.7 mm, width 7.4 mm, height 7 mm) and poorly preserved—partly internal mold, partly inner shell and partly corroded outer shell. The corroded outer shell shows no sculpture, but toward the posterior margin, where the shell is almost or quite gone, there is a faint suggestion of radial sculpture. The part of the specimen that is internal mold shows the impression of what seems to be one side of the cup of *Crucibulum*. The specimen may be a species of *Crucibulum* that was crowded during growth and therefore laterally compressed. On page 83 of chapter A *Capulus? gatunensis* is doubtfully cited under *Crucibulum springvaleense* Rutsch, described in 1942. Examination of the type confirms Dr. Rutsch's opinion that Toula's species is unrecognizable. The only comment that can be added to the discussion on page 83 is that the remark concerning the absence of traces of strong sculpture is irrelevant in view of the absence of outer shell material toward the borders of the fossil. *Capulus? gatunensis* is considered to be a nomen dubium.

Capulus? sp. (p. 83)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 692, pl. 25, fig. 2 (see explanation of pl.), 1909.

The figured specimen (length 14.5 mm, width 7.8 mm, height 8.3 mm), as surmised from the illustration, is a laterally compressed, poorly preserved, immature specimen of *Crucibulum springvaleense* Rutsch. Like the type of *Capulus? gatunensis*, it is partly internal mold, partly inner shell and partly corroded outer shell. The internal mold shows part of the impression of a *Crucibulum* cup, and on the right side the edge of corroded shell clearly shows coarse radial sculpture.

It should be noted that in the description of *Capulus?* sp., Toula included the dimensions of both that form and the type of *Capulus? gatunensis*. Furthermore, in the text, plate 25, figure 2 is erroneously cited for *Capulus? gatunensis*, whereas in the explanation of the plate that illustration is properly cited for *Capulus?* sp. Copies of the illustrations, agreeing with the explanation of the plate, are in the vials with the appropriate specimen.

Natica guppiana Toula (p. 86)

Toula, K. k. Geol. Reichsaustalt Jahrb., Band 58, p. 696, pl. 25, fig. 6, 1909.

Four specimens are in three lots, two collected in 1908 and one in 1910. The type (height 18.5 mm, diameter 17.6 mm) is the immature figured specimen of this species of *Stigmaulax*—the most widespread and most abundant of the Gatun naticids. A specimen of considerably larger size (height 30.5 mm, diameter 28.4 mm) was collected in 1910. Two other naticids in that lot represent *Natica stenopa* Woodring.

Operculum (sp.?) (p. 86)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 511, pl. 31, fig. 26, 1911.

This naticid operculum is missing. There is no doubt, however, that it is the operculum which has

been found in place in the aperture of Toula's own species, "*Natica*" *guppiana*.

Sigaretus (Lupia) gatunensis Toula (p. 93)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 697, pl. 28, figs. 3a–c, 1909.

Two specimens of this small (possibly on account of immaturity) greatly depressed species of *Sinum* are in the collection. The larger specimen (height 5.8 mm, diameter 22 mm) is an internal mold, to which patches of corroded shell are attached; the other is an internal mold that has less shell material. The larger was illustrated and is the type.

As noted on page 93 of chapter A, *Sinum gatunense* is not represented in the collections of the U. S. National Museum and Stanford University. Toula's inadequate specimens, and the fossils from the Bowden formation of Jamaica and the Cercado formation of the Dominican Republic, identified as *S. gatunense*, show no features to distinguish *S. dodonum* Gardner, found in the Shoal River formation of Florida, from *S. gatunense*. It has not yet been demonstrated, however, that any of these fossils can be distinguished from the Recent *S. perspectivum* (Say), except by their smaller size. *S. perspectivum* ranges from Virginia to the West Indies and is found in deposits of Pliocene age. The Recent Panamic *S. noyesi* Dall has somewhat weaker sculpture.

Turritella gabbi Toula (p. 102)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 695, pl. 25, fig. 5, 1909.

The type (height 24.5 mm, diameter 9.8 mm) consists of six intermediate whorls of the typical form of *Turritella altilira* Conrad, one of the most characteristic species in the Gatun formation. As on other specimens found in the lower half of the middle part of the formation, one of the minor spirals between the primaries is stronger and more coarsely noded than the others.

An impression of several whorls in oxidized sandstone, from which a mold was made, also was collected in 1908. Rowland forwarded to Toula in 1910 a four-whorled specimen, much larger than the other two.

Turritella conradi Toula (p. 103)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 694, pl. 25, fig. 4, 1909.

Two specimens, both illustrated under the same figure designation, are in the type lot. The larger (4 whorls, height 34.5 mm, diameter 15.2 mm) is herewith designated the lectotype. As was evident from the illustrations, *Turritella conradi* is *T. gatunensis* Conrad, another characteristic species of the Gatun formation.

Turritella (Haustator) aff. Hanleyana Reeve (p. 110)

Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 498, pl. 30, fig. 6, 1911.

Rowland collected two fragments, both of which were illustrated. As surmised from the illustrations, they represent *Turritella mimetes* Brown and Pilsbry.

ADDITIONAL DESCRIPTIONS OF SPECIES IN FAMILIES COVERED IN CHAPTER A

The first seven species on the following pages were received too late to be included in chapter A.

Family TROCHIDAE

Subfamily MARGARITINAE

Genus Solariella S. Wood

S. Wood, Ann. Mag. Natural Hist., v. 9, p. 531, 1842.
Type (monotype): *Solariella maculata* S. Wood, Pliocene, England.

The Caimito formation at locality 541 on Barro Colorado Island yielded two minute exfoliated fossils (height 1.5 mm) that may represent immature specimens of *Solariella*.

Solariella ephnidia Woodring, n. sp.

Plate 26, figures 2, 3

Solariella n. sp., cf. *S. depressa* Dall, Woodring, U. S. Geol. Survey Prof. Paper 306, p. 27 (list), 1957 (Oligocene, Canal Zone). Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

Small, somewhat turreted, suture of body whorl descending near outer lip. Spire whorls and body whorl above base sculptured with widely spaced spiral threads, three on spire whorls and four on body whorl. Base and umbilicus sculptured with similar, but more closely spaced, threads; umbical threads weaker than those on base. Spaces between spiral threads bearing microscopic strongly retractive accentuated growth lines paralleling outer lip. Faint coarse axial undulations are apparent. Umbical spiral threads weakly noded. Aperture very oblique.

Height 3.5 mm, diameter 3.6 mm (type).

Type: USNM 562557.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth, Canal Zone), upper of Bohio formation.

The exceptional features of the fossils found in subgraywacke of the Bohio formation on Barro Colorado Island at locality 42d are illustrated by the occurrence of this small *Solariella*, the fifth species of the genus to be recorded from the Tertiary deposits of tropical America. It is described and named, although the type is the only specimen.

S. ephnidia is similar to the Recent *S. depressa* Dall (1889, p. 382), but is not as strongly turreted or as depressed. The Miocene Jamaican *S. altiuscula* Guppy (Woodring, 1928, p. 432, pl. 36, figs. 6–8; *altiusulca* by error) is considerably larger, less turreted, and has strong coarsely noded umbical threads.

S. depressa was described as a variety of *S. lacunella* (Dall). The types of both forms, both dead shells, were dredged at a depth of 805 fathoms off Havana. *S. depressa* is represented, however, in a 20-fathom haul from Bimini Island in the Bahamas and *S. lacunella* is very common at depths of 20 to 100 fathoms along the coast of southern Florida.

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

Family THIARINAE

Subfamily THIARIDAE

Genus Hemisinus Swainson

Swainson, A treatise on malacology, pp. 199–200, 341, 1840.

Type (orthotype, p. 200): *Melania lineolata* Gray (cited as *Melania lineata* on p. 200 and as *Hemisinus lineolata* on p. 341), Recent, Jamaica.

Subgenus Longiverena Pilsbry and Olsson

Pilsbry and Olsson, Acad. Nat. Sci. Phila. Proc., v. 87, p. 11, 13, 1935.

Type (logotype, Wenz, Handbuch der Paläozoologie; Gastropoda, pt. 3, p. 719, 1939); *Hemisinus tubereulatus* (Wagner) (*Melania tuberculata* Wagner), Recent, Brazil.

Hemisinus tuberculatus was indicated as the type by Pilsbry and Olsson, but the term type was inadvertently omitted. To claim that that species is the monotype because it was the only species cited on page 11, where *Longiverena* was first mentioned, is a strained interpretation. Page precedence does not deserve the emphasis that is now being attached to it, for it is not real precedence.

The species of the subgenus *Longiverena* are elongate and have axial and spiral sculpture.

Hemisinus (Longiverena) oeciscus Woodring, n. sp.

Plate 25, figures 1–4, 9, 10

Hemisinus (*Longiverena*) n. sp., cf *H. atriformis* Cooke, Woodring, U. S. Geol. Survey Prof. Paper 306, p. 27 (list), 1957 (Oligocene, Canal Zone). Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

Of medium size, somewhat turreted, rapidly enlarging, spire whorls slightly inflated. Axial sculpture consisting of wide flat ribs, practically straight on early whorls, gently curved on later whorls, 12 or 13 on last few whorls. Ribs disappearing on body whorl or penultimate whorl, or represented only by low broad swellings on posterior part of whorl. Spiral sculpture consisting of low flat bands, separated by very narrow interspaces and overriding axial ribs without forming nodes, four or five on later spire whorls, generally absent on body whorl of large specimens, except seven or eight on anterior half of whorl. Posterior half of outer lip, as shown by growth lines (which have same curvature as axial ribs), forming a shallow wide indentation. Basal spout very narrow.

Height (incomplete) 12 mm, diameter (slightly increased by crushing) 6.5 mm (type). Height (incomplete) 15.2 mm, diameter (slightly increased by crushing) 8 mm (larger paratype).

Type: USNM 562558; 2 paratypes, USNM 562559; paratype, Stanford University.

Type locality: 42f (USGS 18836, Barro Colorado Island, northern part of island, stream southeast of Fuertes House, about 335 meters above mouth, from slide on west side of stream, Canal Zone), upper part of Bohio formation.

The type evidently is not mature, as less complete specimens indicate a size about a third larger. Though 18 specimens of this species were collected from the Bohio formation at locality 42f, where marine, brackish-water and fresh-water mollusks were found, none is well preserved. If all are properly referred to one species, both whorl profile and sculpture are variable. The body whorl of some incomplete large specimens has a strong concave construction adjoining the suture. The type shows the beginning of such a constriction (pl. 25, fig. 10). Both axial ribs and spiral bands tend to disappear on the body whorl. The most aberrent specimen, of which only a little more than two whorls remains, has almost coronate stubs of axial ribs adjoining a sutural constriction.

Hemisinus oeciscus appears to be an exceptional form of a group of Oligocene, Oligocene(?), and Miocene(?) species found in Cuba, Antigua, the Magdalena Valley of Colombia, the upper Amazon valley of Brazil and Perú, and Ecuador. It is most similar to the Oligocene Antiguan *H. atriformis* C. W. Cooke (1919, p. 118, pl. 3, figs. 4, 5), which also enlarges rapidly but has spirals that are somewhat swollen as they override the axial ribs. The axials and spirals of *H. atriformis* are persistent, and so are the axials and spirals of the other species of the group just mentioned, all of which are more elongate than *H. atriformis* and *H. oeciscus*.

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

Hemisinus (Longiverena) aff. H. oeciscus Woodring, n. sp.

Many specimens of a species of *Hemisinus* occur in bentonitic clay of the Cucaracha formation on the face of Contractors Hill, on the southwest side of the Pan-

ama Canal at the continental divide (pl. 2). As a result of compaction of the clay, all these fossils are flattened and none can be extracted from the rock. Only a small part of the shell material is preserved. In size, general outline and sculpture this species is similar to *Hemisinus oeciscus* and may, indeed, be that species. It cannot be determined, however, whether the spire of the specimens from the Cucaracha formation is somewhat turreted. One of the large specimens is 16 mm high and 7 mm in diameter, but the diameter is slightly increased by crushing.

These fossils were found by R. H. Stewart, of the Panama Canal Company, in a layer of fossiliferous clay (thickness 10 cm) 7 to 9 meters above the top of the welded tuff in the Cucaracha described on p. 54. The fossiliferous layer, which Mr. Stewart traced for a distance of about 185 meters across the face of Contractors Hill, also contains minute charophyte oögonia, identified by R. E. Peck as *Tectochara* aff. *T. escheri* (Braun), and carbonized plant fragments.

Occurrence: Cucaracha formation (early Miocene), locality 122a.

Family NATICIDAE

Subfamily GLOBULARIINAE

Genus Globularia Swainson (see p. 94)

Subgenus Globularia s. s.

Globularia (Globularia) aff. G. fischeri (Dall)

Plate 26, figures 16, 18, 19

Globularia (Globularia) aff. *G. fischeri* (Dall) Woodring, U. S. Geol. Survey Prof. Paper 306, p. 27 (list), 94, pl. 15, figs. 9, 17, 18, 1957 (Oligocene and Miocene, Canal Zone). Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

A moderately large, greatly inflated *Globularia* is one of the most abundant species in the Bohio formation at locality 42d on Barro Colorado Island. About 40 specimens, ranging in height from 2.5 to 35 mm, were collected and more than that number were discarded as incomplete molds. This *Globularia* is identified as the species from the Caimito and Culebra formations described in chapter A as *Globularia* aff. *G. fischeri*. The new material, however, shows some features that were unavailable or poorly shown on the fossils from the Caimito and Culebra. These features indicate that the species of the Bohio formation, though closely allied to *G. fischeri*, can be distinguished from that form. Nevertheless it is not named as a new subspecies or species, for no adult specimen is well enough preserved to serve as a type. The only specimens retaining the greater part of the thin shell are immature, like that shown on plate 26, figure 16. Accentuated growth lines are much stronger than on *G. fischeri;* they are so strong and so evenly spaced that they practically constitute sculpture. The spire of immature shells is higher and more strongly turreted than that of *G. fischeri*. Some immature shells, like some immature shells of *G. fischeri*, show faint, nonpersistent widely spaced spirals.

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

Genus Pachycrommium Woodring (See p. 86)

Pachycrommium aff. P. guppyi (Gabb)

Pachycrommium aff. *P. guppyi* (Gabb), Woodring, U. S. Geol. Survey Prof. Paper 306, p. 27 (list), 1957 (Oligocene, Canal Zone). Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

A minute shell (height 9.7 mm, diameter 5.5 mm), which shows part of the apertural features, and a small mold (height, minus early whorls, 20 mm, diameter 15.5 mm) were found in the upper part of the Bohio formation on Barro Colorado Island. The mold, which lacks the early whorls, resembles the high-spired globularine from the Culebra formation described as *Pachycrommium* cf. *P. guppyi* (p. 97 of chapter A, pl. 16, fig. 12), but is not quite as strongly shouldered. The minute shell has a higher and more slender spire than specimens of *P. guppyi*, the type of the genus, of the same size.

This material shows that a species of *Pachycrommium*, allied to *P. guppyi*, occurs in strata of late Oligocene age in the Canal Zone.

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

Genus Ampullinopsis Conrad

Conrad, Am. Jour. Conchology, v. 1, p. 27, 1865.
Type (monotype): *Ampullinopsis mississippiensis* (Conrad) (*Natica mississippiensis* Conrad), Oligocene, Mississippi.

Ampullinopsis is found in the Oligocene of western Europe, southeastern United States, the Caribbean region, Central America, and northern South America. It therefore is an expectable fossil in the Oligocene of the Canal Zone, but was not found there until fossils were collected from conglomerate of the Caimito formation on Pato Horqueto Island.

Despite statements to the contrary (Dall, 1909, p. 90), *Ampullinopsis* is not known to occur on the Pacific coast of the United States or farther north. With the exception of *A. citrinensis* Palmer (Richards and Palmer, 1953, p. 26, pl. 3, figs. 10, 11), from the middle or upper Eocene of Florida, in America the genus has an age range of early Oligocene to the early part of early Miocene. The very incomplete molds from the island of Anguilla doubtfully identified as *Ampullinopsis spenceri* (C. W. Cooke, 1919, p. 124) probably repre-

sent *Globularia anguillana* (Cooke), which may be a synonym of *G. fischeri* (Dall).

Ampullinopsis spenceri (Cooke)

Plate 27, figures 2, 5, 7, 8

?*Ampullina amphora* Heilprin, Joukowsky, Soc. Phys. Histoire Nat. Géneva Mém., v. 35, p. 174, pl. 6, figs. 17, 18a, 18b, 1906 (Oligocene, Panamá).

Ampullina (*Ampullinopsis*) *spenceri* Cooke, Carnegie Inst. Washington Pub. 291, p. 123, pl. 5, figs. 1–3, 1919 (Oligocene Antigua). ?Olsson, Bull. Am. Paleontology, v. 17, no. 63, p. 72, pl. 11, figs. 2, 6, 1931 (Oligocene, Perú).

?*Natica* (*Ampullina?*) *collazoensis* Hubbard, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 135, pl. 21, figs. 11, 12, 1920 (Oligocene, Puerto Rico).

Ampullinopsis spenceri (Cooke), Woodring, U. S. Geol. Survey Prof. Paper 306, p. 31 (list), 1957 (Oligocene, Canal Zone).

Moderately large, moderately thick-shelled, low-spired, body whorl strongly inflated. Sutural channel deep, moderately wide. Outer border of sheath (shell layer emerging from umbilicus) marked by a well-defined rim, forming a shelf on well-preserved specimens. Lobe (downward extension of parietal callus) thick, generally completely closing umbilicus only at a late stage (height 47.5 mm), exceptionally closing it completely at an early stage (height 16 mm).

Height (practically complete) 47.5 mm, diameter (incomplete) 42.5 mm (larger figured specimen). Height (practically complete) 36.5 mm, diameter (almost complete) 36.5 mm (smaller figured specimen).

Type material: 2 syntypes, USNM 167031.

Type locality: Antigua, Antigua formation.

The shells of *Ampullinopsis* are more or less similar wherever they are found and it still is uncertain how many species are to be recognized. The fossils from the Canal Zone are identified as *A. spenceri*, which was based on three specimens, all of which were illustrated. These three specimens have a well defined rim, even the largest (C. W. Cooke, 1919, pl. 5, fig. 3), which is somewhat worn. In strength of rim, width and thickness of lobe, height of spire, and inflation of body whorl, the best preserved among 17 specimens collected in the Canal Zone closely resemble the better preserved of the two syntypes of *A. spenceri*. They have a slightly narrower sutural channel, however, and show no traces of faint spiral lineation. Such spiral lineation is not unusual among globularines and evidently is not a specific character. It is not shown by the largest Antiguan specimen, but its absence may be the result of wear. The larger figured specimen from the Canal Zone (the largest found) has a less distinct rim. It is worn, however, and has a badly damaged lobe.

A. spenceri is closely allied to the last surviving North American species, *A. amphora* (Heilprin) (1887, p. 112, pl. 16, fig. 50), of the lower Miocene Tampa limestone of Florida. As noted by Cooke, *A. amphora* has a higher spire. The type (height about 110 mm.), a less complete large specimen of comparable size (USNM 112947) and one of intermediate size have an open umbilicus and thinner lobe than *A. spenceri*. The type and a fragment in the U. S. National Museum have a sharply defined rim, but no rim is apparent on the large specimen just mentioned, which was worn and corroded before it was silicified. A larger suite from Florida may indicate that the Caribbean form is to be assigned to *A. amphora*.

A. mississippiensis (Conrad) (1848, p. 114, pl. 11, fig. 10), of the Vicksburg group, was the first American species to be named. The outer edge of the sheath of that species is marked by a bending and accentuation of the growth lines rather than by a rim, except near the base of the aperture where a rim is recognizable. The thick lobe generally closes the umbilicus at an early stage, even at a height of 14 mm. Of about 60 specimens examined, one (restored height about 22 mm.) has an incompletely closed umbilicus. The sutural channel on the later half of the body whorl of large specimens is wider than that of *A. spenceri* of the same size. As has long been recognized, *A. mississippiensis* closely resembles the Oligocene European *A. crassatina* (Lamarck). Perhaps they can be distinguished by the wider sutural channel on the body whorl of large specimens of the American form.

If *A. spenceri* occurs in Antigua and the Canal Zone, it is to be looked for elsewhere in the Caribbean region. No unequivocal examples have so far been found. The late Oligocene Puerto Rican "*Natica* (*Ampullina?*" *collazoensis* Hubbard is practically unrecognizable as described and illustrated. An exceptionally well preserved large *Ampullinopsis* (height 73 mm), collected by A. D. Zapp and H. R. Bergquist in the type region of "*Natica*" *collazoensis*, can hardly be *A. spenceri*, despite the sharply defined rim and faint spiral lineation. The lobe is thin and overlaps the rim about halfway between the base of the aperture and its top, instead of at a point about four-fifths of the distance between the base and top. *Ampullinopsis*, possibly the species collected by Zapp and Bergquist, reaches an enormous size in Puerto Rico. Many years ago a resident of the island presented to David White, while he was Chief Geologist of the U. S. Geological Survey, a mold that has a diameter of about 185 mm. It was picked up at an unknown Puerto Rican locality and served as a door stop. A Miocene Fijian globularine of comparable size (diameter 142 to 215 mm) was described by Ladd (1934, p. 212, pl. 36, figs. 7, 8,

pl. 37, figs. 1, 2, pl. 38, fig. 1) as *Globularia* (*Waluia*) *edwardsi*.

Joukowsky's "*Ampullina*" *amphora* was found in late Oligocene deposits in the Santiago area near Macaracas, in the interior of the Los Santos Peninsula of western Panamá. His description strongly suggests *A. spenceri*. The only available specimens, collected on a tributary of Río Mariato, on the west side of the peninsula, are badly preserved. Though they have apertural features like those of *A. spenceri*, their body whorl is less inflated: Olsson's Peruvian *A. spenceri* also has a slightly less inflated body whorl and the the body whorl of a large Venezuelan form, *A. santiagana* (F. Hodson) (Hodson, Hodson and Harris, 1927, p. 72, pl. 38, fig. 8, pl. 39, figs. 1, 2,), is decidedly less inflated. Perhaps the somewhat or markedly flattened body whorl of these fossils from Panamá, Perú, and Venezuela is the result of deformation. Insofar as they show other features, they are otherwise similar to *A. spenceri*.

A. spenceri is said to occur in deposits of late Eocene age in Perú (Stainforth, 1955, p. 2,076). Confirmation of this occurrence is desirable. The claim that *Ampullinopsis* is a brackish-water genus (Stainforth, 1953, p. 255) is based on no known justification.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 55b. Antigua formation (late Oligocene), Antigua. San Sebastián formation (late Oligocene), Puerto Rico (identification doubtful). Late Oligocene, Santiago area, Panamá (identification doubtful). Late Oligocene, Perú and Ecuador (identification doubtful).

Family TURRITELLIDAE

Genus Turritella Lamarck (see p. 97)

Subgenus? (Merriam's T. ocoyana stock)

Turritella listrota Woodring, n. sp.

Plate 26, figures 1, 6, 7

Turritella n. sp., aff. *T. venezuelana Hodson*, Woodring, U. S. Geol. Survey Prof. Paper 306, p. 27 (list), 1957, (Oligocene, Canal Zone). Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

Of medium size, slender, late whorls almost flat. Earliest preserved whorls sculptured with two primary spirals: one at middle of whorl, the other about halfway between it and anterior suture, the anterior one modifying whorl profile. Earliest preserved whorls also bearing very fine secondary spirals. With further growth, secondary spirals become as strong as the two original primaries. Late whorls almost flat, though constricted at sutures. Sculpture of late whorls consisting of seven to nine almost uniformly spaced primary spirals. A fine secondary is present in some interspaces and one or two generally stronger secondaries near anterior and posterior suture. Base sculptured with weak closely spaced spirals. Growth-line sinus very shallow and wide, the apex near anterior suture. Growth-line angle very wide.

Height (incomplete, 6 whorls) 35 mm, diameter 11 mm (type). Height (incomplete, 7 whorls) 18.5 mm, diameter 6.5 mm (paratype).

Type material: Type, USNM 562561; paratype, USNM 562562; paratype, Stanford University.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth, Canal Zone), upper part of Bohio formation.

Turritella listrota is fairly abundant at the type locality and is represented by a few doubtfully identified, poorly preserved fragments from locality 42g. Despite the almost flat outline of late whorls, this species is related to the early Miocene *T. venezuelana* Hodson and other species of the *T. ocoyana* group, and appears to be the earliest species of the group to be recognized. *T. venezuelana* occurs in the Culebra formation and is described in chapter A of the present report (p. 106, pl. 16, figs. 8, 9). Immature whorls of *T. listrota* enlarge less rapidly than those of *T. venezuelana* and are not as strongly carinate at the anterior primary spiral. *T. listrota* is larger and not only loses at an early stage the carina formed by the anterior primary spiral, but also soon loses the convex whorl profile. A form included in *T. venezuelana quirosana* by Hodson (1926, p. 34, pl. 22, fig. 9) has somewhat flattened whorls, but no form of that variable species has the strongly flattened whorls of *T. listrota*.

Similar larger and more convex-whorled species are found in the Miocene of Perú and Ecuador: *T. infracarinata* Grzybowski (Olsson, 1932, p. 196, pl. 22, fig. 8; Marks, 1951, p. 101, pl. 6, figs. 1, 14; p. 103, pl. 6, fig. 12) and *T. prenuncia* Spieker (Olsson, 1932, p. 193, pl. 23, figs. 8, 9).

Occurrence: Upper part of Bohio formation (late Oligocene), localities 42d, 42g (identification donbtful).

FAMILIES NOT COVERED IN CHAPTER A

Family VERMETIDAE

Unidentified or doubtful vermetids occur in the Gatuncillo formation, the marine member of the Bohio(?) formation, the Culebra formation, the Alhajuela sandstone member of the Caimito formation, and the Gatun formation.

Genus Serpulorbis Sassi

Sassi, Giornale Ligustico di Scienze, Lettere ed Arti, pt. 5, p. 483, 1827.

Type (monotype): *Serpulorbis polyphragma* Sassi (=*Serpula arenaria* Linné), Recent, Mediterranean Sea.

Chavan (1944, p. 335–338) has discussed the unsatisfactory status of *Lemintina* Risso, a name that has been used for this genus of vermetids (Woodring, 1928, p. 345). He found in the Paris Museum of Natural History the type material of *Lemintina cuvieri* Risso (the monotype of *Lemintina*), consisting of two broken tubes (Chavan, 1944, fig. 1*b*), and concluded that the tubes are those of an annelid. Risso's illustrations of a vermetid-like animal in and withdrawn from a tube, reproduced by Chavan (1944, fig. 3), cannot be taken seriously. Though the outline of the animal is vermetid, the foot bears a rosette that would be unique in a gastropod.

Serpulorbis papulosus (Guppy)

Plate 29, figure 13

Vermetus papulosus Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 292, pl. 17, fig. 3, 1866 (Miocene, Jamaica).

Lemintina papulosa (Guppy), Woodring, Carnegie Inst. Washington Pub. 385, p. 346, pl. 26, fig. 6, 1928 (Miocene, Jamaica; additional citations). Gardner, U. S. Geol. Survey Prof. Paper 142, p. 585, pl. 55, fig. 20, 1947 (Miocene, Florida). Aguayo, Soc. Malacológica Carlos de la Torre Rev., v. 6, p. 62, 1948 (Miocene, Cuba).

Serpulorbis papulosus (Guppy)?, Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 35, pl. 8, fig. 13, 1929 (Miocene, Colombia).

Serpulorbis papulosa (Guppy), Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 144, 1929 (Miocene, Colombia).

Vermetus (*Lemintina*) *papulosus* Guppy, Rutsch, Schweizer. Palaeont. Gesell. Abh., Band 54, no. 3, p. 46, pl. 1, fig. 14, pl. 2, fig. 1, text fig. 6, 1934 (Miocene, Venezuela).

Relatively large, irregularly curved tubes. Sculpture very strong to subdued, dominated by widely spaced heavy spirals bearing widely spaced swollen knobs. Between the knobbed spirals are one to three crudely noded narrower spirals.

Length 37 mm, greatest diameter 9.5 mm (largest fragment). Length 16 mm, greatest diameter 8.8 mm (figured fragment).

Type: British Mus. (Natural Hist.), Geol. Dept. 64081.

Type locality: Jamaica (Bowden), Bowden formation.

The middle part of the Gatun formation yielded three short lengths of tubes representing late stages of a vermetid, identified as *Serpulorbis papulosus* on the basis of the widely spaced swollen knobs. As usual in vermetids, the sculpture is of variable strength depending on the growth stage. *S. papulosus* is widely distributed in the Miocene of the Caribbean region and is recorded from the Miocene of Florida. The swollen knobs distinguish it from *S. graniferus* (Say), from the Miocene of eastern and southeastern United States (Mansfield, 1930, p. 102, pl. 14, fig. 4), and the Recent West Indian species known as *S. decussatus* (Gmelin), which occurs in the Pliocene of Florida (Olsson and Harbison, 1953, p. 305, pl. 46, figs. 3–3c).

Occurrence: Middle part of Gatun formation (middle Miocene) eastern area, localities 155, 155c, 157. Bowden formation (middle Miocene), Jamaica. Miocene, Cuba. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Middle Miocene, Columbia. Punta Gavilán formation (late Miocene), Venezuela. Brasso formation (early middle Miocene) and Springvale formation (late Miocene), Trinidad. Middle Miocene, Costa Rica. Shoal River formation (middle Miocene), Florida.

Genus Petaloconchus Lea

Lea, Am. Philos. Soc. Proc., v. 3, p. 162, 1843.

Type (monotype): *Petaloconchus sculpturatus* Lea, Miocene, Virginia.

The type species was not described when the generic name was proposed. According to Opinion 43 of the International Commission on Zoological Nomenclature, such names are nomenclaturally available. This is a legalistic matter, for the type species was described and illustrated three years later (Lea, 1846, p. 233, pl. 34, fig. 3).

Petaloconchus aff. P. floridanus Olsson and Harbison

Plate 29, figure 9

?Petaloconchus domingensis Sowerby, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 359, 1911 (Miocene, Canal Zone).

Small to moderately large tubes coiled in a short irregular open cylinder or in an irregular coil. Protoconch, presumably representing this species, consisting of at least three rapidly enlarging smooth whorls of hydroboid outline. Slender tube immediately following protoconch sculptured with very closely spaced axials. Later sculpture more or less reticulate, generally strong except toward apertural end of tube; consisting of moderately strong spirals and closely spaced axials, which are swollen as they cross the spirals. Columellar lamellae not present were columellar wall is exposed.

Height of coil 22 mm, greatest diameter of tube 6 mm (figured specimen).

The genus *Petaloconchus* is represented in the Gatun formation, but the representation is so meager that specific identification is uncertain. The figured irregular coil (locality 155*b*), an irregular cylinder (locality 155), and two short irregular cylinders seated on a *Serpulorbis papulosus* tube (locality 157) (all

Caecum cf. C. anellifer Pilsbry and Johnson

A minute imperfect tube (length 1.2 mm, maximum diameter 0.3 mm) evidently is immature. It is faintly sculptured with closely spaced, very low annular rings and closely spaced, very low axial ribs. The sculpture is so faint that it would disappear even with slight wear. The sculptural pattern suggests *Caecum anellifer* (Pilsbry, 1922, p. 378, fig. 18), which was based on a Miocene fossil collected by Gabb at an unknown locality in the Dominican Republic. A form comparable to *C. anellifer* is found in the Miocene of Jamaica (Woodring, 1928, p. 350, pl. 26, fig. 10).

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

Genus Meioceras Carpenter

Carpenter, Zool. Soc. London Proc., p. 438, 1858.
Type (logotype, Cossman, Essais de paléoconchologie comparée, pt. 9, p. 154, 1912): *Meioceras cornucopiae* Carpenter, Recent, West Indies.

Meioceras amblyoceras Woodring, n. sp.

Plate 31, figure 1

Moderately arched, moderately inflated, greatest inflation at about anterior third of length. Anterior part rapidly tapering to form the narrow very oblique aperture. Plug flat, terminating in a sharp apex at dorsal edge.

Length 2.1 mm, diameter of aperture .5 mm (type).

Type: USNM 562591.

Type locality: 155a (USGS 16970, spoil dump of Gatun Third Locks excavation, units 11 and 12 of section [chapter A, p. 44], Canal Zone), middle part of Gatun formation.

Meioceras amblyoceras, like the other caecids, is represented by one specimen. It is the third species of the genus to be recognized in the Tertiary deposits of tropical America. It evidently is not closely allied to either of the other two species, both of Miocene age: the slightly inflated, dome-plugged *M. constrictum* (Gabb) (Pilsbry, 1922, p. 378, fig. 17), from the Dominican Republic, and the Jamaican *M. apanium* Woodring (1928, p. 351, pl. 26, figs. 11, 12), which has a bulging equator. *M. amblyoceras* appears to be more closely allied to the Recent Caribbean and Floridian *M. nitidum* (Stimpson). That species, however, has a less contracted aperture and a more convex plug. The degree of inflation of *M. nitidum* is variable, ranging from less inflated than *M. amblyoceras* to more inflated than it. *M. nitidum* occurs in the Pliocene of southern Florida and has been recognized in the upper Miocene of western Florida (Mansfield, 1930, p. 102, pl. 14, fig. 6).

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

Family ARCHITECTONICIDAE

Genus Architectonica Röding

Röding, Museum Boltenianum, p. 78, 1798.
Type (logotype, Gray, Zool. Soc. London Proc., p. 151, 1847; *Architectonia* by error): *Architectonica perspectiva* Röding (=*Trochus perspectivus* Linné), Recent, tropical western Pacific Ocean.

Gray designated *Trochus perspectivus* as the type without mentioning Röding's name for that species.

The genus *Architectonica* occurs in the marine member of the Bohio(?) formation, the Caimito, Culebra, and Gatun formations, and the Chagres sandstone, but the material from the Bohio(?) and Culebra formations is very meager.

Subgenus Stellaxis Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 323, 1892.
Type (orthotype): *Solarium alveatum* Conrad, Eocene, Southeastern United States.

Architectonica (Stellaxis) aff. A. alveata (Conrad)

Solarium alveatum Conrad, Dall, in Hill, Mus. Comp. Zool. Harvard College Bull., v. 28, p. 273, 1898 (list; Eocene, Canal Zone).

Hill's principal Vamos Vamos collection includes a poorly preserved *Architectonica* (height 7 mm, diameter 15.3 mm). It has a peripheral cord and a cord on both dorsal and ventral surfaces adjoining the peripheral cord. The ventral cord is a little farther from the peripheral cord than that on the dorsal surface. The remainder of the shell is smooth, aside from poorly exposed coarse corrugations at the umbilical border. A better preserved half whorl of the same species was found near Palenquilla Point. It shows to good advantage the spiral cords and the coarse corrugations at the umbilical border. It also shows very faint microscopic spiral lineation on dorsal and ventral surfaces. The umbilical wall is inaccessible.

This species was labeled and listed by Dall as "*Solarium*" *alveatum* Conrad. *Architectonica alveata* occurs in the middle Eocene (Palmer, 1937, p. 173, pl. 19, figs. 8–18) and upper Eocene (Harris and Palmer, 1946–47, p. 276, pl. 32, figs. 9–11, 1947) of the Gulf coast of the United States. Early unworn whorls have weak retractive axial wrinkles, strongest at periphery and suture. The dorsal cord of the Canal Zone form is somewhat stronger than that of *A. alveata*, but the features of the Canal Zone form are too inadequately known for satisfactory evaluation. Nevertheless Dall's identification clearly indicates the affinities of this *Architectonica* and no species similar to *A. alveata*

has been found in the Oligocene of southeastern United States.

A poorly preserved specimen from the upper Eocene deposits of Columbia was identified as *A. alveata* (Clark, in Clark and Durham, 1946, p. 23, pl. 17, fig. 13). Another specimen from the same deposits, probably the same species, was described as *A. gabrielensis* (Idem, p. 23, pl. 17, figs. 11, 12).

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

Subgenus?

Architectonica species

A small, presumably immature, poorly preserved *Architectonica* (height 2.7 mm, diameter 7.7 mm), also collected by Hill at Vamos Vamos, shows few characters. It has a blunt rounded periphery. Though the sculpture of the dorsal surface is obscure, a suggestion of retractive axial wrinkles can be made out. The ventral surface bears five shallow spiral grooves. The umbilical border is corrugated and the corrugations extend outward beyond the border with rapidly diminishing strength. The affinities of this species are undetermined. The specimen may be badly worn.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 40a.

Subgenus?

Architectonica cf. A. fungina (Conrad)

Three specimens of *Architectonica* collected by Hill at Vamos Vamos are assigned to three species. The third species is represented by a small specimen (height about 3.5 mm, diameter 7.5 mm). Much of the dorsal surface is exfoliated and the ventral surface is not exposed. The dorsal surface shows retractive axial wrinkles adjoining the suture. The periphery has a narrow slightly serrate cord. So far as it goes, this specimen is an *Architectonica* suggesting *A. fungina* (Conrad), a species found in the middle Eocene of southeastern United States (Palmer, 1937, p. 162, pl. 17, figs. 17, 21, 24). Similar species are unknown in the upper Eocene or Oligocene of that region.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 40a.

Subgenus Pseudotorinia Sacco?

Sacco, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 12, p. 66, 1892.

Type (orthotype): *Solarium obtusum* Bronn, Miocene and Pliocene, Italy.

Architectonica (Pseudotorinia?) species

An incomplete and partly corroded *Architectonica* (height about 2.2 mm, diameter about 8 mm) from the Culebra formation is sculptured on both dorsal and ventral surfaces with narrow spiral cords overridden and noded by very narrow retractive axial threads. The sutural and peripheral cords are slightly wider than the others, not including the noded cord at the umbilical border, which is still wider. The reticulate sculpture suggests the subgenus *Pseudotorinia*.

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

Subgenus Architectonica s. s.

Architectonica (Architectonica) rhicna Woodring, n. sp.

Plate 26, figures 4, 5, 10

Of medium size, umbilicus wide, peripheral cord overhanging base. Dorsal surface sculptured with four weakly noded spiral cords, not including peripheral cord. Peripheral cord weakly noded. On body whorl cords separated by intervals almost as wide as cords. Ventral surface sculptured with a narrow weakly noded spiral cord near periphery, separated by a smooth space from three more strongly noded cords of about same width as those on dorsal surface. Umbilicus bordered by very coarse corrugations seated on a low cord.

Height 9.5 mm, diameter 17.7 mm (type).

Type: USNM 562569.

Type locality: 56 (USGS 6025, about 200 yards (200 meters) south of southern end of switch at Bohio Ridge station, relocated Panama Railroad, Canal Zone), middle member of Caimito formation.

The type and two other specimens, one of which is a fragment, were collected from the Caimito formation at locality 56, on the Panama Railroad immediately southeast of Bohio Peninsula. Locality 56 is the type locality of *Operculinoides panamensis*, *Lepidocyclina pancanalis*, now considered a synonym of *L. canellei* (Cole, 1952 (1953), p. 18), and *Miogypsina panamensis*. The fragment represents a shell considerably larger than the type.

Architectonica rhicna is remotely allied to the Recent *A. nobilis* (Röding). The less elongate nodes on the more widely spaced spiral cords, the wide umbilicus, the very coarse corrugations bordering the umbilicus, and the smooth space on the ventral surface near the periphery show that it is not in the direct lineage of *A. nobilis*. The short nodes are like those of the early Miocene Brazilian *A. eudaidela* (Maury) (Maury, 1925a, p. 391, pl. 2, fig. 2), the ventral surface of which is unknown.

Occurrence: Middle member of Caimito formation (late Oligocene), locality 56.

Architectonica (Architectonica) cf. A. nobilis (Röding)

Fragmentary remains from the Culebra formation indicate the presence of an *Architectonica* (estimated height 10 mm, diameter about 23 mm) allied to *A. nobilis*, evidently more closely allied than *A. rhicna*. The dorsal surface is sculptured with closely spaced spiral cords bearing elongate nodes. Noded spiral cords also are visible on the ventral surface. Though the material is inadequate for identification, this species may be *A. nobilis*.

The middle member of the Caimito formation on Barro Colorado Island at localities 54h and 54k yielded incomplete specimens that have less elongate dorsal nodes. The relations of this form, listed as *Architectonica* sp., to that of the Culebra formation are undetermined.

Occurrence: Culebra formation (early Miocene), localities 99b, 99c, 100, 116.

Architectonica (Architectonica) nobilis nobilis Röding

Plate 19, figures 1–6, 10–12, 14–16

Architectonica nobilis Röding, Museum Boltenianum, p. 78, 1798 (Recent, locality unknown). Rutsch, Schweizer. Palaeont. Gesell Abh., Band 54, no. 3, p. 42, pl. 1, figs. 5–7, 1934 (Miocene, Venezuela). Gardner, U. S. Geol. Survey Prof. Paper 199, p. 199, pl. 24, figs. 9, 13, 1948 (Miocene, North and South Carolina; figured specimen Recent, off Cape Hatteras). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 91, 1951 (Miocene, Ecuador). Hertlein and Strong, Am. Mus. Nat. History Bull., v. 107, art. 2, p. 275, 1955 (Recent, Panamá to Ecuador; additional citations).

Solarium granulatum Lamarck, Histoire naturelle des animaux sans vertèbres, v. 7, p. 3, 1822 (Recent, locality unknown). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 329, 1892 (Miocene to Pleistocene, southeastern United States). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 131, pl. 23, fig. 13, 1917 (Miocene, Dominican Republic). Maury, Brazil Serv. Geol. Mineral. Mon. 4, p. 61, pl. 2, figs. 6, 12, 1925 (Miocene, Brazil).

Solarium quadriseriatum Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 51, pl. 10, figs. 8*a–e*, 1850 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 131, pl. 23, figs. 1, 2, 1917 (Miocene, Dominican Republic).

Solarium sexlineare Nelson, Connecticut Acad. Arts Sci. Trans., v. 2, p. 11, pl. 6, fig. 11, 1870 (Miocene, Perú).

Architectonica granulata (Lamarck), Gabb, Acad. Nat. Sci. Phila. Jour., n. ser., v. 8, p. 359, 1881 (Pliocene, Costa Rica). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 154, pl. 13, figs. 10–12, 1917 (Miocene, Costa Rica, Panamá). Maury, idem, v. 10, no. 42, p. 236, pl. 40, fig. 1, 1925 (Miocene, Trinidad). Hodson, Hodson, and Harris, idem, v. 13, no. 49, p. 66, pl. 36, fig. 7, 1927 (Miocene, Venezuela). Anderson, Calif. Acad. Sci. Proc. 4th ser., v. 18, no. 4, p. 122, 1929 (Miocene, Colombia). Mansfield, Florida Geol. Survey Bull. 3, p. 110, pl. 18, figs. 1, 2, 1930 (Miocene, Florida). Oinomikado, Geol. Soc. Japan, Jour., v. 46, p. 620, pl. 29, fig. 11, 1939 (Miocene, Colombia).

Solarium intraornatum White, Mus. Nac. Rio de Janeiro Arch., v. 7, p. 191, pl. 10, figs. 21, 22, 1887 (Miocene, Brazil). Maury, Brazil Serv. Geol. Mineral. Mon. 4, p. 59, pl. 2, fig. 1, 1925 (Miocene, Brazil).

Solarium villarelloi Böse, Inst. Geol. México Bol. 22, p. 30, pl. 3, figs. 4–11, 1906 (Miocene, México).

Solarium gatunense Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 692, pl. 25, fig. 3, 1909 (Miocene, Canal Zone). Li. Geol. Soc. China Bull., v. 9, p. 265, pl. 6, fig. 42, 1930 (Miocene, Canal Zone). Trechmann, Geol. Mag., v. 72, p. 549, pl. 21, figs. 21, 22, 1935 (Miocene, Carriacou).

Solarium granulatum gatunensis Toula, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 360, 1911 (Miocene, Canal Zone).

Architectonica (*Architectonica*) *nobilis quadriseriata* (Sowerby), Woodring, Carnegie Inst. Washington Pub. 385, p. 354, pl. 27, figs. 5–7, 1928 (Miocene, Jamaica; additional citations).

Architectonica quadriseriata (Sowerby), Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 123, 1929 (Miocene, Colombia).

Architectonica (*Architectonica*) *sexlinearis* (Nelson), Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 213, pl. 21, figs. 7, 10, 1932 (Miocene, Perú; additional citations). Pilsbry and Olsson, Acad. Nat. Sci. Phila. Proc., v. 93, p. 43, 1941 (Pliocene, Ecuador).

Architectonica sexlinearis corusca Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 214, pl. 21, figs. 5, 8, 9, 1932 (Miocene, Costa Rica, Perú). Marks, idem, v. 33, no. 139, p. 93, 1951 (Miocene, Ecuador).

Architectonica quadriseriata (Sowerby), subsp., Gardner, U. S. Geol. Survey Prof. Paper 142, p. 587, 1947 (Miocene, Florida).

Architectonica quadriseriata waltonensis Gardner, idem, p. 588, pl. 58, figs. 8, 10, 1947 (Miocene, Florida).

Moderately large, ratio of height to diameter variable, umbilicus narrow to moderately wide. Protoconch 2½-whorled, the first 1½ whorls submerged and hyperstrophic, only the last whorl visible on dorsal surface. End of protoconch marked by very thin varix and abrupt beginning of sculpture. Sculpture consisting basically of a peripheral cord, four closely spaced dorsal cords and six closely spaced ventral cords, all cut into flat closely spaced nodes by narrow retractive axial grooves, except umbilical cord which is coarsely corrugated. At first sutural cord and outermost cord (not including peripheral cord, which also is strongly noded) stronger and more strongly noded than other two dorsal cords; and the two cords next to umbilical cord and outermost cord, which is narrow, more strongly set off and more strongly noded than other two ventral cords. With further growth dorsal cords more uniform. With still further growth nodes of dorsal and peripheral cords gradually suppressed, those on sutural cord generally suppressed last. On large shells outermost of four dorsal cords generally flanked by wider grooves than others and sutural cord tends to be slightly wider than others. At intermediate growth stages noding and strength of second, third and fourth cords from umbilical cord variable, but noding generally decreasing outward and groove between third and fourth generally shallow; outermost

ventral cord strong and strongly noded. During late growth stages nodes gradually suppressed on second, third, fourth, and outermost cords beyond umbilical cord, those in second and outermost generally suppressed last; groove between third and fourth gradually suppressed. At all growth stages umbilical cord relatively wide and coarsely corrugated, and next cord more or less strongly noded and set off by deep relatively wide grooves. Secondary spiral thread in first dorsal and ventral grooves from periphery absent or present. Secondary spiral thread in second dorsal and ventral grooves from periphery generally absent. In absence of secondary thread adjoining peripheral cord, outermost ventral cord well separated from peripheral cord or crowded against it. Microscopic spiral lineation visible on late whorls. Umbilical wall sculptured with arcuate growth threads and weak spiral threads.

Height 19.5 mm, diameter 41.2 mm (largest specimen). Height 16.5 mm, diameter 36.5 mm (largest figured specimen).

A widespread *Architectonica* in the Gatun formation is identified as the Recent Caribbean and Panamic *A. nobilis* proper. It is one of the relatively few species widely recognized as surviving on both Caribbean and Pacific coasts of Central America and ranges back to the early Miocene. A total of 181 specimens are available: 38 from the lower part of the Gatun, 106 from the middle part in the eastern area and one in the western area, 30 from the upper part in the eastern area and six in the western area. Numerous minute shells from locality 147b and a few from other localities show the partly hyperstrophic (partly inverted and pseudosinistral), typically architectonicid protoconch.

Though details of the sculpture are variable, the basic plan is uniform and closely matches that of Recent shells. The principal variable details also can be matched, but the frequencies are different. A secondary dorsal spiral thread in the groove between the peripheral cord and the next cord and a similarly located ventral secondary are less frequent on the fossils than on Recent shells, as shown by the following table.

Frequency of secondary spiral threads in Architectonica nobilis

Age	Number of specimens	Dorsal secondary spiral (percent)	Ventral secondary spiral (percent)
Recent, Panamic region	85	93	96
Recent, Caribbean-western Atlantic region	54	96	98
Miocene, Gatun formation	104	48	
	96		40

Three of the fossils have a secondary dorsal spiral thread in the second groove from the periphery and six have a secondary ventral spiral in the same position. None of the Recent shells examined has more than one dorsal or ventral secondary.

Thirty-six percent of the fossils that lack a secondary spiral in the outermost ventral groove have the outermost ventral cord crowded against the peripheral cord (pl. 29, fig. 2), whereas only one of the Recent shells (collected at Mazatlan, México, USNM 359846) is similarly sculptured. The crowding is due to widening of the peripheral or the outermost cord, or both. Two of the fossils show an extra ventral cord resulting from splitting of the fourth from the umbilical cord.

The stage at which nodes are suppressed is variable, particularly for ventral nodes, as shown by the illustrations. Comparable variation is shown by Recent shells. The suppression of ventral nodes follows an almost invariable pattern: first those of the fourth and third cords from the umbilical cord, then those of the fifth (outermost) and second. Those of the first cord are not suppressed and the cord itself is set off by deep relatively wide grooves. Recent shells show the same pattern, one of the striking similarities of fossil and living specimens. Suppression of ventral nodes is accompanied on fossil and Recent shells by suppression of the groove between the third and fourth cords from the umbilical cord.

On an aberrant fossil (locality 155c) the third, fourth, and fifth ventral cords and also the first and second dorsal are disintegrated into faint minor threads. The change in dorsal sculpture abruptly follows a break in the shell near the end of the penult whorl—a break concealed on the ventral surface by overlap of the body whorl—and therefore evidently is a deformity.

It is concluded that the paleontologists (Maury, Olsson, Hodson, Hodson and Harris, Anderson, Rutsch, and Oinomikado) who considered *Solarium gatunense*, based on three specimens from the middle part of the Gatun formation in the eastern area, to be *Architectonica nobilis* were justified in adopting that view. Inasmuch as a named subspecies is recognized in the Chagres sandstone, the Gatun fossils are given the cumbersome designation *A. nobilis nobilis*.

Toula illustrated, under the same figure designation, two of three specimens of his *Solarium gatunense*. The larger illustrated specimen (height 17 mm, diameter 32.7 mm) is herewith designated the lectotype. It represents the prevailing form of *Architectonica nobilis* in the Gatun formation.

With two exceptions the fossils from the Gatun formation show no discernible correlation between sculptural details and stratigraphic or geographic occurrence. The first exception is shown by specimens from the lower part of the formation that lack a sec-

ondary ventral thread (11 specimens). All have the outermost ventral cord crowded against the peripheral cord and have relatively strong ventral nodes. Moreover most of them have a relatively low height to diameter ratio. Similar specimens occur in the middle and upper Gatun of the eastern area (pl. 29, figs. 1–3), but the frequency is much lower: 16 and 29 percent, respectively. The same sculptural features are shown by the middle Miocene Costa Rican form described as *A. sexlinearis corusca*, which has also been recognized in the lower Miocene of Perú and the lower and middle Miocene of Ecuador. In the Gatun formation as well as in the type region in Costa Rica, such specimens—at least in collections that consist of more than one or two specimens—are associated with others that lack the crowded ventral cord and have either strong or suppressed ventral nodes. Association, of course, does not demonstrate a single breeding population. In view, however, of the demonstrable variation shown by the fossils, recognition of two named subpieces or varieties is rejected, at least for the Gatun formation. "*Solarium*" *sexlineare* itself is considered a synonym of *A. nobilis*. The type lot of three worn specimens is available through the kindness of Dr. C. O. Dunbar. On the type, the small specimen (diameter about 25 mm) illustrated by Nelson and Olsson, and on a larger paratype the outermost ventral cord is crowded against the peripheral cord. The other paratype, which is still larger (diameter about 35 mm), has a secondary ventral and dorsal cord.

The second exception is shown by the six specimens from the upper part of the Gatun in the western area, assigned to the upper Miocene. Though six specimens are not an adequate sample, their ventral nodes are strongly suppressed, even at a diameter of 20 mm, and they have a narrow umbilical cord (pl. 29, fig. 15). A Recent shell from St. Thomas, West Indies (USNM 530227) and another from the Gulf of California (USNM 46297) show the same features.

"*Solarium*" *quadriseriatum* is the earliest name proposed for Miocene Caribbean fossils that have the basic plan of *Architectonica nobilis*. It has been treated as a distinct species, a subspecies of *A. nobilis*, or suppressed in favor of *A. nobilis*. Treatment as a subspecies was based on grounds that fossils from the Dominican Republic (the type region) and Jamaica generally have a narrower umbilical cord than Recent shells and dorsal nodes that generally last until a later stage. That view was adopted without adequate consideration of the range of variation of fossil and Recent shells.

Fossils from formations of middle and late Miocene age in Florida and late Miocene in the Carolinas also are referred to *A. nobilis*. A small race from the Chipola formation of Florida, of early Miocene age, was named "*Solarium granulatum*" *chipolanum* by Dall (Gardner, 1926–47, p. 587, pl. 58, figs. 1, 2, 1947). The type (diameter 15 mm) and six other specimens of comparable size have an extra ventral cord, either single or doubled by splitting.

Whether *A. nobilis* arose in Caribbean or eastern Pacific waters is unknown. It is recognized in the lower Miocene of Haiti, Carriacou (the largest of the Grenadines, West Indies), Brazil, Ecuador, and Perú, and is represented by a small race in the lower Miocene of Venezuela and Florida. During middle Miocene time and thereafter it was widely distributed.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136a, 137, 137a, 138, 138a, 138b, 139 (mold, *Architectonica* sp.). Middle part, eastern area, localities 142, 146, 147b, 147f (immature, identification doubtful), 147g, 147h, 147i (immature, identification doubtful), 150a, 151, 153 (mold, identification doubtful), 153a, 155, 155a, 155b, 155c, 157, 159; western area, locality 161c. Upper part, eastern area, localities 172, 173, 175, 176, 176a, 177b, 177c, 178; western area, localities 182, 182a, 183. Lower Miocene, Venezuela (small race), Brazil, Carriacou, Haiti, Florida (small race, *A. nobilis chipolana*), Ecuador, Perú. Middle Miocene, Trinidad, Venezuela, northeastern and southwestern Colombia, Dominican Republic, Jamaica, southeastern Costa Rica, southeastern México, Florida, Ecuador, Perú. Upper Miocene, Trinidad, Venezuela, northwestern Panamá, Florida, North and South Carolina, Perú. Pliocene, Trinidad, Venezuela, southeastern Costa Rica, South Carolina, southwestern Panamá, Ecuador. Pleistocene, South Carolina, southwestern Panamá, Galapagos, Baja California. Recent, Cape Hatteras to Colombia; Magdalena Bay, Baja California, and Gulf of California to Negritos, Perú.

Architectonica (Architectonica) nobilis karsteni Rutsch

Plate 30, figures 1–3

Architectonica nobilis karsteni Rutsch, Schweizer. Palaeont. Gesell. Abh., Band 54, no. 3, p. 44, pl. 1, figs. 8–10, 1934 (Miocene, Venezuela).

Architectonica sexlinearis haughti Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 93, pl. 2, figs. 2, 6, 1951 (Miocene, Ecuador).

Dorsal nodes and groove between second and third dorsal cords from peripheral cord suppressed at an early stage. At intermediate and late growth stages ventral surface sculptured with a relatively wide, coarsely corrugated umbilical cord and an outer nonnoded cord, crowded against peripheral cord. Coarse

tioned, both from the Cercado formation, are the only ones known from the Dominican Republic.

Heliacus stonemanae is closely related to *H. planispira* (Pilsbry and Lowe, 1932, p. 83, pl. 8, figs. 9–11), but is not flat-topped, and has a less distinct sutural cord, narrower umbilicus, and a wide ventral cord adjoining the umbilical cord. Though *H. lowei* Durham is not flat-topped, in other features it is similar to *H. planispira*. No species of *Astronacus* is known to have survived in the Caribbean region.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 137a, 138, 138a. Cercado formation (middle Miocene), Dominican Republic.

Heliacus (Astronacus) anaglyptus Woodring, n. sp.

Plate 30, figures 9–11

Of medium size, moderately low-spired, umbilicus moderately wide. Upper peripheral cord slightly wider than lower, except near outer lip. Last 1¼ whorls of protoconch visible on dorsal surface. About one-eight of first sculptured whorl inflated and crudely sculptured. Later dorsal sculpture consisting of very narrow and very closely spaced retractive axial threads, swollen on well defined peripheral cord (upper peripheral cord of body whorl) to form fine nodes and less swollen at narrow groove adjoining suture. About half of axial threads reach sutural groove, the others falling short or joining a thread that reaches sutural groove. Axial threads and sutural groove gradually suppressed near outer lip, the axial threads being replaced by growth threads. Lower peripheral cord finely noded like upper peripheral cord; the two sets of nodes joined by axial threads. Ventral surface sculptured with a narrow corrugated umbilical cord, set off by a deep groove and followed outward by a wide nongrooved area, a narrow spiral cord and a very narrow spiral thread. Inner part of wide nongrooved area bearing corrugations. Outward from these corrugations ventral surface bearing axial threads like those on periphery and dorsal surface.

Height 5.3 mm, diameter 9.5 mm (type).

Type: USNM 562621.

Type locality: 173 (Stanford University 2654, Panama Railroad realignment cut about three-fourths of a mile (1 kilometer) north of north end of Gatun Third Locks excavation, Canal Zone. Lat 9°18′ N., long 79°55′ W., plus 200 feet [60 meters], upper part of Gatun formation.

The type and only specimen of this handsomely sculptured species was found by T. F. Thompson in the upper part of the Gatun formation at locality 173, between Gatun and Mount Hope. Though it is similar to *Heliacus stonemanae* and *H. planispira* in general features, it is more finely sculptured and the ventral surface is more weekly sculptured. *H. stonemanae* and *H. planispira* may represent a single lineage, but it is unlikely that *H. anaglyptus* represents a direct offshoot from that lineage.

Occurence: Upper part of Gatun formation (middle Miocene), eastern area, locality 173.

Family CERITHIIDAE

Subfamily CERITHIINAE

Unidentified cerithids are in the collections from the Gatuncillo formation, the marine member of the Bohio(?) formation, and the Culebra formation. The Gatuncillo fossils include molds of a few whorls of a large species. Though it is listed as "large cerithid, possibly *Campanile*," it is unidentifiable. The Gatuncillo also yielded two species of *Cerithium* in the unrestricted sense, both represented by fragments of a few whorls. The species listed as "*Cerithium* sp. a" has strong spiral sculpture, but no axial sculpture, at least not on late whorls; "*Cerithium* sp. b" is sculptured with moderately strong narrow axials and weak narrow spirals. The Bohio(?) specimens, which may represent two species, are small and slender. The Culebra formation yielded a large cerithid (height, 4 whorls, 56 mm). It is so firmly encased in tough tuffaceous sandstone that only traces of the sculpture can be made out. Large cerithids are found in the upper Oligocene of southeastern United States and Puerto Rico and in the lower Miocene of the island of Anguilla. Their generic affinities are still undetermined. The sculpture and whorl profile of the Anguillan species, *Cerithium herculeanum* C. W. Cooke (1919, p. 116, pl. 1, fig. 7), suggests *Campanile*.

Genus Cerithium Bruguière

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

Type (virtual tautotype): *Cerithium adansonii* Bruguière (idem, p. 479, 1792; Adanson's Le Cerite, which Adanson arranged under the genus *Cerithium*, cited in synonymy), Recent, Red Sea.

If the interpretation of virtual tautonymy, involving use of a pre-Linnean vernacular name, is too strained, action by the International Commission on Zoological Nomenclature validating *Cerithium adansonii* as the type of *Cerithium* is desirable.

The former uncertainty concerning identification of *Cerithium adansonii* has been resolved by Fischer-Piette (1942, p. 250–253, pl. 8, figs. 16a, b), who found that Adanson's specimen of his Le Cerite is the Red Sea species named *Cerithium erythraeonense* by Lamarck in 1822. Adanson's Le Cerite is considered

at sutural edge of sutural band. Varix appearing on last few adult whorls. Penultimate varix very heavy, located on apertural face of body whorl, about 110° from outer lip. Outer lip varicose, ascending almost to suture of preceding whorl. Median columellar fold strong within aperture; fold bordering siphonal canal not as strong.

Height (incomplete) 35.5 mm, diameter 11.5 mm (type).

Type: USNM 562599.

Type locality: 155*b* (USGS 16949, spoil dump of Gatun Third Locks excavation, units 11 and 12 of section (chapter A, p. 44), Canal Zone), middle part of Gatun formation.

Rhinoclavis costaricana canabina is a slender subspecies of *R. costaricana* proper, which was described by Olsson (1922, p. 144, pl. 10, figs. 3, 4) and occurs in middle Miocene deposits in southeastern Costa Rica. It also is more slender than the Miocene Jamaican *R. costaricana stena* (Woodring) (1928, p. 335, pl. 25, figs. 7, 8), and has wider and stronger axial ribs than that subspecies. *R. venada* (Maury) (1925, p. 222, pl. 41, fig. 10), a middle Miocene species from Trinidad, has more subdued axial ribs and a narrower sutural spiral.

This is the largest cerithid so far found in the Gatun formation. Three specimens, all incomplete, are in the collections: two from the type locality and an immature specimen was locality 162. Neither of the fossils from the type locality was buried soon after death. Both have a worn broken apex and both served as the attachment area for several *Septastrea*-like coral calices. An immature *Echinochama* shell also was attached to the type.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area locality 155b; western area, locality 162.

Genus Dirocerithium Woodring and Stenzel, n. gen.

Type: *Dirocerithium wechesense* Stenzel, n. sp., middle Eocene, Texas.

Though the new name *Dirocerithium* appears in a publication by Woodring, the description of the new genus and the discussion were prepared jointly by Woodring and Stenzel, and the new name is to be attributed to them. The description of *D. wechesense* is by Stenzel, that of *D. ame* is by Woodring.

Dr. L. R. Cox, of the British Museum (Natural History), kindly loaned two topotypes of *Bellatara palaeochroma* and three of *B. gomphoceras*. We also are indebted to Mr. Herman Gunter, Director of the Florida Geological Survey, for the loan of the type of *B. citrana* and paratypes of *B. americana* and *B. floridana*.

Cerithids of medium size to moderately large (50 to 90 mm). Later half of body whorl generally more loosely coiled than spire whorls. Shell profile generally straight, or slightly concave. Spire whorls divided by a groove, or ledgelike groove, into a posterior band (sutural collar) and a generally wider anterior band. Early whorls sculptured with vertical or slightly protractive axial ribs and spiral grooves. Axial ribs disappearing at different growth stages in different species, those on sutural collar disappearing last. Spiral grooves also disappearing at different growth stages, the groove setting off sutural collar most persistent and generally extending to outer lip, or gradually disappearing on late spire whorls. Early sculptured whorls bearing narrow varices. Varices present or absent on early intermediate whorls. Mature shells generally bearing a low wide varix near end of penult whorl and a stronger varix on body whorl almost opposite outer lip. Aperture of varying width depending on presence or absence of slight varix-like swelling near outer lip. Outer lip moderately thick or thin, flaring, slightly indented, apex of indentation below sutural collar; anterior part scoop-shaped. Siphonal canal narrow, of moderate length, strongly bent backward. Parietal callus spreading over inner lip. Posterior canal short and narrow.

The sutural collar, terebrid-like early sculpture, and scoop-shaped outer lip are characteristic features of *Dirocerithium*. Were it not for the varices, early whorls deprived of the aperture might be mistaken for those of *Strioterebrum*.

Dirocerithium apears to be an endemic American genus embraciug species that have been referred to various genera. Their affinities were not understood until Palmer (Richards and Palmer, 1953, p. 17–21) assigned some of them to *Bellatara*, when it became evident that they have Tethyan affinities.

Dirocerithium appears to be an endemic American Texas as an invader during the middle part of middle Eocene time and eventually spread eastward to Florida, where the youngest species in southeastern United States (*D. americanum*) has recently been found. As the genus is known to occur in the early middle Eocene of the Caribbean region, it evidently invaded southeastern United States from the Caribbean region. Its roots are surmised to lie in the lower Eocene of the Caribbean or Mediterranean regions, but the lower Eocene molluscan fauna of the Mediterranean region is poorly known and that of the Caribbean region is practically unknown. *Dirocerithium* and *Bellatara* presumably had a common Tethyan ancestry, for they have the same apertural features and both lose early axial and spiral sculpture covering en-

tire spire whorls. *Bellatara*, however, lacks a sutural collar and late, or even intermediate, whorls bear spines which are very heavy on the penult whorl of the type species. Instead of a sutural collar, *Bellatara* has a low spiral thread at, or near, the anterior edge of spire whorls.

Bellatara (Strand, 1928, p. 39) was proposed as a substitute name for *Bellardia* Mayer (1870, p. 329), which is a homonym of *Bellardia* Robineau-Desvoidy, 1863. The type species, *Cerithium* (*Bellardia*) *janus* Mayer (the monotype of Mayer's *Bellardia*), occurs in middle Eocene strata at Monte Postale, Verona, Italy. According to European authors (de Gregorio, 1894 (1895), p. 3, 16; Oppenheim, 1896, p. 182; Cossmann, 1906, p. 69, footnote), "*Cerithium*" *palaeochroma* Bayan (1870, p. 478; 1870a, p. 35, pl. 1, figs. 1, 1a, 3), described in the same year and from the same locality, has precedence as the name for the type species. Bayan's illustrations of the type species are entirely satisfactory, but the publication in which they appeared (a lithographic reproduction of very neat script) is very rare. A copy is in Stenzel's personal library. Cossmann's illustrations (1906, pl. 2, figs. 6–8) are the best of those that are readily accesible (except for the early sculpture) and Malaroda's (1954, p. 47, pl. 2, fig. 12, pl. 3, figs. 1–4b, pl. 11, fig. 21) are the most recent.

"*Cerithium*" *vellicatum* Bellardi, from the upper Eocene of the French Riviera and the upper(?) Eocene of Yugoslavia (Oppenheim, 1901, p. 261, pl. 19, figs. 10, 11; Boussac, 1911, p. 288, pl. 18, figs. 1–11) is closely related to *Bellatara palaeochroma*. Boussac's series of illustrations show that the early whorls are sculptured with axial ribs and spiral threads, and intermediate and late whorls with blunt spines, but the spines on the penult whorl are not as heavy as those of *B. palaeochroma*.

At first glance "*Cerithium*" *gomphoceras* Bayan (1870, p. 478; 1870a, p. 29, pl. 1, fig. 2, pl. 2, figs. 3, 4; Malaroda, 1954, p. 47, pl. 2, figs. 14–18, pl. 6, figs. 1, 2, pl. 11, figs. 19, 27), a large species (height 100 mm, diameter 35 mm) associated with *Bellatara palaeochroma* at Monte Postale, appears to be a species of *Dirocerithium* that has the slightly concave outline and entirely smooth late whorls of *D. whitfieldi*. Bayan's plate 2, figure 3—the only illustration of a well preserved outer lip—and the growth lines on topotypes show a scoop-shaped outer lip like that of *Bellatara* and *Dirocerithium*, and his plate 2, figure 4 and a topotype show an axially sculptured sutural band on early whorls. What appears to be a sutural band on the late smooth whorls, however, is an entire whorl. Although the adult body whorl has a height of almost 40 mm, the height of the exposed part of spire whorls is only 5 to 7 mm; that is, the whorls are very tightly coiled. The tight coiling and high flat body whorl result in a long very narrow aperture. Unless a great deal of latitude is given to *Bellatara* and *Dirocerithium*, it does not seem to be proper to refer "*Cerithium*" *gomphoceras* to either, at least not in the restricted sense, although it is related to both.

d'Archiac and Haime's (1853–54) illustrations of the species they described as "*Cerithium*" *subnudum* (p. 301, pl. 28, fig. 17), "*C.*" *nudum?* (p. 304, pl. 29, fig. 4), "*Rostellaria*" *angistoma* (p. 314, pl. 30, figs. 14, 15), "*Terebra*" *contorta* (p. 321, pl. 31, fig. 18, pl. 33, fig. 10), and "*T.*" *flemingi* (p. 322, pl. 31, fig. 17) suggest that earlier remote allies of *Bellatara* and *Dirocerithium* are found in West Pakistan. These cerithids, which were overnamed by d'Archiac and Haime, have been discussed by Cossmann and Pissarro (1909, p. 54–56), Vredenburg (1928, p. 51–56), and Cox (1930, p. 146; 1931, p. 43). They occur in the Ranikot and Laki series, both of which appear to be of early Eocene age, although the Ranikot has been assigned to the Paleocene. "*Bellardia*" *indica* Douvillé (1929, p. 53, pl. 9, fig. 6) and "*B.*" *vicina* Douvillé (idem, p. 53, pl. 9, fig. 7), from the early Paleocene of Sind, are melanopsine thiarids, now referred to *Pseudobellardia* (Cox, 1931, p. 46), described as a subgenus of *Pirena*.

The species of *Dirocerithium* now recognized, ranging in age from early middle Eocene to late Eocene, are listed in the table on page 174.

Dirocerithium vinctum, *D. wechesense*, and *D.* aff. *D. wechesense* are progressively younger and form a graded series in progressively earlier loss of axial and spiral sculpture; that is, they meet the requirements of a lineage. *D. americanum*, the youngest species in southeastern United States, however, does not fit into this lineage. In relative width of sutural collar and anterior band it resembles *D. wechesense*, but the axial sculpture, in the form of narrow wrinkles, seems to disappear at a later stage than that of *D. wechesense*. The slightly concave outline of *D. whitfieldi* indicates that it is not closely related to the other species in southeastern United States. It loses its sculpture at a very early stage and, unlike any other species of the genus, even loses its sutural collar.

D. ame is the only Caribbean species for which adequate material is available. It may possibly be a predecessor of *D. whitfieldi*. *D. mariense*, the oldest species of the genus, is characterized by a deep groove setting off the sutural collar. The early whorls are not preserved on the type, but a few additional whorls are preserved on a topotype collected by H. G. Kugler.

Species of the genus Dirocerithium

Age		Southeastern United States				Caribbean region
		Texas	Mississippi	Alabama	Florida	
Early late Eocene.						*D.* cf. *D. mariense* (Trechmann),[1] Carmen formation, Colombia.
Middle Eocene	Late	*D.* aff. *D. wechesense* Stenzel, n. sp., Stenzel's Hurricane marine lentil of Landrum member and Stenzel's Wheelock marl member, Cook Mountain formation.		*D. whitfieldi* (Heilprin),[2] Gosport sand.	*D. americanum* (Palmer),[3] Vernon's Inglis formation and Avon Park limestone.	
	Middle	*D. wechesense* Stenzel, n. sp., Weches greensand member of Mount Selman formation.	*D. vinctum* (Whitfield)[4], Winona sand member of Lisbon formation.	*D. vinctum* (Whitfield), Lisbon formation.		*D. ame* Woodring, n. sp., Gatuncillo formation, Canal Zone. *D.* sp.[5], Charco Redondo limestone member of Cobre formation, Cuba.
	Early					*D. mariense* (*Trechmann*)[6], Carbonaceous Shale, Jamaica.

[1] *Clava* (*Ochetoclava*) aff. *vincta* (Whitfield), Clark (Clark and Durham, 1946, p. 29, pl. 24, fig. 1, deposits of late Eocene age, Colombia).

[2] *Rostellaria whitfieldi* Heilprin (1879, p. 216, pl. 13, fig. 14, [Gosport sand], Claiborne, Alabama). *Cerithium whitfieldi* (Heilprin), Palmer (1937, p. 215, pl. 28, fig. 8, Gosport sand, Claiborne, Alabama).

[3] *Bellatara americana* Palmer (Richards and Palmer, 1953, p. 18, pl. 2, figs. 3, 9, 12, Avon Park limestone and Vernon's Inglis formation, Florida).

[4] *Cerithium vinctum* Whitfield (1865, p. 265, pl. 27, 8, erroneously reported from Vicksburg, Mississippi, actually from Lisbon, Alabama; Gardner (1945, p. 158, pl. 14, figs. 3, 7, syntype). *Clava* (*"Ochetoclava"*) *vincta* (Whitfield), Palmer (1937, p. 217 (part), pl. 29, figs. 7, 10, 11 (type), 18, not figs. 15, 16, 17, 19, Lisbon formation, Lisbon Alabama).

[5] *Terebratia?* sp., Woodring (Woodring and Daviess, 1944, p. 373 (list), Charco Redondo limestone [member of Cobre formation], Cuba). *"Cerithium"* aff. *"C." vinctum* Whitfield, Woodring (1952, p. 61 (mentioned), Charco Redondo limestone [member of Cobre formation], Cuba). Though the Charco Redondo limestone was given formation rank when the name was proposed and was considered of late Eocene age, it is now classified as a member of the Cobre formation and is assigned to the middle Eocene (Lewis and Straczek, 1955 (1956), pp. 230-232, table 1; Bermúdez, 1950, p. 246).

[6] *Morgania mariensis* Trechmann (1924, p. 13, pl. 2, fig. 3, Carbonaceous Shale, Jamaica). Trechmann thought that the fossils of the Carbonaceous Shale "appear to have affinity with forms in the Cuisian, Sparnacian, or Thanetian, or with the Ranikot beds", but its meager fauna indicates an age not older than early middle Eocene.

Although the axially sculptured whorls are missing, the axial sculpture disappears at an early stage. The deep groove setting off the sutural collar of the Colombian species indicates it may be allied to *D. mariense*. A large specimen in the collection of the Museum of Paleontology of the University of California (locality 19162), which is in better condition than Clark's, shows that the apical angle of the Columbian species is larger than that of *D. mariense*, and that the sutural band is wider and the groove setting it off is deeper. On the one specimen from Cuba the last two axially sculptured whorls, bearing relatively wide axial ribs and varices, are present. The axial sculpture disappears at a relatively late stage. The anterior band is only a little wider than the sutural collar, which is set off by a ledgelike groove.

Two cerithids associated with *D. americanum* in Florida have been described as *Bellatara citrana* Palmer (Richards and Palmer, 1953, p. 18, pl. 2, fig. 8) and *Bellatara floridana* Palmer (idem, p. 19, pl. 2, figs. 10, 11, 13). *B. citrana* has relatively strong spiral sculpture, but no axial sculpture, on intermediate whorls. The irregular swellings of *B. floridana* suggest the much larger "*Cerithium*" *coracinum* Oppenheim (1901, p. 262, pl. 19, figs. 1–3), an upper(?) Eocene species from Yugoslavia. These two species from Florida evidently do not represent *Dirocerithium* or *Bellatara*.

Dirocerithium wechesense Stenzel, n. sp.

Plate 24, figures 10, 12–14

[Description and comments prepared by H. B. Stenzel]

Vertagus wechesensis Stenzel, in Renick and Stenzel, Texas Univ., Bur. Econ. Geol., Bull. 3101, p. 87 (name only), pl. 6, fig. 8, 1931 (Eocene, Texas).

Clava ("Ochetoclava") vineta (Whitfield), Palmer, Bull. Am. Paleontology, v. 7, no. 32, p. 217, (part) pl. 29, figs. 15, 16, 17, 19, not figs. 7, 10, 11, 18, 1937 (Eocene, Texas).

Bellatara wechesensis (Stenzel), Palmer, in Richards and Palmer, Florida Geol. Survey Bull. 35, p. 20 (name only), 1953 (Eocene, Texas).

Shell of medium size, slender; spire profile straight in juveniles, somewhat irregular in anterior part of fully adult shells; apical angle about 27°. Juvenile whorls nearly straight-sided, divided into a sutural collar and an anterior band about twice as wide as sutural collar; sculptured with numerous closely spaced slightly protractive axial ribs; two narrow spiral striae setting off sutural collar from anterior band of same whorl; three to four rounded spiral cords overrunning anterior band, but suppressed as they cross ribs and gradually disappearing about 15 mm from apex. Anterior band gradually losing sculpture and becoming smooth in early adult stage, but on sutural collar sculpture persisting until somewhat later stage and ribs changing to vertical closely spaced wrinkles before they too disappear. At that stage (early adult) anterior band 1½ times as wide as sutural collar. Relative width of sutural collar and anterior band changed only during very last stage, when coiling becomes irregular and whorl is angulated at division between sutural collar and anterior band. Spire varices in juvenile stage pronounced and somewhat bulbous; varices absent in early adult stage; in last stage varices consisting of irregular outbulgings which produce irregular rise and fall of suture. Aperture moderately wide; siphonal canal short and twisted; posterior canal simple, located at sutural collar; outer lip thick, generally broken; parietal callus moderately thick, bearing a spiral fold delimiting posterior canal; callus extending from parietal wall over inner lip to siphonal canal, where it forms a fold following twisted edge of canal.

Height (incomplete) 58 mm, diameter 24 mm (type).

Type: Type and paratypes temporarily in collection of H. B. Stenzel, Houston, Texas.

Type locality: Road cut on abandoned county road adjoining new Marquez-Centerville road (State Highway 7), 0.6 mile east of crossroads known as Robbins (crossing of Farm to Market road 39, or Jewett-Normangee road), central Leon County, Tex., Stenzel's Viesca member of Weches formation (to which he assigns formation rank, instead of member rank in Mount Selman formation), middle Eocene (*Cubitostrea smithvillensis* zone).

Dirocerithium wechesense is distinguished from *D. vinctum*, which evidently is its predecessor, by its larger size, the presence of two (not three) spiral striae separating the sutural collar and anterior band, the more conspicuous juvenile varices, the unequal width of sutural collar and anterior band on early adult whorls, and the earlier disappearance of the sculpture.

Occurrence: Weches greensand member of Mount Selman formation (middle Eocene), Robertson County northeastward to San Augustine County, Tex.

Dirocerithium ame Woodring, n. sp.

Plate 24, figures 15–18

Moderately large (restored height about 85 mm, diameter 30 mm), outline very slightly concave, later half of body whorl loosely coiled. Sutural collar of early whorls narrow, ⅓ to ¼ as wide as anterior band. Early whorls also sculptured with practically vertical narrow axial ribs extending from suture to suture, and narrow spiral cords on anterior band. Axial sculpture and spiral sculpture, except for groove setting off sutural band, gradually disappearing about 20 mm from apex. Sutural collar gradually widening until

it is as wide as anterior band, or even a little wider, and groove dividing sutural collar and anterior band becoming ledge-like (ledge of shelf facing sutural collar). Early whorls bearing one or two varices. Varices persisting later than axial sculpture, but gradually disappearing on early intermediate whorls. A wide varix swelling, flattening posteriorly, about 180° in counter-clockwise direction from outer lip and another about 360° from outer lip. Anterior part of outer lip scoopshaped.

Height (incomplete, 6 whorls) 64 mm, diameter 30 mm (largest specimen). Height (incomplete, 9 whorls) 52 mm, diameter 26 mm (type).

Type: USNM 562545; 3 paratypes USNM 562546; paratype, Stanford University.

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.

The silicified Eocene fossils found on Quebrada de Oro include 36 incomplete specimens of this cerithid. Some are fragmentary remains of one or two whorls and many are somewhat riddled by a boring organism, probably a sponge. The only specimen that has a complete aperture is disfigured by a cluster of attached immature oyster shells (pl. 24, fig. 17). A few of the earliest whorls are not preserved on any of these fossils and their granular silica is not an effective medium for showing the sculpture of the early whorls that are preserved. Nevertheless it can be seen, especially on a small paratype (pl. 24, fig. 16) that the sutural collar of the early whorls is relatively very narrow and that the early sculpture is strikingly *Strioterebrum*-like, except for the varices. The outer lip shown on plate 24, figure 17 does not show the slight posterior indentation of *Dirocerithium*, but the edge of the lip is somewhat defective. The two wide varices of adult shells produce a dorso-ventral flattening of the shell and a pronounced constriction of the space occupied by the animal. The constriction is especially marked on shells that have the outer lip broken back a short distance from the aperture, which is the usual condition.

The slightly concave outline suggests that *Dirocerithium ame* may be more closely related to D. *whitfieldi* than to the other species. *D. whitfieldi*, however, has a larger apical angle, loses its sutural collar on the last few whorls, and lacks varices on the body and penult whorls. The only specimen at hand (collected from the Gosport sand at Claiborne, Ala., evidently a topotype) is badly worn and the tip is broken, but the axial sculpture seems to disappear at a later stage than on *D. ame*. Where the sutural collar disappears, the collar is about as wide as the anterior band and in that respect the two species are similar. *D. americanum* has a narrower apical angle that *D. ame*, lacks a sliglitly concave outline, and has a relatively narrower sutural collar on intermediate and late whorls.

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

Subfamily POTAMIDINAE
Genus Potamides Brongniart

Brongniart, Mus. Hist. Nat. (Paris) Ann., v. 15, pp. 367, 368, 1810.

Type (monotype): *Potamides lamarckii* Brongniart, Oligocene, Paris basin.

Potamides suprasulcatus (Gabb)

Plate 28, figures 3–6

Cerithium suprasulcatum Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 237, 1873 (Oligocene?, Dominican Republic.)

Potamides ormei Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 126, pl. 22, fig. 8, 1917 (Oligocene?, Dominican Republic).

Potamides suprasulcatus (Gabb), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 373, pl. 29, figs. 10, 11, 1922 (Oligocene?, Dominican Republic).

Potamides ormei var. *infraliratus* Spieker, Johns Hopkins Univ. Studies in Geology, no. 3, p. 58, pl. 2, fig. 11, 1922 (Miocene, Perú).

Potamides (*Lampanella*) *ormei* Maury, Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 38, pl. 8, figs. 6, 7, 1929 (Miocene, Colombia).

Potamides infraliratus Spieker, Olsson, idem, v. 19, no. 68, p. 193, pl. 23, figs. 5, 12, 1932 (Miocene, Perú). Marks, idem, v. 33, no. 139, p. 105, 1951 (Miocene, Ecuador).

Potamides? suprasulcatus Gabb, Hedberg, Geol. Soc. Am. Bull., v. 48, p. 2024, pl. 8, figs. 10, 11, 1937 (Miocene, eastern Venezuela).

Of medium size, rapidly enlarging, spire whorls practically flat. Protoconch not preserved. Early whorls sculptured with a sutural spiral band and a wider anterior spiral band occupying remainder of whorl. Sutural spiral bearing strong nodes and anterior spiral bearing axial ribs aligned with the nodes. With further growth the wide anterior spiral is divided by a narrow groove into two closely spaced spirals, narrower than sutural spiral. Groove setting off sutural spiral wider than that between the two anterior spirals. On largest shell edge of a fourth spiral emerges at anterior suture. The three spirals of intermediate and late spire whorls bearing strong nodes aligned in slightly arcuate axial series. Alignment of nodes on corresponding spirals of body whorl more strongly arcuate. Base of body whorl sculptured with six to eight additional narrow spirals (the number depending on size of shell), which are not noded, but are somewhat undulatory, less undulatory anteriorly. Aperture very heavily margined. Outer lip strongly varicose, slightly ascending, bearing a shallow indentation, apex of which is opposite second spiral from sutnre. Siphonal canal very short, wide. Inner lip covered with thick callus.

Height (incomplete) 30 mm, diameter (including varicose outer lip) 17 mm (larger figured specimen). Height (incomplete) 21.8 mm, diameter (somewhat increased by crushing; including upper part of varicose outer lip) 14.3 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 2600.

Type locality: Dominican Republic (probably Tabera formation on Río Yaque del Norte below Tabera).

This boldly sculptured potamidine cerithid is fairly common in calcareous sandstone of the Culebra formation, including the transition zone between the Culebra and Cucaracha formations. Fragments of a whorl or two—and most of these fossils are fragments—are readily identifiable. None of the specimens is complete and none has a complete aperture, but by using several specimens complete apertural features are available. Hedberg's illustrations of eastern Venezuelan specimens show perfect apertures and Weisbord's figure 7, illustrating a Colombian specimen, effectively shows growth lines.

Gabb's type lot (his only lot) consists of 14 worn or somewhat worn specimens. The matrix is poorly sorted dirty gray sandstone containing subangular rock and mineral granules. A small collection of fossils from conglomerate and sandstone of the upper Oligocene Tabera formation on Río Yaque del Norte below Baitoa (USGS locality 8557), in the Dominican Republic, includes an incomplete specimen of *P. suprasulcatus* (height, 6 whorls, 24.5 mm). Though the matrix of the type lot is not as coarse grained as that of the specimen from the Tabera formation, the unknown type locality may represent the Tabera on Río Yaque del Norte somewhere downstream from Tabera. The type and only specimen of *P. ormei* was received from Gabb. In morphologic features, preservation, and matrix it is indistinguishable from specimens in Gabb's type lot. It is practically a paratype of *P. suprasulcatus* and *P. ormei* is practically an objective synonym of *P. suprasulcatus*. The apical angle of the fossils in the type lot (but not of the specimen from the Tabera formation) is slightly larger than that of the fossils from the Culebra formation and their sculpture is slightly coarser.

Peruvian, Ecuadorian and Colombian representatives of this species are larger than those from other areas. The fossils from Perú and Ecuador have a decidedly larger apical angle and somewhat coarser sculpture than those from the Canal Zone, markedly coarser on the late whorls of large specimen. Should a name be considered advantageous for the Peruvian-Ecuadorian form, *Potamides suprasulcatus infraliratus* is available. There is, however, as much justification for a subspecific name for the relatively slender and more delicately sculptured Canal Zone form. Moreover, in width of apical angle and coarseness of sculpture, specimens from Colombia are intermediate between the Peruvian-Ecuadorian form and that in eastern Venezuela, which closely resembles the Canal Zone form. It is concluded that *P. suprasulcatus* is a variable species and Hedberg's suppression of Spieker's name, as well as Maury's, is accepted. *P. suprasulcatus* therefore is widely distributed and occurs in deposits ranging in age from late Oligocene to middle Miocene. Though it is unrecorded from Trinidad, it is represented in the Brasso formation at Mayo Quarry, on the north side of the Central Range (USGS locality 19851), in a collection recently forwarded by H. G. Kugler. It occurs also in a mixed fresh-water and brackish-water fauna of Miocene age on Río Carboneras in the Izabel area of eastern Guatemala (USGS loc. 10588).

P. suprasulcatus is not a typical *Potamides* in a narrowly restricted sense. The type of the genus is a small slender species (height 24 mm, diameter 8.5 mm). Nevertheless the type species and *P. suprasulcatus* have comparable apertural features and comparable basic sculpture. The absence of varices on the spire and opposite the outer lip, the shape of the outer lip, and the length and shape of the siphonal canal show similarities. The most marked differences are the heavy sculpture and heavily margined aperture of *P. suprasulcatus*, particularly the heavy outer lip. Close allies of that species have a thin or moderately thick outer lip: *P. roumaini* Pilsbry (1910, p. 487, fig. 1; Miocene, Haiti), *P. caobasensis* Pilsbry (idem, p. 488, fig. 2; Miocene, Haiti), *P. tippenhaueri* Woodring and Mansfield (Woodring, Brown, and Burbank, 1924, p. 611, pl. 16, figs. 3, 4; Miocene, Haiti), and *P. matsoni* Dall (1913, p. 231, pl. 21, figs. 1, 2, 7; Miocene, Louisiana, Texas). This group of potamidine cerithids failed to survive the Miocene. *P. matsoni* is a migrant in southeastern United States. It had no known predecessors in that region and left no known descendants there or elsewhere. It therefore is a useful guide for a brackish-water tongue in the Fleming formation as used in Louisiana and eastern Texas, designated the *Potamides matsoni* zone. At an outcrop locality in eastern Texas that zone has been dated by land vertebrates as late Miocene (Stenzel, Turner, and Hesse, 1944), but is now considered middle Miocene (Quinn, 1955, p. 70, 80).

Occurrence: Culebra formation (early Miocene), localities 103, 104a, 106, 108c, 110, 114, 115a, 115b. Tabera formation (late Oligocene), Dominican Republic. Brasso formation (early middle Miocene), Trinidad. Middle(?) Miocene part of Santa Inés group, eastern Venezuela. Middle Miocene, Colombia. Progreso and Daule formations (middle Miocene), Ecuador. So-called variegated beds of Zorritos group (middle Miocene), Perú. Miocene, Guatemala.

Genus Terebralia Swainson

Swainson, A treatise on malacology, p. 315, 1840.
Type (logotype, Sacco, molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 17, p. 51, 1895): *Terebralia palustris* (Linné) (*Strombus palustris* Linné), Recent, tropical western Pacific and Indian Oceans.

Until about the end of Miocene time *Terebralia* was widely distributed in Tertiary seas. Since then it has become restricted to the tropical western Pacific and Indian Oceans, where it is found in brackish-water mangrove-swamp communities. Miocene species from the Caribbean region are the only well authenticated American species. The following doubtfully identified *Terebralia* occurs in the Culebra formation in association with a close ally of *Littorina angulifera*, which lives in brackish inlets in modern Caribbean mangrove swamps.

Terebralia dentilabris (Gabb)?

Sandstone in the transition zone between the Culebra and Cucaracha formations, on the east side of the Canal at locality 110, yielded two specimens doubtfully identified as *Terebralia dentilabris*. These fossils are in poor condition. They are filled with hard calcite, lack an aperture, and the shell material is recrystallized to calcite, which is corroded. It can be seen, however, that the better preserved of the two represents a fairly large cerithid (height, 6½ whorls, 42 mm), the early whorls of which enlarge rapidly. The sculpture is strongly cancellate, consisting of narrow axial ribs, slightly arcuate on late whorls, and narrower spiral bands, slightly swollen as they override the ribs. Spire whorls bear four or five of these spiral bands. A heavy varix is apparent on at least the last three whorls.

The size, outline, sculpture, and heavy varices strongly suggest *Terebralia dentilabris* (Pilsbry, 1922, p. 374, pl. 29, figs. 6, 7), but the aperture and internal features are unknown. Though Pilsbry assigned Gabb's "*Cerithium*" *dentilabris* to *Potamides*, he pointed out its similarity to the type species of *Terebralia* and later (Pilsbry and Harbison, 1933, p. 115) referred it to that genus. Two other species from the Dominican Republic also represent *Terebralia*: "*Cerithium*" *prismaticum* Gabb (Pilsbry, 1922, p. 373, pl. 29, fig. 12) and "*Potamides*" *gastrodon* Pilsbry and Johnson (idem, p. 374, pl. 32, figs. 5, 6). These three species, collected by Gabb at an unknown locality or localities, presumably are of Miocene age, probably early Miocene. "*Potamides* (*Pyrazisinus*)" *bolivarensis* Weisbord (1929, p. 39, pl. 8, fig. 5), from the middle Miocene of Colombia and also found in the Miocene of eastern Venezuela (Hedberg, 1937, p. 2024, pl. 8, fig. 12), has no columellar fold—at all events the type and 3 specimens in the collections of the U. S. National Museum show none—but the type has a few internal tubercules opposite the only varix that can be examined. Despite the absence of a columellar fold, it is so similar to *Terebralia dentilabris* that it is improbable that the two forms are not closely related, if not the same species. A remarkable species from the late lower Miocene Chipola formation of Florida, described by Maury (1902, p. 66, pl. 28, figs. 2, 2a) as *Pyrazisinus harrisi*, has the same type of sculpture as *Terebralia dentilabris*. Nevertheless its heavily margined aperture and deep indention on the outer lip suggest that it is properly assigned to *Pyrazisinus* (Heilprin, 1887, p. 115; type (monotype) *Pyrazisinus campanulatus* Heilprin, Miocene, Florida). The earliest species of *Pyrazisinus* are found in the early lower Miocene Tampa limestone of Florida and the last in the Pliocene Caloosahatchee marl of Florida.

Occurrence: Culebra formation (early Miocene), locality 110.

Subfamily BITTINAE
Genus Bittium Leach

Leach, Ann. Mag. Natural History, v. 20, p. 270, Oct., 1847.
Type (logotype, Gray, Zool. Soc. London Proc., p. 154, Nov., 1847): *Murex reticulatus* Montagu (*Strombiformis reticulatus* Da Costa), Recent, eastern North Atlantic Ocean.

Bittium scotti Brown and Pilsbry

Plate 28, figures 10, 11

Bittium scotti Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 509, pl. 22, figs. 11, 12, 1913 (Miocene, Canal Zone).

Of medium size, slender, early sculptured whorls rapidly enlarging. Protoconch consisting of about three apparently smooth whorls. Sculpture consisting of relatively wide low axial ribs (12 to 15 on late spire whorls), overridden by narrow spiral threads (six to eight on late spire whorls). Some interspaces bear a very fine secondary spiral. Base of body whorl sculptured with four to six narrow spirals. Body whorl bearing one to three varices. Basal spout very narrow.

Height (not quite complete) 8 mm, diameter 3 mm (larger figured specimen). Height (practically complete) 7.2 mm, diameter 2.7 mm (smaller figured specimen).

Type material: two syntypes, Acad. Nat. Sci. Phila. 3826.

Type locality: Lignitic layers near Tower N, Las Cascadas, Canal Zone (Culebra formation).

Bittium scotti is one of the few mollusks of the Culebra formation that has been described. It is fairly common to abundant in dark-colored carbonaceous shale and mudstone in the type region, the northernmost outcrop area of the Culebra formation in Gaillard Cut, where it can still be collected. Though many

specimens are available—for example about 100 from locality 100a—they leave much to be desired. The apertures are imperfect, the shell material is replaced by fragile gypsum, and adhering flakes of gypsum and particles of carbonaceous shale cannot be removed without damaging the fossils. Therefore the illustrations are poor. The syntypes are in the same condition.

B. scotti is more inflated than *B. permutabile* Dall (1890–1903, p. 272, pl. 21, fig. 17, 1892), of the Chipola formation of Florida, and has fewer and more widely spaced spirals.

Occurrence: Culebra formation (early Miocene), localities 99b, 100, 100a, 101.

Bittium nugatorium Brown and Pilsbry

Plate 38, figure 12

Bittium nugatorium Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 357, fig. 1, 1911 (Miocene, Canal Zone).

Cerithium (Bittium) aff. *scabrum* Olivi, Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 499, pl. 31, fig. 14, 1911 (Miocene, Canal Zone).

Small, slender, early whorls rapidly enlarging. Protoconch consisting of 3½ to 4 smooth whorls. Two spirals appear gradually, followed by axial ribs. Later sculpture strongly reticulate. Axial ribs slightly arcuate, slightly wider than spiral threads, 16 to 19 on penult whorl. Spiral threads weakly noded as they override ribs, increasing from two on first sculptured whorl to three on late whorls. In addition, a weak very slightly noded spiral generally adjoins posterior suture and a narrow nonnoded spiral emerges at anterior suture on penult of large shells. Base of body whorl sculptured with five or six nonnoded spirals. Later half of body whorl bearing a varix. Axial ribs narrow and closely spaced between varix and outer lip. Outer lip slightly arcuate, the curvature the same as that of axial ribs. Basal spout short and narrow.

Height 5.7 mm, diameter 1.7 mm (largest specimen). Height 4 mm diameter 1.4 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 1790.

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

Though *Bittium nugatorium* occurs in the lower, middle, and upper parts of the Gatun formation and is fairly widespread in the middle part, is it abundant only at locality 155c. About 200 specimens from that locality show little variation. Elsewhere there is considerable variation in shell outline and in the presence or absence of a spiral at the posterior suture and its strength, if present. The outline ranges from slender to relatively inflated. Inflated shells, however, are rare.

No closely allied species have been recognized. Brown and Pilsbry compared *B. nugatorium* with *B. collinsii* (Gabb) (1881, p. 362, pl. 46, fig. 54) a Pliocene Costa Rican species. The type lot of *B. collinsii*, consisting of three incomplete specimens glued on a card, is very unsatisfactory. Their apical angle is wider than that of *B. nugatorium*. All except the earliest whorls are sculptured with three spirals. The base is not preserved on any of the specimens now in the type lot.

Toula's *Cerithium (Bittium)* aff. *C. scabrum* is missing in his collection.

Occurrence: Lower, middle and upper parts of Gatun formation (middle Miocene). Lower part: localities 136a, 138, 138a. Middle part, eastern area: localities 147i, 155, 155c; western area: localities 161c, 162, 170a. Upper part, eastern area: localities 163, 174, 178.

Bittium pericallum Woodring, n. sp.

Plate 38, figure 11

Small, very slender, evenly tapering whorls slightly inflated. Protoconch consisting of 2½ to 3 smooth whorls. Two spirals, median and anterior, appearing on first sculptured whorl. On second sculptured whorl two evenly spaced noded spirals appearing, the anterior one stronger. Later sculpture dominated by very strongly noded primary spirals. Late whorls bearing three primary spirals, the anteriormost (continuation of early anterior noded spiral) strongest. A secondary spiral adjoining anterior suture and another between anterior and middle primary. Axial sculpture consisting of very strong nodes on primary spirals and slight swellings joining the nodes across interspaces and on secondary spirals; 13 to 15 nodes on late whorls. Base of body whorl sculptured with five to seven narrow spirals. A varix appearing on body whorl and penult, and on one or two still earlier whorls of some shells. Outer lip broken. Basal spout short and narrow.

Height 5.2 mm, diameter 1.5 mm (largest specimen). Height 4.5 mm, diameter 1.3 mm (type).

Type: USNM 562622; paratype, Stanford University.

Type locality: 177c (USGS 5855 [west side of Panama Railroad] opposite Mount Hope Cemetery, Canal Zone), upper part of Gatun formation.

Bittium pericallum was found at one locality, in the upper part of the Gatun formation at Mount Hope, where 10 specimens were collected. It is well characterized by the slender outline and sharply chiseled, very strongly noded sculpture. The slender outline suggests slender forms of *Alabina asperides* proper, the next species described. The sculpture of *B. pericallum*,

however, is more strongly noded and the basal lip has a more distinct spout.

Occurrence: Upper part of Gatun formation, eastern area (middle Miocene), locality 177c.

Genus Alabina Dall

Dall, Nautilus, v. 15, p. 127, 1902.

Type (orthotype): *Bittium cerithidioide* (Dall) (*Alaba cerithidioides* Dall), Recent, North Carolina to West Indies.

Alabina asperoides asperoides (Gabb)

Plate 38, figures 8, 9

Bittium asperoides Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 239, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 125, pl. 21, fig. 17, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phil. Proc., v. 73, p. 375, pl. 35, fig. 4, 1922 (Miocene, Dominican Republic).

Bittium asperoides asperandum Pilsbry, Idem, p. 375, 1917 (Miocene, Dominican Republic).

Small or moderately small, slender to moderately slender, early sculptured whorls somewhat angulated by a median spiral, later whorls slightly to moderately inflated. Protoconch consisting of three rapidly enlarging smooth whorls. A median spiral gradually appearing on first sculptured whorl, followed immediately by an anterior spiral and later on same whorl by very narrow axial ribs, which form minute nodes on the spirals. These two spirals, still noded, are conspicuous on third or even fourth whorl. In meantime one or two other weaker spirals appearing. Sculpture of late whorls strong, coarse or moderately coarse, consisting of four or five noded spirals, or as many as six or seven less strongly noded spirals, and widely spaced, or relatively widely spaced, slightly arcuate axial ribs. Base of body whorl sculptured with five or six closely spaced spirals. One to three wide varices on body whorl; one or two on penult of some shells. Outer lip arcuate, edge generally broken. Basal lip slightly everted forming a weak shallow spout.

Height 3.1 mm, diameter 1.1 mm (larger figured specimen). Height 1.8 mm, diameter 0.9 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 3100.

Type locality: Dominican Republic (probably Cercado formation).

This minute cerithid, which has a variable outline and variable *Bittium*-like sculpture, is discussed under *Alabina asperoides canaliculata*, the description of which follows.

Occurrence: Lower part of Gatun formation (middle Miocene) localities 136a, 138, 138a, 138b Cercado formation (middle Miocene), Dominican Republic.

Alabina asperoides canaliculata (Gabb)

Plate 38, figures 3–5

Bittium canaliculatum Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 239, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 126, pl. 21, fig. 18, 1917 (Miocene, Dominican Republic).

Alabina canaliculata (Gabb), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 375, pl. 35, fig. 2, 1922 (Miocene, Dominican Republic).

Alabina angustior Pilsbry, idem, p. 376, pl. 35, fig. 3, 1922 (Miocene, Dominican Republic).

Alabina curta Woodring, Carnegie Inst. Washington Pub. 385, p. 339, pl. 25, fig. 13, 1928 (Miocene, Jamaica).

Small, moderately slender. Protoconch, early sculpture, varices and aperture as in *A. asperoides* proper. Sculpture gradually changing on fourth or fifth sculptured whorl to weak nonnoded closely crowded spirals (as many as nine), separated by narrow grooves, and very narrow generally very closely spaced slightly arcuate axial ribs. Spiral sculpture generally faint or absent on posterior part of last whorl or two.

Height 2.5 mm, diameter 1 mm (largest figured specimen).

Type: Acad. Nat. Sci. Phila. 2618.

Type locality: Dominican Republic (probably Cercado formation).

The names *Alabina asperoides asperoides* and *A. asperoides canaliculata* are used with some hesitation for a very variable *Alabina* from the Gatun formation. The variation affects outline (slender to moderately slender; slight to moderate whorl inflation) and sculpture (widely spaced to very closely spaced axial ribs; a few strong noded widely spaced spirals to suppressed closely spaced spirals). Shells that have suppressed spirals generally have very closely spaced axials, but some have widely spaced axials. The combination of strong spirals and very closely spaced axials is not represented. The name *A. asperoides asperoides* is used for the strongly sculptured and intermediate forms and *A. asperoides canaliculata* for those that have suppressed spirals.

The greatest range of variation is shown by 21 specimens from the lower part of the Gatun formation, including *A. asperoides* proper and the variety *A. asperoides canaliculata*. A slender strongly sculptured form referred to *A. asperoides* proper (pl. 38, fig. 9), a less slender and less strongly sculptured form also assigned to *A. asperoides* proper (pl. 38, fig. 8), and the variety *A. asperoides canaliculata* (pl. 38, fig. 4), all from the same locality, have a very different appearance. Twenty specimens from the middle part of the Gatun represent the variety *A. asperoides canaliculata*. They begin where those from the lower Gatun stop in sup-

pression of spiral sculpture (pl. 38, fig. 3) and go farther (pl. 38, fig. 5).

In the following discussion strongly sculptured forms (like *A. asperoides* proper) are designated *adamsi*-like and those that have suppressed spirals (like *A. asperoides canaliculata*) are designed *cerithidioides*-like. *Alabina adamsi* and *A. cerithidioides* are the names for the corresponding Recent forms and are the earliest names.

"*Bittium*" *boiplex* Dall (1890–1903, p. 275, pl. 21, fig. 14, 1892), from the late lower Miocene Chipola formation of Florida, appears to be the earliest form of the ancestral stock of *Alabina adamsi* and *A. cerithidioides*. It was described and illustrated as slender and coarsely and strongly sculptured. The type and other specimens in the collections of the U. S. National Museum are misplaced or lost. Though Dall mentioned variation in outline and sculpture, nothing in his description or comments indicates *cerithidioides*-like suppression of spiral sculpture.

The fauna of the early middle Miocene Cercado formation of the Dominican Republic includes *adamsi*-like and *cerithidioides*-like forms, which have been assigned to different genera: "*Bittium*" *asperoides* and *Alabina canaliculata*, respectively. Were it not for the large number of specimens—estimated to be 2,000—from one locality (USGS locality 8525 on Río Mao), it might not be apparent that they intergrade and are variable in other features. "*Bittium*" *asperoides* and intermediates are six times as abundant as *Alabina canaliculata*, which is given varietal rank under *A. asperoides*. It should be pointed out that "*Bittium*" *asperoides* has the aperture of Alabina; that is, the basal spout is less distinct than in *Bittium*. These shells from the Dominican Republic are slightly larger than those from the Canal Zone. Though hundreds of specimens from the Dominican Republic show the protoconch and early sculptured whorls, only exceptional specimens that escaped slight wear effectively show the two noded spirals of early sculptured whorls. Discounting wear, however, the two spirals are not as strong as those on the fossils from the Canal Zone. They have little effect on whorl profile and lose their distinctive features at an earlier stage. The late middle Miocene Gurabo formation yielded only two specimens. They are *cerithidioides*-like and have strong early spirals. The Canal Zone fossils named *A. asperoides canaliculata* are more similar to them than to the corresponding fossils from the Cercado formation.

A *cerithidioides*-like form in the late middle Miocene Bowden formation of Jamaica was named *A. curta*. It is slightly larger than *A. asperoides canaliculata* of the Dominican Republic and has strong early spirals and exceptionally heavy varices. Though the sculpture is variable, no *adamsi*-like form has been found at Bowden, as in the middle part of the Gatun formation and in the inadequate sample from the Gurabo formation.

Late Miocene deposits in western Florida (Mansfield's *Cancellaria* zone) yielded *adamsi*-like and intermediate forms, for which three names were proposed: *A. adamsi floridana* (Mansfield, 1930, p. 99, pl. 13, figs. 2, 5), *A. adamsi leonensis* (idem, p. 99, pl. 13, fig. 3), *A. adamsi harveyensis* (idem, p. 100, pl. 13, fig. 6).

Both *adamsi*-like and *cerithidioides*-like forms are found in the Pliocene Caloosahatchee marl of Florida. In fact, the names *A. adamsi* (Dall, 1890–1903, p. 276, 1892; Olsson and Harbison, 1953, p. 293, pl. 48, fig. 7) and *A. cerithidioides* (Dall, 1890–1903, p. 276, pl. 16, fig. 8, 1892; Olsson and Harbison, 1953, p. 292, pl. 48, fig. 9) were used for them. The two strong spirals are not noded on the first or first two sculptured whorls. If the material in the U. S. National Museum is representative, *A. adamsi* is more abundant and the two forms do not completely intergrade. Olsson and Harbison's illustration of *A. adamsi* represents a slender shell, the lip of which presumably is defective and does not show the faint basal spout. They proposed the subgeneric name *Caloosalba* for *A. adamsi*.

"*Alaba*" *adamsi* and "*Alaba*" *cerithidioides* were briefly described in the same paragraph and neither was illustrated (Dall, 1889, p. 258). They have practically the same range from North Carolina to the West Indies. The type lot of "*Alaba*" *adamsi*, dredged at a depth of 15 fathoms off Cape Hatteras, consists of four specimens that have strong spiral sculpture and moderately strong closely spaced axials, which begin at a late stage on the third sculptured whorl. Lots from localities farther south have stronger axial sculpture. The type lot of "*Alaba*" *cerithidioides*, from a depth of 22 fathoms off Cape Lookout, consists of two worn specimens that have suppressed spirals and very closely spaced axials. On unworn shells from localities farther south the axials begin on the second or third sculptured whorl. Complete integradation with "*Alaba*" *adamsi* is not apparent.

This brief survey, which does not pretend to be exhaustive and doubtless is oversimplified, indicates that early Miocene *adamsi*-like ancestors evolved by early middle Miocene time into a variable complex including *adamsi*-like and *cerithidioides*-like forms. By Pliocene time *adamsi* and *cerithidioides* lines emerged. Progressive changes in development of the sculpture are apparent in the variable complex and the two lines. The two early spirals become stronger and are conspic-

uous until a later growth stage and the axials begin at a later growth stage.

The names *Alabina asperoides asperoides* and *A. asperoides canaliculata* are not entirely satisfactory for the Canal Zone fossils. Nomenclatural treatment, however, is complicated by the practice of using Linnean trinomials for grades in single populations and for successive chronologic grades involving other characters. In development of sculpture the Canal Zone fossils appear to represent the grade reached by *A. curta*. Both *A. canaliculata* and *A. curta* would ordinarily be given subspecific rank under *A. cerithidioides*. That treatment would not provide for the contemporaneous *adamsi*-like form a name that shows its relation to the *cerithidioides*-like form. Until a better solution is apparent, the name *A. curta*, is suppressed.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a. Middle part, eastern area, localities 147b, 147i; western area, localities 162, 170a. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica.

Family EPITONIIDAE
Genus Epitonium Röding

Röding, Museum Boltenianum, p. 91, 1798.
Type (logotype, Suter, Manual of New Zealand Mollusca, p. 319, 1913): *Epitonium scalare* Röding (= *Turbo scalaris* Linné), Recent, western Pacific Ocean.

Suter cited *Turbo scalaris* as the type without mentioning Röding's name for "die echte Windeltreppe."

A small epitonid, listed as *Epitonium* sp., is represented in calcareous sandstone of the Culebra formation by two incomplete whorls. The lamellae, where undamaged, are blade-like and no spiral sculpture is visible. Though the genus occurs in the Gatun formation and the Chagres sandstone, the material from those formations is meager.

Subgenus Epitonium s. s.
Epitonium (Epitonium) cf. E. foliaceicostum (d'Orbigny)

Plate 38, figures 13, 16

Small, moderately slender, imperforate, whorls strongly inflated, deeply constricted at suture. Protoconch consisting of four slightly inflated smooth whorls. Axial lamellae blade-like, the edge slightly bent backward, prolonged at shoulder of whorl to form a hook, slightly bent backward. Lamellae of successive whorls coalesced at suture, seven lamellae on a whorl. Inner lip and lamellae coalesced.

Height (incomplete) 3.7 mm, diameter 2 mm (larger figured specimen: the largest specimen).

Three small specimens of this species are in the collection from the middle part of the Gatun formation at locality 147b, which includes numerous small shells of other genera. The largest doubtless is immature. Many of the lamellae are broken and fail to show the hook-like extension at the shoulder of the whorl. The lower part of the Gatun at locality 138a yielded a minute shell doubtfully identified as the same species. It consists of a 5-whorled protoconch and 1½ post-protoconch whorls bearing 10 lamellae on a whorl. The lamellae are broken, but some show the base of a shoulder-hook.

The middle Gatun fossils are similar to the Recent Caribbean *Epitonium foliaceicostum* (d'Orbigny) (Clench and Turner, 1951, p. 273, pls. 123, 124), which reaches a height of about 18 mm. On the basis of the inadequate material now available, the fossils are more slender and their protoconch is more slender and has more inflated whorls. An *Epitonium* also identified as *E.* cf. *E. foliaceicostum* occurs in the Pliocene of Florida (Olsson and Harbison, 1953, p. 336, pl. 58, fig. 2).

The type of *Epitonium* is a large (height about 70 mm), deeply umbilicate species, the whorls of which are in contact only at the lamellae and lack spiral sculpture. Nevertheless assignment of the small American umbilicate or imperforate species, the whorls of most of which are in contact and all of which lack spiral sculpture, to subgenera other than *Epitonium* s.s. involves excessive dismemberment of a genus dismembered into many other subgenera—a view adopted by Clench and Turner in their recent review of the west Atlantic species, just cited. According to that view, the Miocene Jamaican species described as *E.* (*Cycloscala*) *eumetrum*, *E.* (*Nitidoscala*) *aduncum*, and *E.* (*Nitidoscala*) *ventulum* (Woodring, 1928, p. 396, 400–401) are to be referred to the subgenus *Epitonium* s.s.

Occurrence: Lower (identification doubtful) and middle parts of Gatun formation (middle Miocene). Lower part, locality 138a (identification doubtful). Middle part, eastern area, locality 147b.

Subgenus Asperiscala de Boury

de Boury, Jour. Conchyliologie, v. 57, p. 258, 1909.
Type (orthotype): *Scalaria bellastriata* Carpenter, Recent, California.

A minute shell from the lower part of the Gatun formation at locality 138a, listed as *Epitonium* (*Asperiscala*) sp., consists of two whorls following a four-whorled protoconch. The post-protoconch whorls are sculptured with numerous low, thin axial lamellae, between which are very fine spiral threads.

Epitonium (Asperiscala) cf. E. gabbi (de Boury)

Plate 38, figure 17

Small, slender, imperforate, whorls strongly inflated, deeply constricted at suture. Protoconch not preserved. Axial lamellae bent backward, prolonged at shoulder to form a low hook, slightly bent backward. At irregular intervals a lamella is varix-like. Lamellae of successive whorls coalesced at suture, eight lamellae on a whorl. Spaces between lamellae sculptured with relatively strong, narrow spiral threads and spaces between spiral threads bearing very fine microscopic axial threads. Aperture broken.

Height (incomplete) 3.9 mm, diameter 2 mm (figured specimen).

Only one middle Gatun specimen, broken at both ends and probably immature, is in the collections. Some of the lamellae are more or less broken. In sculpture and outline this species is comparable to *Epitonium gabbi* (de Boury) (Woodring, 1928, p. 397, pl. 31, figs. 11, 12), but has more sharply sculptured spiral threads. *E. gabbi* occurs in the middle Miocene of the Dominican Republic and Jamaica. The Recent *E. novangliae* (Couthouy) (Clench and Turner, 1952, p. 306, pls. 144–146), which ranges from Virginia to Brazil, reaches a height of 14 mm and like *E. gabbi* has less sharply sculptured spiral threads, even on early whorls, than those of the middle Gatun fossil.

E. gabbi has been assigned to the subgenus *Spiniscala* de Boury (Woodring, 1928, p. 397). For the time being, however, it is placed under *Asperiscala* to agree with Clench and Turner's tentative classification of similar Recent western Atlantic species (Clench and Turner, 1952, p. 290–319). Under that arrangement the other Miocene Jamaican species described under the subgenus *Spiniscala* and also those under the subgenera *Hirtoscala* and *Striatascala* (Woodring, 1928, pp. 397–399) are to be assigned to *Asperiscala*.

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

Epitonium (Asperiscala) cf. E. rushii (Dall)

Plate 38, figure 22

Of medium size, slender, imperforate, whorls strongly inflated. Protoconch and aperture not preserved. Axial lamellae low, narrow, not uniformly alined on successive whorls. At irregular intervals a lamella is varix-like. Eighteen lamellae on last preserved whorl. Spaces between lamellae sculptured with narrow spiral threads and spaces between spiral threads bearing obscure microscopic axial threads.

Height (incomplete) 4.6 mm, diameter 2.3 mm (figured specimen).

The single specimen of this species, from the upper part of the Gatun formation in the western area, is broken at both ends and is somewhat worn, so that some of the lamellae are worn down and the microscopic axial sculpture is obscure. In outline and type of sculpture it is similar to *Epitonium rushii* (Dall) (Clench and Turner, 1952, p. 296, pl. 136), a Recent species ranging from North Carolina to the Florida Keys at depths of 38 to 100 fathoms.

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

Subgenus Depressiscala de Boury

de Boury, Jour. Conchyliologie, v. 57, p. 258, 1909.
Type (orthotype): *Scalaria aurita* Sowerby, Recent, Bay of Bengal.

Epitonium ("Depressiscala") eucteanum Woodring, n. sp.

Plate 28, figure 9

Large, very slender, imperforate, early post-protoconch whorls strongly inflated, later whorls slightly inflated. Protoconch and aperture not preserved. Axial lamellae low, narrow, widely spaced, slightly widened at suture, generally alined on successive whorls and coalesced at suture, 11 or 12 on a whorl. At irregular intervals a lamella is slightly varix-like.

Height (incomplete) 28.3 mm, diameter (slightly increased by crushing) 7.8 mm (type).

Type: USNM 562637.

Type locality: 206b (USGS 16938, Caribbean coast near mouth of Río Piña, road cut about 90 meters west of locality 206, Panamá), Chagres sandstone.

Epitonium eucteanum, found in the Chagres sandstone, is a large slender species sculptured with low, narrow, widely spaced lamellae. No trace of spiral sculpture is discernible. Though the lamellae of the earliest preserved whorls are worn, it is unlikely that those of later whorls are modified by wear. The type is the only specimen.

This species is closely allied to the Recent *E. scipio* (Dall) (1889, p. 310), the only large specimen of which is the type, collected at Vera Cruz, Mexico. It is almost twice as large as *E. scipio* and its early postprotoconch whorls are more inflated than those of *E. scipio*. Clench and Turner (1952, p. 329, pl. 159) illustrated the type of *E. scipio*, identified it as *E. nautlae* (Mörch), and assigned that species to *Depressiscala*. No specimens of "*Scalaria*" *aurita*, the type of *Depressiscala*, are available. Sowerby's illustration (Sowerby, 1844, pl. 33, fig. 62) of the moderately slender, umbilicate "*Scalaria*" *aurita*, however, suggest that *Depressiscala* is not an appropriate name for *E. scipio* and *E. eucteanum*. Whether any of de Boury's

lamellae more erect and extended to form short hook. Between shoulder and suture lamellae lower and not as strongly bent backward as below shoulder. On some shells a lamella is very wide and varix-like, but not higher than others. Well preserved interlamellar spaces show faint, irregularly spaced spiral striae and microscopic spiral lineation.

Height (incomplete) 19.2 mm, diameter 17.3 mm (type). Height (incomplete) 22.5 mm, diameter 20 mm (largest specimen).

Type and paratype: USNM 214345.

Type locality: 186 (USGS 6037, coquina limestone at Toro Point, Canal Zone), Toro limestone member of Chagres sandstone.

This small *Sthenorytis* is represented by 21 more or less damaged shells and fragments. These specimens are in three lots collected at different times at Toro Point, on the west side of Limon Bay opposite Colón. Though Toro Point is the general locality for the three collections, they may represent slightly different localities. MacDonald (1919, p. 545) specified that the type locality (USGS locality 6037) is a quarry one-third of a mile south of the southern end of Toro Point breakwater. Kenny's Bluff, the type locality of "*Stenorhytis*" *chaperi*, presumably is the bluff at Toro Point.

Dall selected as the type lot two specimens from a collection of 14. The one he later illustrated is considered the type. It is a little smaller than the largest specimens, but is in better condition. The immature paratype is the most nearly complete specimen. The paratype and several other specimens have a very wide varix-like lamella. The paratype also shows the upper edge of a slightly swollen basal disk, similar to the more strongly swollen basal disk of very small shells of *Sthenorytis pernobilis*.

S. toroensis toroensis is smaller and more rapidly enlarging than *S. pernobilis*, and has fewer, wider, and more strongly flattened lamellae. For the size of the shell the shoulder hook is farther from the suture. Even at a height of 6 mm the body whorl of *S. pernobilis* bears 12 lamellae. Despite its well defined features, perhaps *S. toroensis* is to be treated as a subspecies of *S. pernobilis*. That a small, rapidly enlarging, nine-lamellae *Sthenorytis*, evidently a subspecies of *S. pernobilis*, is living off the Florida Keys is shown by a dead shell (incomplete height 26 mm, diameter 20 mm) dredged by Henderson at a depth of 98 fathoms off Key West. Though the lamellae are as wide as those of *S. toroensis toroensis*, they are not as strongly flattened. This shell was the home of a hermit crab, the remains of which are still in the shell. The same dredge haul also yielded a dead shell of the typical form of *S. pernobilis*. There is no assurance, however, that the two forms were associated during life. The status of the small form awaits the dredging of live, or at least fresh, shells.

S. ampla (Gabb) (Pilsbry, 1922, p. 388, pl. 34, fig. 22), a Miocene species from the Dominican Republic, enlarges rapidly and has 10 lamellae, but the lamellae are relatively narrow and not strongly flattened. The type (and only) specimen evidently is immature, as the basal disk is visible. *S. stearnsii* (Dall) (1890–1903, pt. 2, p. 245, pl. 21, fig. 4, 1892), a small rapidly enlarging late Pliocene species, is the only species of the genus to reach California. It bears seven lamellae that are not strongly flattened. The Pliocene fossil from Monserrate Island in the Gulf of California, listed as *Sthenorytis toroense*, is that species or a very closely related form. It is sculptured with 12 strongly flattened lamellae. The whorls are not turreted and the lamellae are not extended at the shoulder.

Occurrence: Toro limestone member of Chagres sandstone (early Pliocene), localities 186, 186a, 186b. Deposits of Pliocene age, Monserrate Island, Gulf of California (identification doubtful).

Sthenorytis toroensis euthynta Woodring, n. subsp.

Plate 37, figures 1, 4, 5, 8

Of medium size, rapidly enlarging. Axial lamellae moderately wide, high, bent backward except on shoulder, where they are prolonged to form a practically erect hook. Between shoulder and suture lamellae lower than below shoulder. Body whorl bearing eight lamellae. Interlamellar spaces bearing more or less distinct low, irregularly spaced spiral bands and microscopic spiral striae.

Height (incomplete) 29.5 mm, diameter (incomplete) 24 mm (type). Height (incomplete) 23.2 mm, diameter 20.6 mm (paratype).

Type: USNM 562639; paratype, USNM 562640.

Type locality: 205 (USGS 8387, Caribbean coast between Río Chagres and Piña, near Piña, Canal Zone), Chagres sandstone.

Sthenorytis toroensis euthynta, which occurs in the main body of the Chagres sandstone, is based on two specimens, both damaged. It is distinguished from *S. toroensis toroensis* by its larger size and higher, narrower, less flattened lamellae. Because of the larger size, the greater distance between the shoulder-hook and the suture, as compared with *S. pernobilis*, is more apparent than on *S. toroensis toroensis*. The paratype shows the edge of a faint basal disk, partly modified by slight wear.

The fauna of the Chagres sandstone proper indicates deposition in deeper water than the Toro limestone member at the base of the formation. Perhaps *S.*

genus or a subgenus of *Amaea* H. and A. Adams (1853–54, p. 223, 1853; type (logotype, de Boury, 1909, p. 258): *Scalaria magnifica* Sowerby, Recent, western Pacific Ocean), as was done by Clench and Turner (1950, p. 243), is a matter of preference. The type of *Amaea* has a less distinct basal disk and is twice as large as the species of *Scalina*.

The marine member of the Bohio(?) formation at Vamos Vamos (localities 40a, 40d) yielded two incomplete specimens that have the outline and sculpture of a slender *Scalina*, but the basal disk is not preserved. This species is listed as *Scalina?* sp.

Scalina pseudoleroyi (Maury)

Plate 38, figures 6, 21

Epitonium (Acrilla) pseudoleroyi Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 242, 1925 (Miocene, Jamaica).

Ferminoscala pseudoleroyi (Maury), Woodring, Carnegie Inst. Washington Pub. 385, p. 402, pl. 32, figs. 3, 4, 1928 (Miocene, Jamaica; additional citations).

Moderately large, moderately slender. Earliest preserved whorls somewhat angulated, later whorls rounded and moderately inflated. Sculpture modified by wear. Undamaged axial lamellae slightly extended on shoulder. At irregular intervals, particularly on later half of body whorl of large specimens, a lamella is slightly wider than others. Primary spiral threads worn on periphery of whorls, six or seven on late whorls, not including several closely spaced weak threads between shoulder and suture. Secondary spirals microscopic, barely visible on primary spirals, stronger on spaces between them. Basal disk sculptured with subdued axial lamellae and closely spaced narrow spiral threads.

Height (incomplete) 35 mm, diameter 16 mm (largest specimen, figured).

Type: USNM 115437.

Type locality: Bowden, Jamaica, Bowden formation.

Seven incomplete, more or less worn shells are identified as *Scalina pseudoleroyi*. A very small specimen was found in the middle part of the Gatun formation in the eastern area, the others in the upper part of the formation in the eastern area. The identification is based on size and outline, sculpture of the main body of the shell and basal disk, and slight angulation of the earliest preserved whorls. The Canal Zone fossils are more worn than those from Jamaica and the early whorls increase more rapidly in diameter. The earliest preserved whorls of the figured specimen are somewhat flattened dorso-ventrally. The rock matrix cannot be removed from the sutural area without damaging the axial lamellae.

S. pseudoleroyi is more closely related to the eastern Pacific *S. ferminiana* (Dall) (1908, p. 316, pl. 8, fig. 8) than to either of the two species now living in the Caribbean Sea and the Gulf of Mexico. The early whorls of *S. pseudoleroyi* are not as strongly angulated as those of *S. ferminiana*. *S. ferminiana* has been recognized in the Pliocene deposits of southwestern Panamá (Olsson, 1942, p. 76, pl. 9, fig. 6).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 147g. Upper part, eastern area, localities 175, 176. Bowden formation (middle Miocene), Jamaica.

Scalina weigandi (Böse)

Plate 29, figures 7, 8

Scala (Acrilla) weigandi Böse, K. k. Geol. Reichsanstalt Jahrb., Band 60, p. 228, pl. 12, fig. 8, 1910 (Miocene, México).

Moderately large, moderately slender. Earliest preserved whorls rapidly enlarging in diameter, very slightly angulated, later whorls rounded and moderately inflated. Axial lamellae blade-like, extended on shoulder to form short hook. At irreguar intervals a lamella is wider than others. Primary spiral threads strong, seven on late whorls, not including several narrower and more closely spaced threads between shoulder and suture. Primary spirals and spaces between them bearing microscopic spiral threads and fainter microscopic axial threads. Axial lamellae relatively strong on basal disk. Basal disk also bearing narrow closely spaced spiral threads and microscopic sculpture like that on main part of whorl.

Height (incomplete) 26.5 mm, diameter 14.5 mm (larger figured specimen).

Type: Geol. Bundesanstalt, Vienna.

Type locality: Kilometer 70, Tehuantepec Railroad, Vera Cruz, México, deposits of late Miocene age.

This strongly sculptured *Scalina* is represented by three incomplete specimens from the Chagres sandstone. One is larger than those illustrated, but is in poor condition. No specimens from the type region of *S. weigandi* are available. According to Böse's illustration, the type is a small, rapidly enlarging shell that has strong sculpture, including relatively strong axial lamellae on the basal disk. The sculptural plan is the same as that of *S. pseudoleroyi* and there is a possibility that the sculptural difference between the two forms is a matter of wear. It seems to be unlikely, however, that wear would uniformly plane down the sculpture of large specimens. Nevertheless a small specimen (height of 10 whorls 19.2 mm) from locality 208, doubtfully referred to *S. weigandi*, has uniformly reduced sculpture, including suppressed axial lamellae on the basal disk. Its early whorls enlarge a little more rapidly than those of the Gatun fossils identified

for unequivocal identification of the Canal Zone species.. The Eocene Colombian *Strombus* (*Oostrombus?*) *cedroensis* Clark (Clark and Durham, 1946, p. 32, pl. 24, fig. 9) appears to be *Oostrombus chiraensis*. More complete specimens than Clark's are now in the collections of the Museum of Paleontology of the University of California. The winglike outer lip is preserved on the largest (height 76 mm), which is much larger than the fossils from the Canal Zone. Nine Colombian specimens have practically flat-topped whorls, but on one the top of the whorls bulges slightly.

Despite the defective outer lips and apertures, the outline, unsculptured late whorls and thick parietal callus—especially thick on the upper part of the parietal wall—of the fossils from Perú, Colombia, and Panamá strongly point to the Eocene and Oligocene Mediterranean genus *Oostrombus*, as suggested by Olsson for "*Strombus*" *chiraensis*. In fact, the fossils from Panamá are very similar to *O. tournoueri* (Bayan) (1870, p. 480; 1870a, p. 45, pl. 7, figs. 5, 6), which occurs in the middle Eocene strata at Ronca, Italy, and perhaps also at Monte Postale (*O.* cf. *O. tournoueri* (Bayan), Malaroda, 1954, p. 58, pl. 4, figs. 7, 9–12, 14, pl. 12, figs. 15, 22).

Oostrombus evidently is an early Tertiary genus. Sacco thought that *Strombus gibberulus* Linné, one of the numerous strombids living in the tropical western Pacific and Indian Oceans, is a Recent species of *Oostrombus*, presumably on account of the outline and sharply limited thick parietal callus. *Strombus gibberulus*, however, has a nonflaring outer lip, bearing a wide notch at the posterior end and a deep strombid notch near the anterior end, and its body whorl is weakly sculptured.

Despite records to the contrary, the genus *Strombus* is unknown in the Eocene of America. *Strombus albirupianus* Dall (1890–1903, p. 174, pl. 12, figs. 2, 10, 1890) was said to occur in limestone of Jackson age at Claiborne Bluff, Alabama, but really occurs in limestone of late Oligocene age at Jacksonboro, Georgia (idem, p. 1400, footnote, 1903). "*Strombus*" sp.? (Kellum, 1926, p. 27, pl. 5, fig. 7), from the upper Eocene Castle Hayne limestone of North Carolina, does not have a backward bent pillar and therefore is rejected as a *Strombus*. The Eocene Peruvian "*Strombus*" *burhinus* Olsson (1929, p. 24, pl. 5, figs. 5, 6) lacks characteristic strombid features.

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

Genus Strombus Linné

Linné, Systema naturae, 10th ed., p. 742, 1758.

Type (logotype, Montfort, Conchyliologie systématique, v. 2, p. 515, 1810): *Strombus pugilis* Linné, Recent, West Indies and Florida.

Unidentified poorly preserved small species of *Strombus* were found in limestone of late Oligocene age in the lower part of the Caimito formation of Madden basin, in the Culebra formation and its Emperador limestone member, and in limestone of the La Boca marine member of the Panamá formation. The Caimito species has weak spiral sculpture and blunt spines on spire whorls. Two species appear to occur in the Culebra formation, one of which has a slightly ascending outer lip and the other a strongly ascending outer lip. The only fairly complete specimen, collected at locality 115a, has a slightly ascending outer lip, weak spiral sculpture, and strong spines that disappear on the body whorl. The one specimen from the La Boca is slender and has a high slender spire.

Strombus gatunensis Toula

Plate 38, figures 15, 19, 20, 23

Strombus gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 697, pl. 25, fig. 7, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 355, pl. 36, figs. 3–5, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 141, pl. 13, figs. 5, 6, 1922 (Miocene, Panamá, Costa Rica).

Strombus sp., Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 698, pl. 25, fig. 8, 1909 (immature; Miocene, Canal Zone).

Of medium size, strongly inflated. Spire high, outline strongly concave. Suture of body whorl gradually withdrawing from shoulder of penult whorl, but rising again to shoulder at end of whorl. Protoconch consisting of 3½ to 4 rapidly enlarging smooth whorls. Early whorls sculptured with very closely spaced, very narrow, slightly arcuate axial ribs extending from suture to suture. Between the ribs lie weak closely spaced spirals. Early whorls also bearing one to three varices. Narrow ribs of early whorls gradually transformed into widely spaced blunt spines limited to the subangular shoulder. Spines disappearing on the rounded or bluntly subangular shoulder of mature body whorl, or practically disappearing and later reappearing. All except last whorl or two of mature shells sculptured with closely spaced narrow spirals. On mature body whorl spirals limited to space between suture and shoulder and to base. Outer lip bearing a wide shallow notch between shoulder and suture and a shallow strombid notch. Interior of outer lip coarsely puckered.

Height (not quite complete) 59.5 mm, diameter 37.5 mm (larger figured specimen). Height (incomplete) 47.3 mm, diameter 32.3 mm (smaller figured specimen).

Type: Tech. Hochschule, Vienna.

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

Strombus gatunensis occurs in the lower, middle, and upper parts of the Gatun formation and possibly in the Chagres sandstone. The only specimen from the Chagres is worn and incomplete. This *Strombus* is most widely distributed in the middle part of the Gatun in the eastern area, but is nowhere abundant. Two specimens from the lower part of the Gatun are available. One of these, collected at locality 138a, has somewhat stronger spirals on the penult whorl than other specimens and the withdrawal of the body-whorl suture from the shoulder of the penult is more marked than on specimens from the middle part of the formation. All mature body whorls, however, have spiral sculpture only at the top and base. The weakest body-whorl spiral sculpture is shown by two well preserved specimens from the upper part of the formation in the western area, one of which is illustrated (pl. 38, figs. 20, 23). On both withdrawal of the body-whorl suture is as marked as on the lower Gatun fossil just mentioned. Miocene deposits in Costa Rica and on islands in Almirante Bay off the northwestern coast of Panamá, contain somewhat larger specimens, which also have very weak spiral sculpture on the body whorl but only slight body-whorl withdrawal from the suture.

The type of *S. gatunensis* (incomplete height 41.5 mm, incomplete diameter 30.7 mm), the illustrated specimen, closely resembles that shown on plate 38, figures 15, 19, but the shell is replaced by calcite and the early whorls are missing. Toula's *Strombus* sp. is an immature, and therefore strongly strongly sculptured, specimen of *S. gatunensis*. His *Strombus* sp. indet. is missing.

Strombus gatunensis is perhaps most closely related to *S. bifrons* Sowerby (1850, p. 48, pl. 9, fig. 9), which occurs in the Gurabo formation of the Dominican Republic and the Bowden formation of Jamaica, both of middle Miocene age. *S. bifrons* has more widely spaced axial ribs on early whorls, spiral sculpture on the entire body whorl, and persistent shoulder spines. It also has a peculiar bulge on the body whorl beyond the apex of the shallow strombid notch.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136a, 138a. Middle part, eastern area, localities 141 (identification doubtful), 155, 155a, 155b, 155c, 159 (identification doubtful), 160. Upper part, western area, localities 182, 182a. Chagres sandstone (early Pliocene), locality 208 (identification doubtful). Middle Miocene, Costa Rica. Deposits of late Miocene age, Bocas del Toro area, Panamá.

Genus Orthaulax Gabb

Gabb, Acad. Nat. Sci. Philadelphia Proc., v. 24 (1872), p. 272, 1873.

Type (monotype): *Orthaulax inornatus* Gabb, Miocene, Dominican Republic.

Orthaulax is an endemic American genus found in the Caribbean region and its borders. It is recorded from Georgia, Alabama, Florida, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Vieques, St. Croix, Anguilla, Antigua, México, Guatemala, Canal Zone, Venezuela, and Brazil. Twelve species and subspecies have been described, but some of them are purely nominal. *O. gabbi*, the last species in southeastern United States, is the only species represented by a full suite of growth stages and is the only species well enough preserved to have an undamaged outer lip.

The genus appears throughout its known maximum geographic range (except Brazil) during late Oligocene time and survived until the end of early Miocene. That is, it occurs in three faunal zones: one late Oligocene and two early Miocene. As suggested by Davies (1935, p. 266), the massive shell of *Orthaulax*, strengthened by the thick parietal callus under the successively overlapping whorls, is reasonably interpreted as an adaptation to strongly surging water. Its wide distribution in the late Oligocene coincides with an equally wide development of coral reefs. It appears as suddenly as an invader and has no known immediate predecessors in the Caribbean region or elsewhere. Nevertheless it presumably arose from an *Oostrombus*-like ancestor in the Caribbean region. A suitable facies for immediate ancestors has not yet been found in the lower Oligocene deposits of that region.

A Japanese Eocene species has been described as *Orthaulax japonica* (Nagao, 1924, p. 15, pl. 1). It has been pointed out that the occurrence of this American genus in Japan should be deleted (Woodring, 1928, p. 91). The Japanese fossil is not a strombid; it evidently is a buccinid.

In the Canal Zone and adjoining parts of Panamá *Orthaulax* occurs in the upper Oligocene and the lower part of the lower Miocene. The material is very inadequate, too inadequate for illustrations. In fact, it is not suitable for much more than establishing the presence of the genus.

Orthaulax cf. O. pugnax (Heilprin)

Orthaulax pugnax (Heilprin), Cooke, in Vaughan, U. S. Natl. Mus. Bull. 103, p. 550 (mentioned), 553 (list), 1919 (Oligocene, Canal Zone).

Orthaulax gabbi Dall, Cooke, U. S. Geol. Survey Prof. Paper 129, p. 29, 30 (USGS locality 5901), 1921 (Oligocene, Canal Zone).

Orthaulax cf. *O. pugnax* (Heilprin), Woodring, Smithsonian Misc. Coll., v. 135, no. 3, p. 15 (list), 1958 (Oligocene, Canal Zone).

Fragmentary remains of *Orthaulax* from the upper part of the Bohio formation on Barro Colorado Island, the middle member of the Caimito formation in the Gatun Lake area, and in limestone of the lower part of the Caimito in Madden basin are identified as *Orthaulax* cf. *O. pugnax*. Of the nine specimens, one of medium size (diameter 26 to 36 mm) from each area shows the shoulder outline, which is triangular. All except one of the few topotypes and other specimens of *O. pugnax* (Heilprin) (Dall, 1890–1903, p. 170, pl. 8, figs. 5, 8, 1890) in the collections of the U. S. National Museum have a triangular shoulder outline, formed by swellings produced by the thick callus pad on the posterior part of the parietal wall and two earlier concealed callus pads. The exception is an unusually well preserved topotype of medium size (diameter 25 mm), which has a circular outline. A fairly large specimen from Madden basin (diameter 52 mm) appears to be low-spired and circular. An axial section, however, shows that what appears to be shell outline is modified by hard fine-grained calcareous sediment.

O. gabbi Dall (1890–1903, p. 170, pl. 12, figs. 5–5b, 1890) has a triangular or circular outline. Immature shells are circular; a few of medium size are circular, but most are triangular; and mature shells are triangular. *O. gabbi* is more strongly shouldered than *O. pugnax*. As *O. gabbi* nears maturity, and at maturity, a bulging ridge projects from the shoulder between the swellings producing the triangular outline (Dall, 1890–1903, pl. 12, fig. 5b, 1890). Behind the ridge the shell is flattened or even concave. None of the large specimens, on which the shoulder ridge is particularly strong, has yet been illustrated. The lower part of the well preserved circular-shouldered topotype of *O. pugnax* is sculptured with closely spaced, narrow, weak spirals. *O. gabbi* has no spirals, but stronger spiral sculpture covering a larger part of the shell is present or absent on *O. aguadillensis* Maury.

O. pugnax is found in deposits of late Oligocene age in southeastern United States, northeastern México, and Antigua, and in the lower Miocene Tampa limestone of Florida (type locality). *O. gabbi* occurs in the lower Miocene Chipola formation of Florida, which is younger than the Tampa limestone.

Occurrence: Upper part of Bohio formation (late Oligocene), locality 42d. Middle member of Caimito formation (late Oligocene), Gatun Lake area, localities 57, 57a. Lower part of Caimito formation (late Oligocene), Madden basin, locality 71.

Orthaulax cf. O. aguadillensis Maury

Orthaulax gabbi Dall, Cooke, U. S. Geol. Survey Prof. Paper 129, p. 29, 30 (USGS localities 6515, 6019g ("identification very doubtful" for 6019g), 1921 (Miocene, Canal Zone).

The Culebra formation and its Emperador limestone member yielded six poorly preserved incomplete fossils (maximum diameter 55 mm) identified as *Orthaulax* cf. *O. aguadillensis*. The circular shoulder outline of the specimens that have a complete and unmodified outline and the thick parietal callus on enveloped whorls suggest *O. aguadillensis* (Maury, 1920, p. 58, pl. 9, fig. 4). To be sure, the outline of some specimens is incomplete or modified by rock matrix and only the lower part of the concealed parietal callus is shown in axial section. *O. aguadillensis* has a circular shoulder outline at growth stages ranging in diameter from 15 to 100 mm. *O. gabbi* shows thick callus in an axial section passing through a shoulder swelling and thin callus in other axial sections (C. W. Cooke, 1921, pl. 3, fig. 7; pl. 4, fig. 1). Any random axial section of *O. aguadillensis*, however, shows thick callus (C. W. Cooke, 1921, pl. 4, figs. 5, 6; pl. 5, fig. 1b; Woodring, 1923, pl. 1, figs. 3, 4, 10, 11; pl. 2, fig. 4).

O. aguadillensis is widely distributed in both the lower and the upper early Miocene faunal zones. It has been recognized in Guatemala (identification doubtful), Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico (type locality), Vieques, St. Croix, and Anguilla (identification doubtful). The early Miocene Cuban *O. bermudezi* Clench and Aguayo (1939) seems to be *O. aguadillensis*. Unlike other fossils identified as *O. aguadillensis*, the type of *O. bermudezi* has part of the outer lip preserved. It is flaring and winglike, like that of many strombid gastropods.

Occurrence: Culebra formation (early Miocene), localities 99g, 115a. Emperador limestone member of Culebra formation (early Miocene), localities 119, 120.

Genus Terebellum Röding

Röding, Museum Boltenianum, p. 135, 1798.

Type (tautotype and logotype, Winckworth, Malacological Soc. London Proc., v. 26, p. 144, 1945): *Terebellum nebulosum* Röding (=*Bulla terebellum* (Linné)=*Conus terebellum* Linné), Recent, tropical western Pacific Ocean.

Both *Terebellum nebulosum* Röding and *T. lineatum* Röding are available as tautotype, for under both *Bulla terebellum* (Linné) is cited. This is a legalistic matter

of no importance, for both of Röding's names refer to one species, *Terebellum terebellum* (Linné), the only Recent species of the genus.

Subgenus Terebellum s.s.

Terebellum (Terebellum) procerum Merian?

Plate 25, figures 5, 7

Large, moderately slender, high-spired. Height of spire whorls increasing at moderate rate, except penult, the height of which increases very rapidly. Body whorl slightly inflated. Suture of body whorl rapidly descending, then straightening near outer lip. Outer lip and aperture unknown.

Height (incomplete) 53.5 mm, diameter (slightly increased by crushing) 17 mm (largest specimen). Height (incomplete) 43.7 mm, diameter (slightly increased by crushing) 16.5 mm (larger figured specimen).

Incomplete molds of a large *Terebellum* from limestone of the Gatuncillo formation at locality 12, so far as they go, closely resemble *T. subdistortum* Trechmann (1923, p. 349, pl. 18, figs. 8, 9), which was based on more complete molds from the middle Eocene Yellow Limestone of Jamaica. The largest mold collected at locality 12 would have a height of about 75 mm, if it were complete. As may be seen on Trechmann's photographs, the outer lip of *T. subdistortum* extends upward, how far is not determinable on molds. The straightening of the body-whorl suture near the outer lip indicates that adult shells from Panamá also had an ascending outer lip. The outer lip of *T. fusiforme* Lamarck (Cossmann and Pissarro, 1910–13, pl. 31, fig. 158–1), a small slender Eocene European species, ascends the spire, but generally is partly broken. The sole surviving Recent species, *T. terebellum* (Linné), has a nonascending outer lip and an extension of the parietal callus borders the slit-like suture. *T. fusiforme* has a closely appressed suture not bordered by an extension of the parietal callus. It evidently is intermediate between *Terebellum* proper and the involute subgenus *Seraphs*, the slit under the extension of thte outer lip corresponding to the slit-like suture of *T. terebellum*.

According to Rutsch (1931, p. 254, footnote), *T. subdistortum* is the species casually named *T. procerum* by Merian (1844, p. 64) at a much earlier date. Merian reported on a few Jamaican fossils attributed to the White Limestone of de la Beche, which included both the White Limestone and the Yellow Limestone of later usage. Merian's species is unrecognizable on the basis of his one-sentence description "* * * has about the shape of *T. subulatum* Lam., but is almost twice as long and wide". The type, in the collection of the Basel Naturhistorisches Museum, saves the name. The type and also the type of the Antiguan *Scalaria melanoidea*, described even more briefly at the same time, should be illustrated. As a matter of fact, *T. subdistortum* is not almost twice as large as *T. subulatum* (that is, *T. terebellum*); it is only slightly larger.

There are at least three species of *Terebellum* in the lower Tertiary limestones of Jamaica: *T. procerum* and two species collected by J. W. Spencer "near Port Antonio," both represented by molds made up of miliolid white limestone. One is high-spired and very slender; the other is low-spired and has a relatively strongly inflated body whorl.

T. procerum is the largest of the few American species of the subgenus *Terebellum* proper. The subgenus was widely distributed in the Eocene, survived until Oligocene time in America and Europe, and is now a relic in the tropical western Pacific Ocean, where one species survives.

Occurrence: Gatuncillo formation (late Eocene), locality 12.

Subgenus Seraphs Montfort

Montfort, Conchyliologie systématique, v. 2, p. 575, 1810.
Type (orthotype): *Seraphs convolutus* (Lamarck) (*Terebellum convolutum* Lamarck), Eocene, Europe.

Terebellum (Seraphs) belemnitum Palmer?

Plate 25, figure 6

The silicified fossils collected in the Río Casaya area include three incomplete remains of a relatively large *Seraphs*. The figured specimen, which is the largest, is estimated to have had a height of abont 55 mm when it was complete. This specimen shows the slit-like extension of the aperture and that the slit is bordered on the parietal wall by a ledge. It does not show any parietal callus, but the parietal callus of *Seraphs* is very thin. The type species of *Seraphs* and other species in western Europe do not have a ledge on the parietal wall; the wall extends smoothly under the outer lip.

These fossils are almost as large as the molds from the same formation identified as *Terebellum procerum?* and have a similar outline. The molds, however, cannot he molds of the *Seraphs*, because one of the silicified shells of the *Seraphs* shows that it is involute at an early stage.

This involute *Terebellum* probably is *T. belemnitum* Palmer (Richards and Palmer, 1953, p. 25, pl. 3, figs. 9, 12), which occurs in the middle or upper Eocene of Florida. Though the figured Canal Zone specimen (the only large specimen showing the apical end of the shell) tapers a little more rapidly than the type of

T. belemnitum, the Florida species has a ledge on the parietal wall.

Seraphs, like *Terebellum* proper, was widespread during the Eocene and less extensively distributed during the Oligocene. Unlike *Terebellum* proper, it failed to survive the Oligocene. *T. belemnitum* is the sole American species.

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

Genus Ectinochilus Cossmann

Cossmann, Soc. Roy. Malacologique Belgique Annales, v. 24, p. 87, 1889.

Type (orthotype): *Strombus canalis* Lamarck, Eocene, Europe.

Ectinochilus cf. E. gaudichaudi (d'Orbigny)

Plate 25, figures 8, 14–16

Molds of a fairly large *Ectinochilus* are common in limestone of the Gatuncillo formation at some localities and a few molds of small specimens, presumably representing the same species, were found in sandstone. The molds collected from limestone show the general outline (approximate maximum dimensions: height 37 mm, diameter 14 mm). Some show a few of the relatively strong widely spaced axial ribs on the body whorl (pl. 25, fig. 15) and some show coarse spirals at the base of the body whorl. The total number of ribs on the body whorl is estimated to be 14. The ascending outer lip and accompanying slitlike extension of the aperture are preserved on one of the molds from sandstone (pl. 25, fig. 16). There is no strombid notch on the outer lip. This specimen and the other two small molds from sandstone show body-whorl axial ribs like those of the larger limestone molds, more numerous and more closely spaced axial ribs on at least two preceding whorls, coarse spirals on the basal third of the body whorl, and a suggestion of fine spirals on the remainder of the body whorl and on spire whorls.

Ectinochilus has been found in middle and upper Eocene deposits in Perú, Colombia, Venezuela, Trinidad, and Jamaica, and also in Southeastern United States and on the Pacific coast of United States. Most of the species from tropical America are not well known. The inadequate material from Panamá suggests a species that is more inflated and has stronger axial ribs than the typical form of the Peruvian *E. gaudichaudi* (d'Orbigny) (1842–47, p. 116, pl. 14, figs. 6–8; Olsson, 1928, p. 71, pl. 16, figs. 6, 7), and has stronger body-whorl axial ribs than *E. gaudichaudi aulada* Olsson (1928, p. 73, pl. 16, figs. 3, 4), a small form more strongly sculptured than the typical form.

Ectinochilus is another strombid genus that is widely distributed in the Eocene (Wrigley, 1938, p. 71). It survived until early Oligocene time in Europe. The species from Panamá, like other American species, is much larger than the European species.

Occurrence: Gatuncillo formation (late Eocene), localities 9, 11, 12, 34.

Family CYPRAEIDAE

Genus Cypraea Linné

Linné, Systema naturae, 10th ed., p. 718, 1758.

Type (logotype, Montfort, Conchyliologie systématique, v. 2, p. 631, 1810): *Cypraca tigris* Linné, Recent, tropical western Pacific Ocean. (Montfort spelled the generic name *Cypræa*.)

Molds of an unidentified small strongly inflated *Cypraea* (height 21 mm, lateral diameter 16 mm, dorsoventral diameter 10.5 mm) were found in limestone of the Gatuncillo formation at localities 11 and 12. Their exposed spire distinguishes them from molds of *Cypraedia* aff. *C. subelegans* (p. 196) that show no trace of sculpture. The two species are associated and have practically the same dimensions.

Subgenus?

Cypraea cf. C. chilona Dall

Incomplete molds of a wide *Cypraea*, strongly inflated dorsally, occur in strata of late Oligocene and early Miocene age. They suggest *Cypraea chilona* Dall (Gardner, 1926–47, p. 541, pl. 54, figs. 7, 9, 1947), of the lower Miocene Chipola formation of Florida. These molds are of medium size (approximate dimensions: height 32 mm, lateral diameter 26 mm, dorsoventral diameter 20 mm) and with one exception are smaller than *C. chilona*. The exception is a specimen from the Culebra formation which, were it complete, would have a height of about 42 mm, comparable to that of *C. chilona*.

The Anguilla formation of the island of Anguilla and the Güines limestone of Cuba, both of early Miocene age, have yielded similar molds (C. W. Cooke, 1919, p. 115).

C. chilona was referred to the genus *Cypraeorbis* Conrad, subgenus *Proadusta* Sacco, by Schilder (1932, p. 125) and to *Cypraeorbis*, as a subgenus of *Cypraea*, by Gardner.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 56. Quebrancha limestone member of Caimito formation (late Oligocene), locality 62. Lower part of Caimito formation (late Oligocene), Madden basin, locality 71. Culebra formation (early Miocene), localities 99g, 100b, 110. Emperador limestone member of Culebra formation (early Miocene), localities 119, 121.

Subgenus Muracypraea Woodring

Woodring, Nautilus, v. 70, p. 88, 1957.

Type (orthotype): *Cypraea mus* Linné, Recent, south border of Caribbean Sea.

As outlined in the publication just cited, *Muracypraea* was proposed for *Cypraea mus* and its fossil allies, for which the name *Siphocypraea* has been used erroneously. The American Tertiary species of *Muracypraea* represent the lineage of *Cypraea henekeni* Sowerby. That lineage appeared in strata of early Miocene age in Trinidad (*C. henekeni*), Venezuela (*C. angustirima hyaena* (Schilder), and Perú (*C. angustirima* Spieker) and reached its maximum distribution in the middle Miocene: in Jamaica (*C. henekeni*), the Dominican Republic (*C. henekeni*), Trinidad (*C. henekeni*), Venezuela (*C. henekeni*), Colombia (*C. henekeni*), the Canal Zone (*C. henekeni*), Costa Rica (*C. henekeni*), Ecuador (*C.* cf. *C. henekeni*), and Baja California (*C. henekeni amandusi* Hertlein and Jordan, which may be indistinguishable from *C. henekeni* proper). The known distribution in late Miocene time included Trinidad (*C. henekeni*), Venezuela (*C. henekeni*), and Panamá (*C. henekeni*, *C. almirantensis* Olsson), but during early Pliocene time it dwindled to Venezuela (*C.* aff. *C. henekeni*) and Ecuador (*C. cayapa* Pilsbry and Olsson). *C. mus* is smaller than the species of the lineage of *C. henekeni*. It is not known to antedate the Pleistocene and its immediate predecessor has not been recognized. *C. mus* is found along the Caribbean coast of Colombia and Venezuela. That is, the geographic range of *Muracypraea* has steadily dwindled since middle Miocene time. *Muracypraea* reached the western Pacific Ocean during the Miocene. Martin's illustrations (1891–1922), p. 168, pl. 26, figs. 386, 386a, b, pl. 27, figs. 387, 387a, 388, 1899) indicate that his *Cypraea murisimilis*, from the Miocene of Java, is closely allied to *C. henekeni;* in fact Vredenburg (1920, p. 95) claimed that it is *C. henekeni.*

Cypraea (Muracypraea) henekeni Sowerby

Plate 31, figures 6–10; plate 32, figures 1, 4, 6, 9

Cypraea henikeri Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 45, pl. 9, fig. 3, 1850 (Miocene, Dominican Republic; error for *henekeni*).

Cypraca henekeni Sowerby, Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 235, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 114, pl. 19, fig. 4, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 365, 1922 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 219, pl. 37, fig. 1, 1925 (Miocene, Trinidad). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 139, 1929 (Miocene, Colombia). Ingram, Bull. Am. Paleontology, v. 24, no. 85, p. 8, pl. 1, fig. 3, 1939 (Miocene, Dominican Republic).

Cypraca henikeni Sowerby, var., Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 356, pl. 26, fig. 8, 1911 (Miocene, Canal Zone; error for *henekeni*).

Cypraca henekeni lacrimula Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 220, pl. 37, fig. 2, 1925 (Miocene, Trinidad).

Cypraca caroniensis Maury, idem, p. 221, pl. 37, figs. 3, 5, 6, 1925 (Miocene, Trinidad).

Siphocypraca isthmica Schilder, Arch. Naturgesch., 91st year (1925), pt. A, no. 10, p. 99, 144, 1927 (Miocene, Canal Zone).

Siphocypraca henikeri (Sowerby), Schilder, Schweizerischen Palaeont. Gesell. Abh., Band 62, p. 24, 1939 (Miocene, Trinidad).

Siphocypraca caroniensis (Maury), Schilder, idem, p. 24, figs. 26, 27, 1939 (Miocene, Trinidad).

Siphocypraca quagga Schilder, idem, p. 25, fig. 28, 1939 (Miocene, Venezuela).

Cypraca henekeni potreronis Ingram, Bull. Am. Paleontology, v. 24, no. 85, p. 5, pl. 1, figs. 8, 9, 1939 (Miocene, Dominican Republic).

Cypraca andersoni Ingram, idem, v. 31, no. 120, p. 42, pl. 2, fig. 2, 1947 (Miocene, Colombia). Ingram, Calif. Acad. Sci. Proc., 4th ser., v. 26, no. 6, p. 125, pl. 2, figs. 5, 7, 1948 (Miocene, Colombia).

Cypraca tuberae Ingram, Bull. Am. Paleontology, v. 31, no. 120, p. 61, pl. 2, fig. 1, 1947 (Miocene, Colombia). Ingram, Calif. Acad. Sci. Proc., 4th ser., v. 26, no. 6, p. 129, pl. 2, figs. 9, 12, 1948 (Miocene, Colombia).

Cypraca projecta Ingram, Bull. Am. Paleontology, v. 31, no. 121, p. 5, pl. 1, figs. 4, 5, 1947 (Miocene, Colombia).

Cypraca grahami Ingram, idem, p. 6, pl. 2, figs. 6, 7, 1947 (Miocene, Venezuela).

Cypraca rugosa Ingram, idem, p. 7, pl. 2, figs. 8, 9, 1947 (Miocene, Venezuela; not *C. rugosa* Broderip, 1827).

Of medium size, pyriform, very wide, strongly inflated dorsally. Lips, sides, and posterior part of dorsal surface heavily enameled. Outer lip and sides smooth, roughened, or slightly corrugated. Posterior part of dorsal surface smooth, roughened, warty, or bituberculate. Outer lip wide, slightly constricted near anterior end, bearing 17 or 18 short teeth on large specimens. Inner lip of large specimens bearing 13 to 16 short teeth. Fossula indistinct; wide, shallow, smooth. Aperture moderately wide. Siphonal canal long and deep, bordered on columellar side by a strong narrow terminal ridge and a weak ridge on outer lip. Outer and inner lips prolonged to form short flanges bordering siphonal canal or long flaplike flanges. Posterior outlet very deep and long, it sides indistinctly or strongly rimmed. Color pattern consisting of brownish mottling on central part of dorsal surface and interrupted narrow brownish bands on sides of dorsal surface. The bands reaching ventral surface, but on inner lip, and on outer lip of some specimens, obscured by enamel. If present on outer lip, they are alined with teeth, except small anterior teeth.

Height 55.3 mm, lateral diameter 40.8 mm, dorsoventral diameter 29.3 mm (largest figured specimen from middle part of Gatun formation). Height 55.7

mm, lateral diameter 44 mm, dorsoventral diameter 32.5 mm (figured specimen from upper part of Gatun formation).

Type: British Museum (Natural History), Geol. Depart., Geol. Soc. London collection, 12772.

Type locality: Northern part of Dominican Republic (presumably Cercado or Gurabo formation, middle Miocene).

The trivial name of this species has been spelled in three ways: *henikeri*, *henekeni*, and *henikeni*. The original orthography was *henikeri*. That spelling was used consistently, both by Sowerby and by Moore in his accompanying paper, for the name of the British Army officer who was the collector of the first fossils from the present Dominican Republic to reach England. Three years later, however, the collector himself published an article on his observations in Santo Domingo and his name is printed T. S. Heneken (1853). He then was a Fellow of the Geological Society of London, which printed his paper. Mr. Arthur Greig, Assistant Secretary of the Society, kindly informs me that there is no doubt that the name was Col. T. S. Heneken, as that spelling appears in all of the records of the Society. Mr. Greig suggests "a reasonable explanation is that he sent the fossils and notes from San Domingo and, as he was personally unknown to Moore and Sowerby, they misread his handwriting." Though there is no internal evidence in the original account, the original orthography clearly was an unintentional error and alteration to *henekeni* is justified. To claim that the alteration is inadmissible because Sowerby did not state that the species (and three others) was named for the collector is unrealistic. Guppy and Gabb, who were the first to deal with the fossils named for Heneken, made the change without any comment, as though it were to be done as a matter of course. Maury (1917, p. 53) and Pilsbry (1922, p. 305) commented on the change in spelling. The third spelling, *henikeni*, evidently is a typographic error.

This variable species occurs in the three parts of the Gatun formation, but has not been found in the middle part in the western area or in the upper part in the eastern area. A total of 17 specimens, or parts of specimens, is available: eight from the lower part, seven from the middle part, and two from the upper part. The presence or absence of dorsal warts or tubercules, the length of the flanges bordering the siphonal canal, and the height of the rim bordering the posterior outlet are the most conspicuous expressions of variability. Shells that are only roughened are most common, but warty or tuberculate shells occur in the three parts of the formation. Variation affecting the flanges is well shown by two specimens collected at the Gatun Locks excavation (pl. 31, figs. 6–8). Though the short flanges of the larger specimen are intact, the longer flanges of the smaller specimen are broken back. The most extended flaplike flanges are shown by a specimen from the lower part of the Gatun (pl. 32, figs. 6, 9). Their anterior edge is nicked and therefore irregular in outline. Another specimen from the lower part of the Gatun has the highest rim bordering the posterior outlet (pl. 32, figs. 1, 4).

At least part of the color pattern is visible on almost all of these fossils. It is best shown on the two specimens from the Gatun Locks excavation just mentioned (pl. 31, figs. 6–8). They have well preserved smoothly polished enamel. Their pale ocherous overall color probably is a bleached version of the original color. Some specimens show a darker brownish background color.

The variability of *Cypraea henekeni* has resulted in excessive naming. *Siphocypraea isthmica* was based on Brown and Pilsbry's remarks and illustration. *Cypraea henekeni lacrimula*, *C. caroniensis* and *C. henekeni potreronis* were based on features depending on the amount and shape of enamel on the posterior part of the dorsal surface. *C. andersoni*, *C. tuberae*, and *C. projecta* occur in middle Miocene strata near Tuberá, Colombia. *C. grahami* and *C. "rugosa"* were found at the same locality on the island of Cubaga, off the coast of Venezuela. Some of the names in the synonymy may prove to be useful for local populations when adequate samples are available. Most of the names, however, are based on features shown by small samples from a single region.

With due regard for variability, *Cypraea henekeni* has an extensive distribution in Miocene deposits: in the Dominican Republic, Jamaica, Trinidad, Venezuela, Colombia, and the Canal Zone. It is recognized in the lower Miocene, is most widely distributed in the middle Miocene, and continues into the upper Miocene. In the type region Maury's collectors found *C. henekeni* in both the Cercado and Gurabo formations; the U. S. Geological Survey party only in the Gurabo formation. The species was well illustrated by Sowerby, except that on his illustration the aperture is too sinuous and the anterior construction of the outer lip is too pronounced. *C. henekeni* is rare in the Bowden formation of Jamaica. A few years ago C. B. Lewis, Director of the Institute of Jamaica, collected two fragments of a large specimen at Bowden.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136a, 138, 138a. Middle part, eastern area, localities 155, 155a, 159b. Upper part, western area,

localities 182, 182a. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Machapoorie limestone (early Miocene), Brasso formation (middle Miocene), and Springvale formation (late Miocene), Trinidad. Deposits of middle and late Miocene age, Venezuela. Deposits of middle and late Miocene age, Colombia. Deposits of middle Miocene age, Costa Rica.

Family OVULIDAE

Genus Cypraedia Swainson

Swainson, A treatise on malacology, p. 325, 1840.

Type (monotype): *Cypraedia cancellata* Swainson (?=*Cypraea elegans* Sowerby, Eocene, western Europe).

Cypraedia aff. C. subelegans (Trechmann)

Limestone of the Gatuncillo formation yielded molds of a strongly inflated *Cypraedia* of medium size. The molds are involute and some show traces of cancellate sculpture, the axial threads being fainter than the spiral. The dimensions of the largest specimen are as follows: height 27.5 mm, lateral diameter 22 mm, dorsoventral diameter 16 mm. These molds strongly suggest *Cypraedia subelegans* (Trechmann, 1923, p. 352, pl. 15, fig. 4), which was based on poorly preserved material from the middle Eocene Yellow Limestone of Jamaica. *C. subelegans* evidently is more closely related to the larger *C. fenestralis* (Conrad) (Harris and Palmer, 1946–47, p. 320, pl. 40, figs. 9, 10, 17, 18, 1947), an upper Eocene species from southeastern United States, than to the middle and upper Eocene European *C. elegans* (Sowerby), which is smaller and less inflated. Trechmann's (1923, p. 352, pl. 15, figs. 5, 6) *Cypraedia* cf. *C. elegans*, associated with *C. subelegans* in the Yellow Limestone, presumably is *C. subelegans*.

Occurrence: Gatuncillo formation (late Eocene), localities 11, 12.

Genus Eocypraea Cossmann

Cossmann, Essais de paléoconchologie comparée, pt. 5, p. 162, 1903.

Type (orthotype): *Cypraea inflata* Lamarck, Eocene, western Europe.

Subgenus Apiocypraea Schilder?

Schilder, Arch. Naturgesch., 91st year (1925), pt. A, no. 10, p. 75, 1927.

Type (orthotype): *Cypraea michaudiana* Grateloup, Miocene, southwestern Europe.

Eocypraea (Apiocypraea?) keenae Woodring, n. sp.

Plate 32, figures 8, 10

Very large, elongate ovate, moderately inflated, involute, thin-shelled. Outer lip moderately wide, its inner edge bearing about 37 teeth, which extend about a third of distance across lip. Anterior and apical parts of outer lip not preserved. Terminal ridge (on columellar side of siphonal canal) wide and swollen. Inner lip bearing a deep indentation adjoining terminal ridge, followed in succession by two short oblique teeth and a shallow indentation. Remainder of inner lip smooth, at least down to level of outer lip. Aperture very narrow. Posterior outlet evidently absent.

Height (not quite complete) 115 mm, lateral diameter (increased by dorsoventral crushing) 76 mm, dorsoventral diameter (diminished by dorsoventral crushing) 56 mm (type).

Type: USNM 562604.

Type locality: 155 (Stanford Univ. 2653, Gatun Third Locks excavation, lat. 9°16′ N., plus 4,700 feet (1,430 meters), long. 79°54′ W. plus 5,800 feet (1,770 meters), Canal Zone, units 11 and 12 of section (chapter A, p. 44), middle part of Gatun formation.

This remarkable fossil is one of the few undescribed large species from the middle part of the Gatun formation. The type, found by T. F. Thompson at the Gatun Third Locks excavation, is the only specimen. It was recognized as a new species by Miss Myra Keen, for whom it is named. The thin shell is crushed dorsoventrally and at numerous places is cracked, or cracked and displaced. Part of the shell on the dorsal surface and much of the outer lip are missing. The fine-grained mold, however, shows impressions of the missing teeth of the outer lip. Though the posterior part of the outer lip is missing, it evidently formed a low arch as it curved down to the concealed apex. There apparently was not even a poorly defined posterior outlet. Except at its anterior end, the inner lip is smooth, down to the level of the outer lip. It was not excavated to a lower level in order to leave support for the undamaged part of the outer lip and the mold where the shell is missing. If there were any teeth or tubercles on the apparently smooth part of the inner lip, they presumably would be visible at the level of the outer lip.

Despite its large size—seven times as large as the little Eocene type species of *Eocypraea*—the architectural plan of this species indicates alliance to *Eocypraea*. *Eocypraea* proper, however, is pyriform and has a low rim at the outer edge of the outer lip. It also has short teeth on the inner lip, a low callus swelling at the posterior end of the inner lip, and a narrow terminal ridge. European species of medium size, ranging in age from Oligocene to Pliocene, have been assigned to the subgenus *Apiocypraea* (Schilder, 1932, p. 219–222). According to Cossmann and Peyrot's (1922, p. 357, pl. 9, figs. 22, 23, pl. 10, fig. 5; de-

scribed as *Cypraea* (*Adusa*) *subamygdulum* d'Orbigny) description and illustrations of the type species, typical *Apiocypraea* has no teeth on the posterior half of the inner lip, but the outer lip is rimmed and there is no indication of a wide swollen terminal ridge. A new subgeneric or generic name may be justified for *Eocypraea keenae*. A new name, however, should be based on more complete material.

The Miocene Venezuelan moderately large ovulid described as *Marginocypraea paraguana* by Ingram (1947, p. 3, pl. figs. 1, 2) is the only American fossil or living species with which *Eocypraea keenae* needs to be compared. The Venezuelan species has a thicker shell, rimmed outer lip, narrower terminal ridge, and teeth along the entire inner lip. It is the type of *Marginocypraea*. Despite the presence of teeth along the entire inner lip, *Marginocypraea paraguana* seems to be not far removed from *Apiocypraea*.

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

Family ATLANTIDAE

Genus Protatlanta Tesch

Tesch, Notes from Leyden Mus., v. 30, p. 8, 1908.
Type (orthotype): *Atlanta lamanonii* Souleyet=*A. souleyeti* Smith, Recent, circumtropical.

Subgenus Atlantidae Pilsbry

Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 314, 1922.
Type (orthotype): *Atlanta rotundata* Gabb, Miocene, Dominican Republic.

Protatlanta (Atlantidea) lissa (Woodring)

Plate 30, figures 5, 6

Atlanta (*Atlantidea*) *lissa*, Woodring, Carnegie Inst. Washington Pub. 385, p. 134, pl. 2, figs. 26, 27, 1928 (Miocene, Jamaica).

Of medium size, nautiloid. Early whorls deeply and asymmetrically recessed. Protoconch consisting of about two slowly enlarging whorls. Remaining three whorls rapidly enlarging and strongly inflated. Periphery of body whorl broadly rounded, early half bearing two very low faint ridges. Aperture broken.

Height 2.5 mm, diameter 5 mm (figured specimen).

Type: USNM 369336.

Type locality: Bowden, Jamaica, Bowden formation.

Two specimens of this inflated heteropod, which has a rounded *Oxygyrus*-like periphery, were collected by Rowell and Hill many years ago at and near Mount Hope. One is fragmentary: half of an immature body whorl. The periphery of this fragment bears two faint grooves, instead of ridges, and obscure, somewhat oblique spiral undulations are visible on the sides. The figured specimen is larger than the type of *Protatlanta lissa* (diameter 2.8 mm), which does not show any indication of peripheral ridges or grooves. *P. rotundata* (Gabb) (Pilsbry, 1922, p. 314, fig. 15) has a similar outline, but is sculptured with microscopic spirals. It occurs in the Cercado formation of the Dominican Republic. The periphery of the type bears two faint grooves.

Whether the periphery of these two species bears two ridges or two grooves, or shows no indication of either evidently is determined by the state of shell preservation. The significance of the ridges (or grooves) is uncertain. They may mark the trace of the attachment of a cartilaginous keel split into two limbs at the apertural margin, or may possibly mark the borders of a shallow V-shaped apertural slit. The sides of the figured specimen show faint gently arcuate growth lines which step at the ridges. There is a vague suggestion of V-shaped growth lines in the narrow space between the ridges, but they are too obscure for unqualified interpretation.

As suggested by Pilsbry, *P. souleyeti* (Smith) (Tesch, 1949, p. 13, figs. 4–6), the type and only species of the subgenus *Protatlanta* s.s., appears to be the most closely related Recent species. The early whorls of that species form a spire visible in apertural view and the periphery bears a very thin, transparent cartilaginous keel split at the aperture into two coalescing limbs. Until the features of *P. rotundata* and *P. lissa* are better known, *Atlantidea* is treated as a subgenus of *Protatlanta*.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, localities 174, 177. Bowden formation (middle Miocene), Jamaica.

Family CASSIDIDAE

Genus Galeodea Link?

Link, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, pt. 3, p. 113, 1807.
Type (monotype): *Galeodea echinophora* (Linné) (*Buccinum echinophorum* Linné) Recent, Mediterranean Sea and eastern Atlantic Ocean.

Galeodea? cf. G. nodosa (Solander)

Plate 25, figures 18, 19

Moderately large, strongly inflated, shouldered, relatively high spired. Body whorl sculptured with four low spiral ridges, all except anteriormost of which bear strong blunt knobs; 12 knobs on ridge forming shoulder. Similar knobs on shoulder of spire whorls. Traces of narrow spiral threads and exaggerated growth lines visible between ridges. Aperture not preserved.

Height (incomplete) 46 mm, diameter (modified by crushing) 40 mm (figured specimen).

A crushed mold, to which some leached shell material is attached, was found in siltstone of the Gatuncillo formation at locality 27 on the Transisthmian Highway. The mold presumably represents *Galeodea*, but the aperture is not preserved and generic assignment therefore is uncertain. The outline is modified by crushing. In apertural view the mold is somewhat turreted, but not in dorsal view.

If this fossil is a *Galeodea*, it is a moderately large species and appears to be more similar to *G. nodosa* (Solander) (Wrigley, 1934, p. 120, pl. 17, figs. 31, 32) than to described American species. The knobs of *G. nodosa* are more compressed axially than those of the fossil from Panamá. *G. nodosa* occurs in the middle and upper Eocene of western Europe from England to the Mediterranean region.

Occurrence: Gatuncillo formation (late Eocene), locality 27.

Genus Bathygalea Woodring and Olsson

Woodring and Olsson, U. S. Geol. Survey Prof. Paper 314-B, p. 22, 1957 [1958].

Type (orthotype): *Cassis coronadoi* Crosse, Recent, north coast of Cuba, off Cape Fear, N. Car.

Subgenus Miogalea Woodring and Olsson

Woodring and Olsson, U. S. Geol. Survey Prof. Paper 314-B, p. 22, 1957 [1958].

Type (orthotype): *Cassis* (*Phalium*) *dalli* Anderson, Miocene, Colombia.

Bathygalea (Miogalea) hadra Woodring and Olsson

Plate 37, figures 10, 13

Bathygalea (*Miogalea*) *hadra* Woodring and Olsson, U. S. Geol. Survey Prof. Paper 314-B, p. 23, pl. 8, figs. 1, 2, 1957 [1958] (Pliocene, Panamá).

Of medium size, moderately thick-shelled, *Galeodea*-like in outline, strongly shouldered at early stage, spire turreted. Varices absent, except for terminal varix. Protoconch worn, consisting of about three naticoid whorls. Body whorl bearing 10 sharply pointed knobs on shoulder. Three low swellings on body whorl below shoulder bearing lower blunt knobs on early two-thirds of whorl. Spiral threads narrow, closely spaced on early whorls; closely spaced, but less uniform in width and spacing, on body whorl, in general widest on knob-bearing swellings. Axial sculpture limited to exaggerated growth lines and faint wrinkles at suture of late whorls. Microscopic spiral and axial lineation visible on faintly worn parts of shell. Outer lip moderately thick; its interior bearing short moderately strong ridges. Parietal callus and shield thin. Siphonal canal and siphonal fasciole missing. Insertion of siphonal wide.

Height 43.7 mm, diameter 33.6 (type).

Type: USNM 562268.

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

The type and a small damaged shell were collected by Olsson at the mouth of Río Indio, 37 kilometers southwest of Colón, where the Chagres sandstone crops out (chapter A, fig. 3, p. 45). Part of the type (the part that was exposed when it was collected) is corroded and the entire shell is slightly or faintly worn. The siphonal canal and siphonal fasciole are missing on both specimens, but the wide insertion of the canal on the type shows that the canal itself was wide.

As pointed out when this species was described, it evidently is a direct descendant of *Bathygalea dalli* (Anderson) (Woodring and Olsson, 1957 [1958], p. 23, pl. 7, figs. 1–4, pl. 8, figs. 3, 4), the type of the subgenus *Miogalea*. *B. hadra*, the youngest known species of *Miogalea*, has a thinner shell, corresponding thinner outer lip, parietal callus and shield, and weaker ridges on the interior of the outer lip.

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

Genus Semicassis Möreh

Mörch, Catalogus conchyliorum * * * Comes de Yoldi, pt. 1, p. 112, 1852.

Type (logotype, Harris, Catalogue of Tertiary Mollusca in the Department of Geology, British Museum; pt. 1, Australasian Tertiary Mollusca, p. 198, 1897): *Cassis japonica* Reeves, Recent, Japan.

Subgenus Echinophoria Saeco

Sacco, I molluschii dei terreni terziarii del Piemonte e della Liguria, pt. 7, p. 39, 1890.

Type (logotype, Dall, U. S. Geol. Survey Prof. Paper 59, p. 62, 1909): *Buccinum intermedium* Brocchi, Miocene and Pliocene, southwestern Europe.

Wrigley (1934, p. 109, 129) proposed to treat *Echinophoria* as a small, strongly knobbed, Oligocene to Pliocene subgenus of *Semicassis*, which seems to be a satisfactory arrangement. For a further discussion of *Echinophoria* see Woodring and Olsson (1957 [1958], p. 25).

Semicassis (Echinophoria) apenes Woodring, n. sp.

Plate 26, figures 11, 17

Small, strongly inflated, weakly shouldered, spire low, conical. Varix preceding terminal varix present or absent on body whorl. Shoulder of body whorl marked by about 11 blunt knobs arranged along a low, obscure spiral band. Lower knobs on three or four other low spiral bands. Three or 4 narrower, but relatively wide, spiral bands between anteriormost knob-bearing band and base of body whorl. Three weakly noded spiral bands lying between shoulder and suture,

the sutural band widest and most distinctly noded. Knob-bearing shoulder band of body-whorl forming a knob-bearing band at anterior edge of spire whorls. Three other poorly preserved, narrow, noded spirals on spire whorls. Apertural features missing.

Height (almost complete) 31 mm, diameter (incomplete) 22 mm (type).

Type: USNM 562570.

Type locality: 56 (USGS 6025, about 200 yards (200 meters) south of southern end of switch at Bohio Ridge station, relocated Panama Railroad, Canal Zone), middle member of Caimito formation.

MacDonald and Vaughan collected three poorly preserved specimens of this strongly knobbed cassid at the type locality. Despite the absence of the siphonal canal and siphonal fasciole, there seems to be no reasonable doubt that this species is to be referred to *Echinophoria*. Unlike the type of *Echinophoria*, *Semicassis apenes* has no shoulder on the penult whorl and a weak shoulder on the body whorl.

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

Semicassis (Echinophoria) species

Plate 26, figures 8, 12

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

Small, moderately inflated, strongly shouldered, spire turreted. Varix present or absent on penult whorl. Shoulder bearing strong blunt knobs, about 10 on body whorl. Body whorl bearing three other rows of somewhat lower knobs. Narrow spiral threads of unequal width closely spaced. Apertural features missing. Insertion of siphonal fasciole suggesting fasciole is inflated and limited posteriorly by a sharp narrow thread.

Height (incomplete) 30 mm, diameter (incomplete) 23.5 mm (most nearly complete specimen, figured).

Four specimens of a species of *Echinophoria*, all of which are incomplete and in poor condition, were recovered from the moderately deep-water facies of the Caimito formation on Barro Colorado Island. The shell is thinner than that of *Semicassis apenes*, and the late spire whorls and body whorl are strongly shouldered. In outline and emplacement of knobs the unnamed species is more similar to the type of *Echinophoria* than any other described American cassid. The knobbed shoulder of the fossils from Barro Colorado Island, however, appears at an earlier stage.

This is a new species, but none of the specimens is suitable as type material.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, localities 54h, 54j, 54l.

Subgenus Tylocassis Woodring

Woodring, Carnegie Inst. Washington Pub. 385, p. 306, 1928. Type (orthotype): *Buccinum inflatum* Shaw (=*Buccinum granulatum* Born), Recent, North Carolina to Brazil.

"*Buccinum*" *inflatum* is a large Caribbean form of the species for which Clench (1944, p. 6) adopted the name *Phalium* (*Semicassis*) *granulatum* (Born). Should Born's type be found at the Zoological Museum in Vienna, confirmation of the adoption of that name would be welcome.

Tylocassis was proposed for the Caribbean and eastern Pacific species of *Semicassis*, all of which have wart-like denticles on the outer part of the fully formed inner lip. Wrigley (1934, p. 109, footnote) pointed out that the Mediterranean and eastern Atlantic *Semicassis undulata* (Gmelin) (also known as *S. sulcosa* (Born)) belongs in this group of species. Unlike American waters, the Mediterranean Sea and eastern Atlantic Ocean harbors another group of *Semicassis*, represented by *S. saburon* (Bruguière), which has allies extending back at least to the Miocene. The earliest American species of *Tylocassis*, and apparently also the earliest European species, are of Miocene age.

Generic rank for both *Phalium* (Link, 1806–07, p. 112, 1807; type (logotype, Dall, 1909, p. 62): *Phalium glaucum* (Linné) (*Buccinum glaucum* Linné), Recent western Pacific Ocean) and *Semicassis*, and subgeneric rank for *Tylocassis* represents a nomenclatural fragmentation of *Phalium*-like cassids which some paleontologists and zoologists are unable to accept. Nevertheless on the basis of the wart-like dentieles, Clench (1944, p. 9) was enabled to conclude that an alleged Australian species presumably is a Caribbean species.

Semicassis? (Tylocassis?) cf. S. aldrichi (Dall)

The uppermost part of the Culebra formation in Gaillard Cut (the transition zone between the Culebra and Cucaracha formations) yielded four incomplete molds of a small, inflated, shouldered cassid (approximate dimensions: height 22 mm, diameter 17 mm). The shoulder is noded and below the shoulder the body whorl is sculptured with closely spaced spirals. There is little doubt that this species is a *Semicassis*, and the small size and noded shoulder suggest comparison with *S. aldrichi* (Dall) (Gardner, 1926–47, p. 536, pl. 54, fig. 6, 1947), an early *Tylocassis* from the lower Miocene Chipola formation of Florida. The wartlike denticles of the type and only specimen of *S. aldrichi* do not extend over the parietal wall as shown in Dall's illustration, reproduced by Gardner.

Occurrence: Culebra formation (early Miocene), localities 110, 111, 111b.

Semicassis (Tylocassis) reclusa (Guppy)

Plate 34, figures 1, 4–6

Cassis monilifera Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 287, pl. 17, fig. 8, 1866 (Miocene, Jamaica). Not *Cassis monilifer* Sowerby, 1846.

Cassis reclusa Guppy, Sci. Assoc. Trinidad Proc., v. 2, no. 2, p. 84, 1873 (Miocene, Jamaica). (Reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 68, 1921).

Dolium? (*Endolium*) sp. indet., Toula, K. k. Geol. Reichstantalt Jahrb., Band 58, p. 698, 1909 (Miocene, Canal Zone).

Dolium sp. indet., Toula, idem, Band 61, p. 500 (first paragraph under *Dolium* (*Malea*) sp.), 1911 (Miocene, Canal Zone).

Semicassis (*Tylocassis*) *reclusa* (Guppy), Woodring, Carnegie Inst. Washington Pub. 385, p. 307, pl. 19, figs. 7–9, pl. 20, figs. 1, 2, 1928 (Miocene, Jamaica; additional citations).

Cassis (*Phalium*) *moniliferum* Guppy, Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 142, 1929 (Miocene, Canal Zone).

Of medium size, inflated, slightly shouldered or nonshouldered. Protoconch consisting of 3½ naticoid whorls. Sculpture consisting of flat spiral bands separated by narrow grooves, some of which contain a secondary spiral. Spiral bands more or less weakly noded or undulated along retractive axial lines. Nodes most distinct on shoulder of shouldered specimen. Outer lip, siphonal canal, and siphonal fasciole not preserved. Inner lip incomplete, upper part bearing spirally arranged denticles. Parietal wall thinly glazed.

Height (incomplete) 34.5 mm, diameter (incomplete) 30 mm (largest specimen, figured).

Type: USNM 115505.

Type locality: Jamaica (Bowden), Bowden formation.

Though *Semicassis reclusa* occurs in the lower and middle parts of the Gatun formation, it is a rare species in the Canal Zone. All of the five specimens are incomplete. Toula's *Dolium?* (*Endolium*) sp. indet. (three specimens) and his *Dolium* sp. indet. (one specimen) are poorly preserved, incomplete specimens of *S. reclusa*. The two that show the top of the body whorl are nonshouldered.

As elsewhere in the Miocene deposits of the Caribbean region, *S. reclusa* includes shouldered and nonshouldered forms. The shouldered form in the Canal Zone (pl. 34, figs. 1, 4) is slightly shouldered and noded, whereas in the Gurabo formation of the Dominican Republic it is strongly shouldered and noded. The shouldered form is similar to the Recent eastern Pacific *S. centiquadrata* (Valenciennies) and the nonshouldered form to the Recent *S. granulata* (Born). Pilsbry (1922, p. 361) suggested *S. reclusa* is the ancestor of both Recent species. The Miocene species is much smaller than its probable descendants on both sides of Central America. *S. centiquadrata* (Pilsbry and Olsson, 1941 p. 40, pl. 8, fig. 2) and a very weakly shouldered form of that species (idem, p. 41, pl. 7, figs. 3, 6) occur in the Pliocene of Ecuador, and *S. granulata* in deposits of Pliocene age at Limón, Costa Rica.

A moderately large, relatively slender *Semicassis* that has weak axial sculpture is found in the upper Miocene Punta Gavilán formation of Venezuela and was described by Rutsch as *Phalium* (*Tylocassis*) *sulcosum senni* (Rutsch, 1934, p. 55, pl. 3, figs. 1, 2); that is, as a subspecies of the Recent Mediterranean-eastern Atlantic species. *Semicassis granulata* has a considerable range in degree of inflation and strength of axial sculpture. It is suggested that the Venezuelan fossil be considered a slender subspecies of *S. granulata* that is weakly sculptured axially and intermediate in size between *S. reclusa* and *S. granulata* proper.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 138 (fragment, identification doubtful). Middle part, eastern area, localities 147h, 160; western area, locality 161d (immature, identification doubtful).

Genus Sconsia Gray

Gray, Zool. Soc. London Proc., p. 137, 1847.

Type (orthotype): *Cassidaria striata* Lamarck, Recent, southeastern Florida and Bahamas to Gulf of Mexico and West Indies.

Though *Sconsia* has Eocene predecessors in America and Europe (Pilsbry, 1922, p. 361; Woodring, 1928, p. 308; Wrigley, 1934, p. 114; Palmer, 1937, p. 253; Gardner, 1939, p. 27; age changed to early Oligocene, Gardner, 1945, p. 182) the earliest species in the restricted sense are of Oligocene age in southeastern United States ("*Cassidaria*" *lintea* Conrad, 1848, p. 118, pl. 11, fig. 43; Vicksburg group, Mississippi) and of early Miocene age in the Caribbean region (*S. cocleana* Olsson, 1922, p. 138, pl. 12, fig. 7; Uscari shale, Costa Rica).

During Miocene time the genus gained a temporary footing in the Pacific Ocean, both in the western Pacific (Martin, 1891–1922, p. 158, pl. 26, figs. 366, 367, 1899) and in the eastern Pacific. It is represented in the lower Miocene of Ecuador (Marks, 1951, p. 107, pl. 7, fig. 14) and in the middle Miocene of the Darién area of Panamá, where the Canal Zone form has been found (USGS locality 8477, Río Tuyra). Mark's illustration is poorly drawn, but his specimen, as he recognized, is a typical *Sconsia*. *S. striata*, which ranges from southeastern Florida and the Bahamas to the Gulf of

Mexico and the West Indies at depths of 35 to 255 fathoms, is the sole surviving species. Because it is obtainable only by dredging, it formerly was rare in museum collections, but now is more common as a result of shrimp trawling in the Gulf of Mexico.

Sconsia laevigata sublaevigata (Guppy)

Plate 34, figures 8, 9, plate 35, figures 1–4

Cassidaria, sublaevigata Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 287, pl. 17, fig. 10, 1866 (Miocene, Jamaica).

Sconsia sublaevigata (Guppy), Böse, Inst. Geol. México Bol. 22, p. 36, pl. 4, figs. 9, 10, 1906 (Miocene, México).

Leucozonia (*Lagena*) sp. aff. *L. smaragdula* Linné, Toula, K. k. Geol. Reichsanstalt, Jahrb., Band 58, p. 699, pl. 25, fig. 9, 1909 (Miocene, Canal Zone).

Sconsia laevigata (Sowerby), Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 356, 1911 (Miocene, Canal Zone). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 142, 1929 (Miocene, Columbia, Canal Zone).

Sconsia (*Sconsia*) *striata sublaevigata* (Guppy), Woodring, Carnegie Inst. Washington Pub. 385, p. 309, pl. 20, figs. 3–6, 1928 (Miocene, Jamaica).

Moderately large, strongly inflated. Body whorl generally bearing a varix of variable strength 180° to 225° (in counter-clockwise direction) from outer lip. One or two low varices present or absent on penult whorl. Protoconch consisting of about three naticoid whorls. Spire whorls sculptured with narrow, closely spaced spiral bands and threads of unequal width and more or less exaggerated growth lines. Strength of body-whorl sculpture variable, but generally more or less reduced, particularly on middle part of whorl. Outer lip bearing strong ridges. Siphonal canal broken, evidently short and slightly notched. Siphonal fasciole barely swollen. Basal part of inner lip bearing strong ridges, the remainder and parietal wall bearing shorter ridges and irregular swellings. Parietal wall thinly glazed.

Height (incomplete) 57 mm, diameter (modified by crushing) 37.5 mm (largest figured specimen). Height 42 mm, diameter 26.5 mm (smallest figured specimen).

Type: British Mus. (Natural History), Geol. Depart. 64075.

Type locality: Jamaica (Bowden), Bowden formation.

Twenty-four specimens of a *Sconsia*, identified as *S. laevigata sublaevigata*, are available. They were found in the middle part of the Gatun formation in both the eastern and western areas and in the upper part in the eastern area; that is, in strata considered of late middle Miocene age. All except two of intermediate size are incomplete and the largest are distorted by crushing. The body-whorl sculpture is variable, but only one specimen (pl. 35, figs. 1, 2) has moderately strong sculpture. The degree of inflation appears to be fairly uniform. Comparison of the crushed large specimens, however, with large specimens from other localities is difficult. A shell of intermediate size (locality 155a) shows a color pattern of brownish, narrow, axial bands of irregular outline. Some specimens of the Recent *S. striata* (Lamarck) have a similar pattern, but the usual pattern of that speices consists of spirally arranged more or less rectangular blotches.

Toula's *Leucozonia* (*Lagena*) sp. aff. *L. smaragdula* is an immature specimen (incomplete height 25.5 mm, diameter 18.6 mm) of *Sconsia laevigata sublaevigata* that has fairly strong sculpture, comparable to that of other immature specimens from the Canal Zone.

There are two groups of *Sconsia* in the late middle and upper Miocene deposits of the Caribbean region: the weakly sculptured, more or less strongly inflated *S. laevigata* (and its subspecies) and the strongly sculptured, moderately inflated *S. bocasensis*, which is considered a subspecies of *S. striata*.

S. laevigata laevigata (Sowerby) Maury, 1917, p. 111, pl. 19, fig. 2), the first Caribbean fossil form to be named, is widespread and abundant in the late middle Miocene Gurabo formation of the Dominican Republic and was chosen by Maury as the zonal index for the strata she later named as the Gurabo formation. It is weakly sculptured, greatly inflated, and the dorsal surface of the body whorl of large specimens and those of medium size is somewhat shouldered—a feature not shown in Maury's illustration, an apertural view. Though *S. sublaevigata* (Guppy), the form found in the late middle Miocene Bowden formation of Jamaica, has been treated as a subspecies of the Recent *S. striata*, subspecific assignment under *S. Laevigata* is a better arrangement. The Jamaican form is not as greatly inflated as *S. laevigata laevigata* and immature shells are more strongly sculptured. The dorsal surface of the one large topotype is not as distinctly shouldered. The type of *S. laevigata gabbi* Olsson (1922, p. 136, pl. 12, fig. 3) is from upper Miocene strata on Toro Cay, in the Bocas del Toro area of northwestern Panamá and southeastern Costa Rica. According to seven well preserved topotypes, that form like *S. laevigata laevigata*, is weakly sculptured and greatly inflated, but the dorsal surface is not as distinctly shouldered. It is more or less intermediate between *S. laevigata laevigata* and *S. laevigata sublaevigata*. *S. laevigata gabbi* also occurs in upper Miocene deposits on Water Cay, near Toro Cay, but fossils from the late middle Miocene of Río Banana and Río Bananito and the upper Miocene of Coco Plum (localities in the same area) are more similar to Canal Zone fossils. The name *S. laevigata sublaevigata* is adopted

for the Canal Zone *Sconsia*, although the specimen shown on plate 35, figures 1, 2 is strongly sculptured at a later stage than Jamaican specimens and it is uncertain whether the dorsal surface of the large specimens (pl. 34, figs. 8, 9) was slightly shouldered before crushing.

The three forms so far discussed more or less intergrade and it may be a strained interpretation to attempt to distinguish them. If they are accepted, *S. laevigata laevigata* and *S. laevigata gabbi* have a restricted geographic distribution, whereas *S. laevigata sublaevigata* is more widely distributed. And if they are accepted, it follows from the next paragraph that three forms of *Sconsia* are represented in the late middle and upper Miocene strata of the Bocas del Toro area.

The strongly sculptured and moderately inflated *S. bocasensis* Olsson (1922, p. 137, pl. 12, figs. 12, 13; type locality Bocas Island or Isla de Colón) also occurs in the late middle and upper Miocene deposits of the Bocas del Toro area. Three well-preserved topotypes of late Miocene age and a late middle Miocene specimen from Río Estrella, in Costa Rica, indicate that *S. bocasensis* is a subspecies of *S. striata*. It is a little smaller than the typical Recent form, and has a more conspicuous sutural band and strong ridges on the entire parietal wall and columellar lip. *S. striata* proper occurs in Pliocene strata at Limón, Costa Rica. No other Miocene occurrence of a form of *S. striata* is known, unless the poorly preserved *Sconsia* from the upper Miocene Punta Gavilán formation of Venezuela, described by Rutsch (1934, p. 53, pl. 2, fig. 11) as *Sconsia* cf. *S. striata*, is that species. The sculpture of *S. striata* is stronger than suggested by Clench and Abbott's illustrations (Clench and Abbott, 1943, p. 6, pl. 4, figs. 1–4).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 142, 155, 155a, 155b; western area, locality 161a. Upper part, eastern area, localities 173, 175, 176 (fragments, identification doubtful), 177 (immature, incomplete, identification doubtful), 177b, 177c (immature, incomplete, identification doubtful), 178. Deposits of middle and late Miocene age, northwestern Panamá and southeastern Costa Rica. Middle Miocene, southeastern México. Bowden formation (middle Miocene), Jamaica. Middle Miocene, Colombia. Middle Miocene, Darién area, Panamá.

Family CASSIDIDAE?

Genus Morum Röding

Röding, Museum Boltenianum, p. 53, 1798.

Type (monotype): *Morum purpureum* Röding (=*Strombus oniscus* Linné), Recent, southeastern Florida and Bahamas to Brazil.

Morum in the restricted sense is unknown in the Caribbean region before Pliocene time.

Subgenus "Oniscidia Swainson"

Oniscidia has been used widely for the cancellate species of *Morum*. That name (Swainson, 1840, p. 299), however, was attributed by Swainson to Sowerby. As pointed out repeatedly, first by Herrmannsen (1846–52, v. 2, pp. 150, 151, 1847), it evidently is an error for Sowerby's name *Oniscia*, which is cited elsewhere in Swainson's book, including an index citation for the page where *Oniscidia*, but not *Oniscia*, appears. *Oniscia* is a synonym of *Morum*. A Recent Japanese species of "*Oniscidia*" has been cited recently as *Morum* (*Onimusiro*) *grande* (A. Adams) in the explanation of a plate (Kira, 1954, p. 43). If *Onimusiro* has been properly published, it has not come to the attention of the compiler of the part of the Zoological Record dealing with mollusks.

"*Oniscidia*" is an ancient group, first appearing in the Eocene of the Caribbean and Mediterranean regions. The last European species are of Miocene age and the survivors are living in the Caribbean Sea and the western Pacific Ocean. The Recent species are larger than the American and European fossils. The Caribbean *Morum dennisoni* (Reeve) (Clench and Abbott, 1943, p. 5, pl. 4, fig. 5), a rare species living in moderately deep water, has weaker axial sculpture than the American fossils and the Recent western Pacific forms.

Morum ("Oniscidia") species

Plate 25, figures 11, 17

Small, slightly inflated, slightly shouldered, spire and dorsal part of body whorl not preserved. Axial ribs relatively wide, at least near outer lip, and widely spaced. Spiral cords swollen on axial ribs. Body whorl bearing eight axial ribs between outer and inner lips and 11 spiral cords from shoulder to siphonal fasciole. Axial ribs and spaces between them sculptured with fine axial lamellae. Outer lip thick and wide for size of shell; inner edge bearing ridges, which are subdued at anterior end and fade out at posterior end. Inner lip spreading widely over parietal wall; inner part bearing ridges, outer part bearing irregular denticles disappearing outward. Siphonal fasciole slightly inflated, its growth lines lamellar.

Height (incomplete) 21 mm, diameter (incomplete) 13.5 mm (figured specimen).

The fossiliferous limestone of the Gatuncillo formation in the Río Casaya area yielded a small incomplete specimen of "*Oniscidia*." Though it is too incomplete to determine its affinities, it is of special interest. Ac-

cording to current age assignments, it is the earliest American species.

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

Morum ("Oniscidia") cf. M. antiquum (Bayan)

Plate 25, figures 12, 13

Small, moderately inflated, moderately shouldered, spire low. Sculpture strongly cancellate. Axial ribs narrow, widely spaced on spire whorls and beginning of body whorl, closely spaced on remainder of body whorl. Spiral cords noded on axial ribs. Body whorl bearing 16 axial ribs between outer and inner lips and 11 spiral cords on preserved part of body whorl on and below shoulder. Fine lamellar axial sculpture poorly preserved. Aperture greatly expanded. Outer lip thick and wide; inner edge bearing wide swellings. Inner lip spreading widely over parietal wall; inner part bearing ridges, outer part bearing irregular elongate denticles disappearing outward. Siphonal fasciole not preserved.

Height (incomplete) 21.5 mm, diameter 18.3 mm (figured specimen).

The axial groove in the apertural view (pl. 25, fig. 12) is due to a broken axial rib.

This strongly cancellate, low-spired species, evidently a new species, is represented by an incomplete specimen collected by Hill at Vamos Vamos. The sculpture suggests "*Oniscia*" *antiqua* Bayan (1870, p. 479; 1870a, p. 53, pl. 7, fig. 4), a species found in Eocene strata at Croce Grande and Val di Ciuppio, Italy. Bayan's illustration, however, show narrower and more widely spaced axial ribs. *M.* cf. *M. antiquum* is less pyriform and more strongly shouldered than the upper Eocene or lower Oligocene Peruvian *Morum chiraense* Olsson (1931, p. 96, pl. 17, figs. 6, 8) and the upper Eocene Colombian *M. corrugatum* Clark (Clark and Durham, 1946, p. 34, pl. 21, figs. 5, 21). The Peruvian and Colombian forms may be found to represent the same species. "*Athleta* (*Volutospina*)" *caracoli* Anderson (1938, p. 19, pl. 1, fig. 5) is an earlier name for *M. corrugatum*, if not also for *M. chiraense*. The type of "*Athleta*" *caracoli*, which is unrecognizable on the basis of Anderson's illustration, was assigned to *Morum* and refigured by Clark (Clark and Durham, 1946, p. 35, pl. 21, fig. 12). It is in poor condition, but is a small, pyriform *Morum*.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), locality 40a.

Morum ("Oniscidia") cf. M. chipolanum Maury

A small specimen (estimated height about 23 mm, diameter 16.8 mm), broken at both ends and otherwise defective, was found in the Culebra formation at a locality near Paraiso. It represents an "*Oniscidia*" characterized by strong axial ribs that are widely spaced on the later half of the body whorl, relatively strong axial lamellae, and strong, widely spaced spiral cords. The body whorl bears 11 axial ribs. The strength of the axial lamellae suggests that this "*Oniscidia*" is allied to *Morum chipolanum* Maury (1925*a*, pp. 115, 617, pl. 4, fig. 4; Gardner, 1926–47, p. 538, pl. 54, fig. 18, 1947), which has narrower and more closely spaced axial ribs and more closely spaced spiral cords. The typical form of *M. chipolanum* occurs in the lower Miocene Chipola formation of Florida. A very similar, perhaps identical, form from the Tampa limestone of Florida has been named *M. chipolanum tampanum* Mansfield (1937, p. 141). The type of that form—the specimen illustrated by Dall (1915, p. 85, pl. 12, fig. 28) as *M. domingense* (Sowerby)—is low-spired and has widely spaced axial ribs on the later half of the body whorl, as on the fragmentary specimen from the Culebra formation. Two other specimens, however, one of which was identified by Mansfield (1937, p. 141) as *Morum* cf. *M. chipolanum*, are more similar to the form from the Chipola formation. According to Maury's illustration, the axial ribs of the lower Miocene Brazilian *M. harrisi* Maury (1925a, p. 115, pl. 4, fig. 14) are narrow.

The name *Morum chipolanum*, which Maury attributed to Dall, was first published by Maury and the type is the specimen she illustrated. The name as used by Mansfield in 1937 was nude, but, unkown to him, it has been validated 12 years earlier. Dr. K. V. W. Palmer reports that the type is not in Maury's Chipola collection at the Paleontological Research Institution and was not sent to Rio de Janeiro. If it is not found at Cornell University, the specimen illustrated by Gardner and designated by her as the type is available as the neotype. The type is more inflated than Gardner's specimen or its proportions were not properly drawn.

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

Family CYMATIIDAE

Poorly preserved immature cymatids, representing undetermined genera, occur in the marine member of the Bohio(?) formation, the Bohio formation of Barro Colorado Island, and the Caimito and Culebra formations.

Genus Cymatium Röding

Röding, Museum Boltenianum, p. 129, 1798.

Type (logotype, Dall, Smithsonian Misc. Coll., v. 47, no. 1475, p. 133, 1904): *Cymatium femorale* Röding (*Murex femorale* Linné), Recent, West Indies.

Subgenus Septa Perry

Perry, Arcana, pl. 2, fig. 2, 1810.
Type (monotype): *Septa scarlatina* Perry=*Murex rubecula* Linné, Recent, Western Pacific Ocean.

As pointed out by Clench and Turner (1957, p. 214), *Septa* is available for the group of cymatids for which Schumacher's name *Lampusia* has long been used.

Cymatium (Septa) ogygium Woodring, n. sp.

Plate 27, figures 4, 6

Small, moderately inflated, slightly shouldered. Protoconch not preserved. Varices on all except earliest preserved whorl, very heavy, about two-thirds of a whorl apart. Body whorl slightly humped between outer lip and preceding varix. Sculpture consisting of heavy primary spiral cords, poorly preserved subdued secondary spiral threads, and wide low axial ribs. Primary spirals swollen on varices and slightly swollen on axial ribs. Three primary spirals on spire whorls and a narrower more subdued spiral between shoulder and suture; six on body whorl. Seven axial ribs between varices, subdued on body whorl. Secondary spirals slightly noded. Outer lip very heavy, interior bearing seven heavy ridges. Inner lip bearing short ridges. Tip of siphonal canal broken.

Height (almost complete) 40 mm, diameter 23 mm (type).

Type: USNM 562573.

Type locality: 55b (USGS 18847, Pato Horqueto Island, south coast about 75 meters west of southeast end of island, Canal Zone), middle member of Caimito formation.

The type and only specimen of this small *Cymatium* was found in a conglomerate lens interbedded with siltstone of the middle member of the Caimito formation on Pato Horqueto Island. It was somewhat battered before fossilization. The broken apex is smoothly worn. The subdued secondary spirals are best preserved on the sides of varices, where they were protected.

Cymatium ogygium is the oldest species of the genus so far found in the Caribbean region. It is smaller and less humped than the Recent Caribbean and western Pacific species long known as *C. chlorostomum* (Lamarck), and has narrower and more subdued secondary spirals. The name *C. nicobaricum* (Röding) has recently been resurrected for that Recent species (Clench and Turner, 1957, p. 210).

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

Cymatium (Septa) pileare henicum Woodring, n. subsp.

Plate 36, figures 1, 4

Of medium size, moderately inflated, moderately shouldered. Protoconch not preserved. Varices on last four whorls, about two-thirds of a whorl apart. Body whorl humped between outer lip and preceding varix. Scultpure consisting of closely spaced spiral cords and threads, low wide axial ribs, and fine axial threads. Primary spiral cords swollen on varices and axial ribs. Three primary spirals (anteriormost partly overlapped) on spire whorls and five on body whorl; posteriormost forming shoulder. Axial ribs ending on shoulder; five ribs between varices, the last of the five subdued and subdivided into minor riblets at beginning and end of body whorl. Fine axial threads conspicuous and forming fine nodes on spirals of earliest preserved whorls, subdued on late whorls. Interior of outer lip bearing seven long heavy ridges; the second, third, fourth and fifth from anterior end doubled at edge of lip. Inner lip bearing narrow ridges. Siphonal canal broken.

Height (incomplete) 53.5 mm, diameter 28 mm (type).

Type: USNM 562584.

Type locality: 136a (Stanford University 2611, Transisthmian Highway, lat. 9°21′ N., plus 1,100 feet (335 meters), long. 79°49′ W., Panamá; same as USGS 16192), lower part of Gatun formation.

The type, collected by T. F. Thompson from the lower part of the Gatun formation, is the only specimen of this cymatid. It is considered a subspecies of the widely distributed Recent *Cymatium pileare* (Linné), perhaps representing a stage earlier than the appearance of uniform paired ridges, or denticles, on the interior of the outer lip. The later whorls of the fossil also have more subdued fine axial threads and correspondingly subdued nodes on the spirals. The subduing of the fine axials does not appear to be a matter of wear.

A specimen of *C. pileare*, which, like some Recent shells, has subdued axial ribs but strong fine axial threads, is in a lot of Gatun fossils collected by W. S. Standifer at the Gatun Locks excavation in 1909, when the excavating was in progress (locality 159). A little muddy matrix, unlike the matrix of the Gatun fossils, remains on this fossil, which presumably is of Pleistocene age. The north end of the excavation penetrated fossiliferous Pleistocene strata. *C. pileare*, however, has been recognized in the Gurabo formation of the Dominican Republic (Maury, 1917, p. 105) and in the Gabb collection of Miocene fossils from that country

(Pilshry, 1922, p. 356). The Recent distribution of *C. pileare* has heen discussed recently by Dodge (1957, p. 117–118) and Clench and Turner (1957, p. 218–220).

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

Subgenus Ranularia Schumacher?

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 253, 1817.

Type (logotype, Gray Zool. Soc. London Proc., p. 133, 1847): *Ranularia longirostra* Schumacher (*Murex clavator* Dillwyn), Recent western Pacific Ocean.

Gray designated *Murex clavator* as the type without citing Schumacher's name for that species.

Cymatium? (Ranularia?) species

Triton sp., Toula, K. k. Geol. Reichanstalt Jahrb., Band 58, p. 699, pl. 28, figs. 5a, 5b, 1909 (Miocene, Canal Zone).

Toula's internal mold (incomplete height 43.2 mm, diameter 33 mm) from the Gatun formation suggests a species of *Cymatium* of the subgenus *Ranularia*. He suggested similarity to the Recent Carihhean *C. cynocephalum* (Lamarck)—now designated *C. caribbaeum* Clench and Turner (1957, p. 204)—but the mold shows no indication of the heavy primary spirals of that species. This cymatid is not represented in the collections at hand.

Another mold in Toula's collection, received in Rowland's second lot and labeled "*Triton* sp. indet.", was not mentioned by Toula. Its affinities are indeterminable.

Occurrence: Middle part of Gatun formation (middle Miocene) (Toula's record).

Genus Distorsio Röding

Röding, Museum Boltenianum, p. 133, 1798.

Type (logotype, Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 357, 1922): *Distorsio anus* Röding (*Murex anus* Linné), Recent, western Pacific Ocean.

The gender of *Distorsio*, derived from a Latin noun of the same spelling, is feminine. Not only is the derivation unmistakable, Röding's adjective trivial names are feminine.

Pilsbry (1922, p. 356–359) skillfully traced the geologic history of the genus, which has its immediate roots in the Eocene genus *Personella* of southeastern United States. Emerson and Puffer (1953) have published a useful catalog of trivial names in *Distorsio*. "*Triton*" *simillimus* Sowerby (1850, p. 48), the first Caribbean fossil form to be named, however, is omitted except in a discussion (p. 99).

Oinomikado's (1939, p. 623, pl. 29, fig. 17) *Cancellaria cossmanni* is an immature specimen of *Distorsio*.

Subgenus Rhysema Clench and Turner

Clench and Turner, Johnsonia, v. 3, no. 36, p. 236, 1957.

Type (orthotype): *Triton clathratum* Lamarck, Recent, West Indies.

The much smaller parietal shield and less strongly bent siphonal canal distinguish *Rhysema* from *Distorsio* s.s., which is monotypic.

Distorsio (Rhysema) decussata gatunensis Toula

Plate 34, figures 7, 10, plate 36, figure 5

Distorsio (*Distortrix*, *Persona*) *gatunensis* Toula, K k. Geol. Reichsanstalt Jahrb., Band 58, p. 700, pl. 25, fig. 10, 1909 (Miocene, Canal Zone).

Distorsio gatunensis Tonla, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 356, pl. 26, fig. 8, 1911 (Miocene, Canal Zone).

Distorsio decussatus gatunensis Toula, Rutsch, Eclogae Geol. Helvetiae, Band 23, pp. 609, 614, pl. 17, fig. 6 (type), 1930 (Miocene, Canal Zone). Emerson and Puffer, Biol. Soc. Washington Proc., v. 66, p. 100, 1953.

?*Distorsio decussatus* cf. *gatunensis* Toula, Rutsch, Eclogae Geol. Helvetiae, Band 23, p. 610, pl. 17, fig. 7, 1930 (Miocene, Venezuela).

not *Distorsio* (*Distorsio*) *clathratus gatunensis* Toula, Woodring, Carnegie Inst. Washington Pub. 385, p. 300, pl. 19, figs. 2, 3, 1928 (Miocene, Jamicia;=small form of *D. clathrata* (Lamarck)).

not *Distorsio* aff. *gatunensis* Toula, Weisbord, Bull. Am. Paleontology v. 14, no. 54, p. 41, pl. 8, fig. 3, 1929 (Miocene, Colombia;=small form of *D. clathrata* (Lamarck)).

not *Distortrix gatunensis* Toula, Li, Geol. Soc. China Bull., v. 9, p. 269, pl. 7, fig. 54, 1930 (Miocene, Panamá Bay;=*D. decussata* (Valenciennes), Recent; see Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 433, 1931).

Moderately large, strongly humped. Protoconch large, low-spired, strongly tilted, consisting of 3½ whorls, rapidly enlarging in diameter, last whorl strongly inflated. End of protoconch marked by abrupt appearance of reticulate sculpture: four spiral cords, noded by axial ribs. Anteriormost spiral overlapped as first sculptured whorl straightens out and generally overlapped on other spire whorls, except midway between varices of succeeding whorl. First varix appearing on third sculptured whorl. Later whorls progressively more strongly humped and shouldered between varices, which are about two-thirds of a whorl apart. The two primary spirals on shoulder of humped and shouldered whorls more closely spaced than others. Body whorl sculptured with 11 to 13 primary spirals. Primary spirals faintly doubled on late spire whorls and posterior part of body whorl. Secondary spirals subdued, generally most conspicuous between shoulder and suture. Axial ribs widely spaced on late whorls, except those immediately preceding varices and outer lip; subdued between primary spirals on humped part

conspicuous on six Recent Caribbean shells and on all except one of 38 Recent Panamic shells. The exception is a shell collected at Venado Beach, Canal Zone (USNM 589628). On some Recent shells, especially large shells, wartlike denticles as well as more elongate denticles are present on the outer part of the inner lip, but that feature is variable. There is some justification for Morrison's (1949, p. 12) view that the same name is to be used for *B. amphitrites* and the Recent Panamic and Caribbean forms. He adopted for them the name *B. corrugata* (Perry) (1811, pl. 5, fig. 1; type locality unkown). Perry's illustration suggests a coarsely noded Caribbean or eastern Atlantic shell. In view of the uncertain status of Perry's name, Broderip's name is used for the American species complex and Maury's name is given subspecific rank, despite the occurrence of a Panamic shell that closely resembles the fossils. Regardless of what names are used, Morrison's treatment calls attention to the Miocene appearance of a lineage that survived without any significant modification on both sides of Central America.

The sculpture of the fossils from the Canal Zone is much like that of *B. cubaniana* (d'Orbigny) (1841–47(?), v. 2, p. 165, pl. 23, fig. 24), also living in the Caribbean Sea. The varices of that species are less strongly pinched and more nearly alined. Its outer lip also is not as strongly flared or as strongly set off from the varix, and the trace of earlier lips and posterior canals is correspondingly suppressed.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138. Middle part, eastern area, localities 155, 155b, 157. Cercado and Gurabo formation (middle Miocene), Dominican Republic. Punta Gavilán formation (late Miocene), Venezuela.

Family TONNIDAE

Genus Malea Valenciennes

Valenciennes, in Humboldt and Bonpland, Voyage aux régions équinoxales du nouveau continent; Recueil d'observations de zoologie et d'anatomie comparée, tome 2, p. 324, 1832.

Type (logotype, Herrmannsen, Indicis generum malacozoorum, Band 2, p. 13, 1847): *Malea latilabris* Valenciennes (=*Cassis ringens* Swainson). Recent, Baja California to Perú.

The lower Miocene part of the Ciamito formation in Madden basin, at localities 79, 82*a*, and 85*a*, yielded unidentified small tonnid molds. One of these molds (locality 79) shows that the outer lip was strongly constricted and therefore can be accepted as *Malea*. The others, though probably the same species, are listed as *Malea?* sp.

Malea camura Guppy

Plate 33, figures 1–4.

Malea ringens (Swainson), Conrad, U. S. Pacific R. R. Expl. v. 6, pt. 2, p. 72, pl. 5, fig. 22, 1857 (Miocene, Canal Zone). Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 223 (part), 1873 (Miocene, Dominican Republic).

Malea camura Guppy, Geol. Soc. London Quart. Jonr., v. 22, p. 287, pl. 17, fig. 9, 1866 (Miocene, Jamaica). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 356, 1911 (Miocene, Canal Zone). Manry, Bull. Am. Paleontology, v. 5, no. 29, p. 112, pl. 19, fig. 3, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 363, 1922 (Miocene, Dominican Republic). Woodring, Carnegie Inst. Washington Pub. 385, p. 311, pl. 20, figs. 7, 8, 1928 (Miocene, Jamaica).

Dolium (*Malea*) sp., Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 500, pl. 30, fig. 7, 1911 (Miocene, Canal Zone).

Malea elliptica Pilsbry and Johnson, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 139, pl. 12, fig. 2, 1922 (Miocene, Costa Rica, Panamá).

Moderately large, rapidly enlarging in diameter, slightly to distinctly shouldered. Protoconch consisting of about three smooth naticoid whorls. Sculpture consisting of low spiral bands, which are wider than the grooves between them, or near shoulder are of about same width as grooves; 16 to 18 bands on body whorl from shoulder to siphonal fasciole, three or four on antepenult from shoulder to suture of body whorl. In addition one to three narrow bands between shoulder and suture on body whorl and penult. First two sculptured whorls, or a little more, bearing one or two fine secondary spiral threads between the narrow bands and retractive exaggerated growth threads. Well preserved shells show microscopic spiral lineation. Apertural face of outer lip relatively narrow. Apertural features of columellar lip and parietal wall not clearly shown.

Height (slightly reduced by crushing) 105 mm, diameter (increased by crushing) 83 mm (largest specimen, figured). Height (incomplete) 75 mm, diameter 56 mm (smaller figured specimen).

Type: British Museum (Natural History), Geol. Depart. 64076.

Type locality: Jamaica (Bowden), Bowden formation.

A moderately large *Malea* occurs in the Gatun formation: in the three parts of the formation, and in both eastern and western areas of the middle and upper parts. It is most widespread in the middle part in the eastern area and was, in fact, among the first of the fossils to be recorded near Gatun. Almost three-quarters of the 33 specimens from the entire formation are molds or shell fragments, all of which are listed with various qualifications depending on how much they show.

Toula had four fragments of this species, all presumably from the same small shell. He illustrated two of these fragments, one of which shows the apertural face of the outer lip.

This *Malea* is identified as *M. camura*. Though *M. camura* is very closely allied to *M. ringens* (Swainson), the type of the genus (a Recent species ranging from Magdalena Bay, Baja California, to Perú), it may be distinguished from the Recent species by its smaller size and, as pointed out by Pilsbry (1922, p. 363), by the narrower and less flattened apertural face of the outer lip. No large specimens of *M. camura* have so far been found at Bowden, Jamaica, the type locality. The largest so far known have a height of between 35 and 40 mm. The largest from the Dominican Republic range from 60 to 70 mm; the largest from the Canal Zone measures 105 mm. *M. ringens* reaches a height of 190 mm. The *Malea* from the Gatun formation has been claimed to be more distinctly shouldered than *M. camura* (Woodring, 1928, p. 312). Though no available specimens of Jamaican and Dominican Republic fossils are as distinctly shouldered as the most strongly shouldered Canal Zone fossils, the degree of shouldering of those fossils is variable and *M. ringens* includes both rounded and shouldered forms.

A mold collected at the Gatun Locks excavation (locality 159b, which also yielded the crushed shell shown on plate 33, figures 1, 2) and a mold in the collection of the Academy of Natural Sciences of Philadelphia (1728) show an unusual feature: a deep impression of an outer lip preceding the terminal lip. That is, the earlier outer lip was not absorbed when shell growth was resumed. No such varix has been observed on any Recent or other fossil specimen of *Malea* that was examined.

According to present identifications, *M. camura* is the most widely distributed of the Miocene species of *Malea* in the Caribbean region. It has been suggested that *M. goliath* Pilsbry and Johnson (Pilsbry, 1922, p. 363, pl. 29, fig. 1, 9) is a large form of *M. camura* (Woodring, 1928, p. 312). Though *M. goliath* has a relatively narrow outer lip, like *M. camura*, it is not known that the narrow spiral grooves of the type of *M. goliath* represent a variable feature. *M. goliath* is the largest Caribbean form (height 129 mm). *M. elliptica* Pilsbry and Johnson (Pilsbry, 1922, p. 363, pl. 29, fig. 3) is high spired and relatively slender. Both of the preceding two species have been recognized only in the Gabb collection of Miocene Dominican Republic fossils. Their locality and horizon therefore are unknown. *M. ringens densecostata* (Rutsch) (1934, p. 60, pl. 3, figs. 6, 7) an upper Miocene Venezuelan form, has the outline and narrow outer lip of *M. camura*, but is sculptured with about 25 closely spaced spiral bands and even the siphonal fasciole is strongly banded. Subspecific rank under *M. camura* may be better for this form. Rutsch, however, preferred subspecific rank under *M. ringens* for *M. camura* itself. Anderson's (1929, p. 140, pl. 12, figs. 3–6) *M. ringens*, from the middle Miocene of Colombia, should be compared with *M. densecostata*.

In both America and Europe the earliest species of *Malea* are of Miocene age. The youngest Caribbean species also are Miocene, whereas in the Mediterranean region the genus survived until Pliocene time. The genus did not reach southeastern United States, but in Miocene time reached the Colorado Desert, in southern California. Two species survive in the present seas: *M. ringens* in the eastern Pacific and *M. pomum* (Linné) in the western Pacific.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136 (mold, *Malea?* sp.), 136a, 138. Middle part, eastern area, localities 141 (molds, identification doubtfnl), 143 (molds, identification doubtful), 146 (mold, *Malea?* sp.), 147 (mold, identification doubtful), 147h (mold, *Malea?* sp.), 150 (immature, identification doubtful), 153 (molds, identification doubtful), 155, 156 (molds and incomplete replaced shell, identification doubtful), 159b, 159c; western area, localities 161a (fragment, identification doubtful), 162a (immature and incomplete, identification doubtful), 168. Upper part, eastern area, localities 171, 175 (fragment, *Malea?* sp.); western area, locality 182. Middle Miocene, Costa Rica. Deposits of late Miocene age, northwestern Panamá. Bowden formation (middle Miocene), Jamaica. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Records from deposits of early Miocene age in Cuba, Puerto Rico, and Trinidad, and of Miocene age in Perú, all based on molds, need confirmation.

Malea? cf. M. elliptica Pilsbry and Johnson

Plate 31, figures 2, 5

Small, relatively slender, high spired, slightly shouldered. Protoconch consisting of three smooth naticoid whorls. Body whorl sculptured with 16 low spiral bands, wider than the grooves between them except near siphonal fasciole, and two very narrow spiral bands between the poorly defined shoulder and suture. Penult sculptured with four spiral bands and two threads between shoulder and suture. Penult and earlier sculptured whorls also bearing a fine secondary spiral thread between the bands and retractive exaggerated growth threads. This spiral and axial microscopic sculpture fainter on body whorl, except a relatively strong secondary spiral in anteriormost two