

erally faint spiral cords more or less roughened by growth threads. Upper part of peristome gently arched forward.

Height 1 mm, diameter 1.6 mm (figured bicarinate specimen). Height 1.1 mm, diameter 2.3 mm (figured large specimen).

Type: Acad. Nat. Sci. Phila. 2831.

Type locality: Dominican Republic, Miocene.

This small *Cyclostremiscus* occurs throughout the Gatun formation. It is rare in the lower part, rare to abundant in the middle part, and rare in the upper part. Several hundred specimens were collected from the middle part at locality 147b.

These fossils show a considerable range of variation in the outline of the body whorl, in the presence or absence of spiral threads near the upper and lower carinae, and in the strength and coarseness of the spiral cords facing the umbilicus. The usual form is bicarinate (pl. 17, figs. 7-9). Though tricarinate shells (pl. 17, figs. 10-12) are not common in the middle part of the Gatun formation, the few specimens from the lower and upper parts (one and two, respectively) are tricarinate. Spiral threads, generally faint, near the upper and lower carinae are exceptional. The umbilical spirals generally are weak. They are, however, exceptionally strong on the large specimen shown on plate 17, figures 13-15. This large specimen, collected from the middle part of the Gatun formation, shows a further modification in the rounded outline of the body whorl. At the beginning of the body whorl of this specimen the upper carina is moderately strong, the basal carina is weak, and the peripheral angulation is faint. These carinae and angulation rapidly disappear. This specimen is larger than the bicarinate and tricarinate forms. Inasmuch as mature bicarinate and tricarinate forms are rounded near the peristome, the exceptional features of the rounded specimen are presumably correlated with its size. Toulou's illustrations, however, show a shell of moderate size, the body whorl of which is rounded at an early stage.

Cyclostremiscus pentagonus occurs in the Cercado formation of the Dominican Republic and in the Bowden formation of Jamaica. The few available specimens from the Dominican Republic and Jamaica are tricarinate. It was formerly thought that the Gatun form could be differentiated by the weak sculpture on the umbilical wall (Woodring, 1928, p. 441). That sculpture, however, is too variable for consistent differentiation.

Closely related forms are living in the western Atlantic and the eastern Pacific. "*Circulus*" *trilix* (Bush) (1897, p. 127, pl. 22, figs. 6, 10, 10a, 12, pl. 23, figs. 10, 15), ranging from Cape Hatteras to Cuba, is consistently tricarinate and enlarges more rapidly, so

that with the same number of whorls (about 4½) Recent shells are almost twice as large. Recent shells and those from the Gatun formation have the same kind of protoconch and aperture. Inasmuch as the degree of enlargement is the only character now apparent to differentiate Recent shells and tricarinate fossils, treatment of "*C.*" *trilix* as a subspecies of *C. pentagonus* appears to be preferable. Fossils from the early Miocene Chipola formation and the middle Miocene Shoal River formation of Florida have been referred to "*Circulus*" *trilix* (Gardner, 1926-47, p. 600, 1947). These Florida fossils are tricarinate and are larger than those from the Gatun formation.

"*Circulus*" *cerrosensis* Bartsch (1907, p. 173, figs. 9a, b, c), which ranges from Santa Catalina Island, California, to Baja California and the Gulf of California, and probably to Panamá, is the eastern Pacific analog of "*Circulus*" *trilix*. It has not been determined whether Pacific and Atlantic shells can consistently be distinguished. Relatively strong spiral cords facing the umbilicus are more common in the few lots of Pacific shells. Shells from both oceans that are still lustrous show under strong light very faint microscopic spiral lineation. It is doubtful whether *Cyclostremiscus glyptomphalus* Pilsbry and Olsson (1945-52, p. 67, pl. 7, fig. 3, 1952), a Pleistocene form from the Pacific coasts of western Panamá, can be distinguished from "*Circulus*" *cerrosensis*. Pilsbry and Olsson suggested the probability of local races of a widely spread species. *Cyclostremiscus glyptobasis* Pilsbry and Olsson (1945-52, p. 66, pl. 7, figs. 4, 4a, 1952), also from the Pleistocene of western Panama, probably is a variety, or subspecies, of "*C.*" *cerrosensis* with a sculptured base. The Ecuadorean form "*Circulus*" *cosmius* Bartsch (1907, p. 173, figs. 8a, b, c) also is closely allied to "*Circulus*" *cerrosensis*, but is characterized by a slight downward bending of the upper margin of the peristome where it extends forward. Though the peristome of the type of "*Circulus*" *cosmius* is damaged, four specimens in the type (and only) lot have a perfect peristome. The seven specimens in the type lot have very weak umbilical sculpture. "*Circulus*" *occidentalis* Pilsbry and Olsson (1941, p. 48, pl. 9, fig. 3), from the Pliocene of Ecuador, shows downward bending of the peristome and should be compared with "*Circulus*" *cosmius*.

Cyclostremiscus tricarinatus (C. B. Adams) (Pilsbry and Olsson, 1945, p. 271, pl. 28, figs. 3, 3a, 3b), living on the Pacific coast of Panamá, is similar to the tricarinate species so far mentioned. It has, however, faint axial riblets between the periphery and suture, and therefore is intermediate between *Ponocyclus* and *Cyclostremiscus* s.s.

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

part, localities 138, 138a. Middle part, eastern area, localities 146, 147b, 147f, 147g, 147h, 153a, 155c; western area, locality 161. Upper part, eastern area, locality 173; western area, locality 185. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica.

Genus Solariorbis Conrad

Conrad, American Jour. Conch., v. 1, p. 30, 1865.

Type (logotype, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 414, 1892): *Delphinula depressa* Lea, Eocene, Alabama.

Subgenus Solariorbis s.s.

The subgenus *Solariorbis* s. s. is characterized by relatively large size, faint spiral sculpture (microscopically punctate in the type species), and a wide umbilical wall on the body whorl adjoining the aperture.

Solariorbis (Solariorbis) strongylus Woodring, n. sp.

Plate 17, figures 43-45

Of medium size, thick-shelled, moderately depressed. Periphery faintly and bluntly angulated, except at and near peristome where it is rounded. Penuit and part of preceding whorl sculptured with closely spaced spiral threads. Spirals become faint and even disappear on body whorl, but most persistent near suture and just above periphery. Under strong light base shows barely discernible microscopic spiral striation. Umbilicus moderately narrow, asymmetrical, bounded by a crude spiral ridge, which is slightly roughened by growth wrinkles. Parietal callus thin.

Height 1.3 mm, diameter 2.4 mm (type). Height 1.5 mm, diameter 3 mm (largest specimen).

Type: USNM 561322; paratypes, Stanford Univ.

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

The weak sculpture and moderately narrow asymmetrical umbilicus are characteristic features of this species. It is represented by 13 specimens, all from the type locality.

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

Subgenus Hapalorbis Woodring, n. subgen.

Type: *Circulus liriopae* Bartsch, Recent, Gulf of California.

The name *Hapalorbis* is proposed for a minor group of *Solariorbis* consisting of small carinate species that have a narrow umbilical wall on the body whorl adjoining the aperture. The type species has a spiral thread above and below the peripheral carina-forming thread. Others have one to three threads below the periphery and one or two above. Still others have none below or above the periphery.

The subgenus *Systellomphalus* (Pilsbry and Olsson, 1941, p. 48; type (orthotype): *Systellomphalus perornatus* Pilsbry and Olsson, Pliocene, Ecuador), with which Pilsbry and Olsson associated species closely allied to "*Circulus*" *liriopae*, may be defined as embracing species that have axial riblets on spire whorls and axial wrinkles on the base of the body whorl adjoining the umbilicus.

Hapalorbis is not known to have survived the Miocene in Caribbean waters.

Solariorbis (Hapalorbis) hyptius hyptius Woodring, n. sp. and n. subsp.

Plate 17, figures 16-18

Small, thick-shelled, depressed, body whorl increasing rapidly in diameter. Periphery sharply or moderately carinate, except at and near peristome. Umbilicus very narrow, asymmetrical. Umbilical wall very narrow, the angulated umbilical border being inserted almost flush with base of body whorl where it emerges from umbilicus. Parietal callus moderately thick.

Height 0.7 mm, diameter 1.4 mm (type).

Type: USNM 561323; paratypes Stanford Univ.

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

The very narrow and asymmetrical umbilicus, and very narrow umbilical wall are conspicuous and characteristic features of this species. It is closely related to the type of *Hapalorbis*: "*Circulus*" *liriopae* Bartsch (1911, p. 231, pl. 40, figs. 7-9), which is represented by the type and an imperfect specimen, both dredged at a depth of 21 fathoms off La Paz, Lower California. The fossils are smaller, more depressed, have a smaller more asymmetrical umbilicus and narrower umbilical wall, and lack a spiral thread above and below the peripheral carina.

Solariorbis hyptius proper was found in the lower and middle parts of the Gatun formation, but is rare except at the type locality. The 68 specimens collected at the type locality and the 2 additional specimens from the middle part of the Gatun have remarkably uniform characters. The five specimens from the lower part, however, are not so sharply carinate and reach a slightly larger size.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138a. Middle part, localities 146, 147b, 147f.

Solariorbis (Hapalorbis) hyptius anebus Woodring, n. subsp.

Plate 17, figures 34-36

Resembling *S. hyptius* proper, but larger and umbilicus correspondingly larger. Peripheral carina flanked above and below by a narrow low spiral thread.

Type: British Mus. (Nat. Hist.), Geol. Dept., Geol. Soc. London 12842.

Type locality: Dominican Republic, Miocene.

An incomplete *Xenophora*, found by T. F. Thompson in the upper part of the Gatun formation at Stanford University locality 2654 near Fort Davis, is referred to *X. delecta*. The attached shells and shell fragments with one exception (a fragment of the body whorl of a *Phos*-like gastropod, attached by the exterior surface) consist of pelecypods, *Aequipecten* being most abundant. These pelecypods and pelecypod fragments are concave side upward, also with one exception: a fragment of a mature *Aequipecten scissuratus*.

The generally open umbilicus and relatively strong sculpture differentiate *X. delecta* from the only Recent species in the Caribbean region, *X. conchyliophora* (Born). The Gatun fossil is widely umbilicate. On specimens of comparable size from the Dominican Republic the umbilicus is narrower and even reduced to a narrow groove. Rutsch's illustration of a specimen from the late Miocene Punta Gavilán formation of Venezuela also shows only a narrow groove.

The type of *X. delecta* is a small specimen, like specimens from the Gurabo formation in the collections of the U. S. National Museum (maximum diameter 24 mm). Two imperfect shells from the Cercado formation are even smaller. The Bowden formation of Jamaica also has yielded only small specimens (maximum diameter 19 mm). The ripples on the base of these small specimens, from both the Dominican Republic and Jamaica, are so strong that they form nodes. Pilsbry figured two large specimens (diameter 51 and 56 mm) that are in Gabb's collection of fossils from the Dominican Republic, and Maury illustrated, under the name *X. conchyliophora*, a large specimen from the Gurabo formation.

X. textilina Dall (Gardner, 1926-47, p. 561, pl. 58, figs. 31, 32, 1947), of the Chipola formation of Florida, evidently is an early form of *X. delecta*. It is umbilicate, but its sculpture is not as strong as that of *X. delecta*. The larger of the two syntypes figured by Gardner is herewith designated the lectotype. The widely umbilicate strongly sculptured fragment from the Shoal River formation, doubtfully recorded as *X. textilina*, is indistinguishable from *X. delecta*. It might, however, be the high-spined subspecies of *X. delecta*, *X. delecta floridana* Mansfield (1930, p. 121, pl. 18, figs. 5, 6), which occurs in upper Miocene deposits in western Florida.

X. delecta left no descendants in the Caribbean or Panamic regions. It is closely related, however, to *X. senegalensis* Fischer, a Recent west African species, and its close Recent Mediterranean ally, *X. crispa* "König" Bronn, which occurs in rocks of late Miocene and

Pliocene age in Italy. *X. delecta* has somewhat coarser sculpture than those species.

The Recent Caribbean *X. conchyliophora* has a long history in the southeastern states and is one of the few Recent species recognized in the Eocene of that region. The Recent Panamic *X. robusta* Verrill, characterized by the deep orange-brown parietal callus and adjoining inner half of the interior of the body whorl, is better treated as a subspecies of *conchyliophora*.

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 173. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Punta Gavilán formation (late Miocene), Falcón, Venezuela.

Family HIPPONICIDAE

Genus *Hipponix* DeFrance

DeFrance, Jour. Phys. Chim. Hist. Nat. Arts, t. 88, p. 217, 1819. Type (logotype, Gray, Zool. Soc. London Proc., p. 157, 1847): *Patella cornucopia* (*Patella cornucopia* Lamarek), Eocene, Paris Basin.

Hipponix species

The Gatuncillo fossils from the Río Casaya area include a small presumably immature *Hipponix*, shaped like a wide cornucopia. Some growth lamellae are exaggerated and there is a faint suggestion of fine radial sculpture. The muscle scar is not discernible.

Length (not quite complete) 9 mm, width 7.5 mm, approximate height 6.5 mm.

So far as this small specimen goes, it suggests a miniature replica of the type species of the genus.

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

Family HIPPONICIDAE?

Hipponix? species

A poorly preserved limpet-shaped fossil from the Culebra formation is doubtfully referred to *Hipponix*. It is moderately large and elongate, and the apex is near the posterior end. The apex is worn and practically smooth. Preserved parts of the outer shell are sculptured with crude radial ribs overridden by crude concentric threads. The interior is inaccessible.

Approximate dimensions: length 21 mm, width 17 mm, height 9 mm.

If this fossil is an *Hipponix*, it is more similar to the Pacific *H. pilosus* (Deshayes) (an earlier name for *H. barbatus* Sowerby) than to Caribbean Recent species. *H. pilosus* ranges from California to Ecuador and the Galapagos, and is found in the western Pacific. It is recorded from the Miocene of the Dominican Republic (Pilsbry, 1922, p. 384).

Occurrence: Culebra formation (early Miocene), Gailard Cut, locality 108c.

Family CREPIDULIDAE

Genus *Crepidula* Lamarck

Lamarck, Soc. Hist. Nat. Paris Mém., p. 78, 1799.

Type (monotype): *Patella fornicata* Linné, Recent, eastern United States.

Molds from the Culebra formation are identified as *Crepidula* sp.

Crepidula cf. *C. maculosa* Conrad

Plate 19, figures 4, 5

Crepidula gatunensis Toulou, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 498, pl. 31, figs. 12a, b, 1911 (Miocene, Canal Zone).

Of medium size, moderately narrow, moderately vaulted. Protoconch of small specimens consisting of about $1\frac{1}{4}$ whorls of neritoid outline. Deck of small specimens moderately deep seated, bearing a wide shallow median indentation.

Length 28.5 mm, width 17.5 mm, approximate height 10.5 mm (figured specimen).

A species of *Crepidula* from the Gatun formation is comparable to the Recent *C. maculosa*, to which attention has recently been called (Stingley, 1952). As pointed out by Stingley, *C. maculosa* has a pedal muscle scar adjoining the adapical insertion of the deck and the edge of the deck has a very slight median indentation, whereas the better known and more northern *C. fornicata* (with which *C. maculosa* has been confused) lacks the muscle scar and has a pronounced median indentation.

The only fairly large shell from Gatun (pl. 19, figs. 4, 5) is attached to a crab carapace and the interior is inaccessible. Owing presumably to inequalities on the carapace, this shell has two faint depressions and correspondingly modified growth lines. The other shells (all of which are small, ranging in length from 1.5 to 12 millimeters) evidently represent the same species as the fairly large specimen. Two that are moderately small show the muscle scar of *C. maculosa*.

According to Toulou's description and illustration, *C. gatunensis* was based on a small shell (length 2.8 millimeters) like those in the collections at hand. That name is available, should the name *C. maculosa* be found to be inappropriate for the fossils.

Though *C. fornicata* is recorded from the Miocene of Trinidad (Maury, 1925, p. 244), it is unlikely that that species lived in the Caribbean Sea at any time.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 138. Middle part, eastern area, localities 147b, 155c, 157. Upper part, eastern area, locality 178.

Crepidula plana Say

Plate 19, figures 1-3

Crepidula plana Say, Acad. Nat. Sci. Phila. Jour., 1st ser., v. 2, p. 226, 1822 (Recent, Maryland to Florida). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 358, 1892 (Miocene to Recent, eastern United States). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 360, 1911 (Miocene, Canal Zone). Brown and Pilsbry, idem, v. 65, p. 495, 1913 (Pleistocene, Canal Zone). Pilsbry, idem, v. 73, p. 385, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 159, 1922 (Miocene, northwestern Panamá). Gardner, U. S. Geol. Survey Prof. Paper 142, p. 565, 1947 (Miocene, Florida); see this publication for other citations.

Crypta fornicata (Linné), Gabb, Am. Philos. Soc. Trans., v. 15, p. 242, 1873 (Miocene, Dominican Republic).

Of medium size, narrow, compressed, flat or concave. Protoconch of immature shells consisting of $1\frac{1}{4}$ to $1\frac{1}{2}$ rapidly enlarging whorls of neritoid outline, destroyed at later stage by encroachment of aperture. Deck bearing a moderately deep narrow abapical marginal indentation and a moderately deep very wide median indentation.

Length 15 mm, width 10.5 mm, height 2 mm (larger figured specimen).

Slipper limpets recovered from the apertures of Gatun coiled gastropods agree closely with the Recent *Crepidula plana*. All the fossils were found in the lower part of the formation. *C. plana* is already recorded from the Gatun formation of the Canal Zone and from late Miocene strata in northwestern Panamá.

A species of *Crepidula* that has a similar outline and similar deck characters is living in the eastern Pacific Panamic region. It presumably is *C. nivea* C. B. Adams, but is generally known as *C. nummaria* Gould. The few specimens of this species from Panamá in the collection of the U. S. National Museum have slightly deeper deck indentations than *C. plana*.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 137a, 138, 138a. Middle part of Gatun formation (middle Miocene), eastern area (Brown and Pilsbry). Late Miocene, Water Cay, Panamá. Miocene, Dominican Republic. Early to late Miocene, Maryland to Florida. Pliocene, North Carolina to Florida. Pleistocene, Massachusetts to Florida, Canal Zone. Recent, Prince Edward Island, Canada, to Texas and the West Indies.

Family Calyptraeidae

The genus *Cheilea* is not represented in the collections at hand. *Cheilea princetonia* Brown and Pilsbry (1911, p. 360, fig. 2), based on an internal and external mold from the Gatun formation, may be conspecific with the *Cheilea* from the Bowden formation of Jamaica

identified as the Recent Caribbean form designated *C. equestris* (Linné) (Woodring, 1928, p. 375, pl. 30, figs. 1, 2).

Genus *Calyptraea* Lamarek

Lamarek, Soc. Hist. Nat. Paris Mém., p. 78, 1799.

Type (monotype): *Patella chinensis* Linné, Recent, western Europe.

An unidentified small *Calyptraea* that has an eccentric apex is represented by poorly preserved specimens from the marine member of the Bohio(?) formation at Vamos Vamos.

Calyptraea cf. *C. aperta* (Solander)

Molds of a relatively large, relatively high-spined *Calyptraea* from the Gatuncillo formation of Madden basin are comparable to *C. aperta*, which is widely distributed in the Eocene and Oligocene of western Europe and southeastern United States. (For citation and synonymy see Palmer, 1937, p. 145.) In tropical America *C. aperta*, or a comparable form, is recorded from the Paleocene of Trinidad and the Eocene of Colombia and Perú.

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

Calyptraea centralis (Conrad)

Infundibulum centralis Conrad, Am. Jour. Sci., 1st ser., v. 41, p. 348, 1841 (Miocene, North Carolina, p. 343). Conrad, Fossils of the Tertiary of the United States, No. 3 (Fossils of the Miocene formation of the United States), p. 80, pl. 45, fig. 5, 1845 (Miocene, North Carolina).

Trochita sp. indet., Gabb, Am. Philos. Soc. Trans., v. 15, p. 242, 1873 (Miocene, Dominican Republic).

?*Trochita collinsii* Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 342, pl. 44, figs. 11, 11a, 1881 (Miocene, Costa Rica).

Calyptraea centralis (Conrad), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 353, 1892 (Miocene to Recent). Maury, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 15, p. 100, pl. 13, fig. 6, 1912 (Miocene, Trinidad). Maury, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 1, p. 48, 1920 (Miocene, Puerto Rico). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 385, 1922 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 243, pl. 43, fig. 2, 1925 (Miocene and Pliocene, Trinidad). Gardner, U. S. Geol. Survey Prof. Paper 142, p. 562, pl. 56, figs. 3-5, 1947 (Miocene, Florida); see this publication for other citations.

?*Calyptraea* cf. *centralis* (Conrad), Hubbard, N. Y. Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 2, p. 133, 1920 (Miocene, Puerto Rico). Maury, 1925, Brasil Serv. Geol. Min. Mon. 4, p. 65, pl. 1, figs. 5, 10, 1925 (Miocene Brazil).

Of medium size, circular in ventral plan, apex central. Protoconch of about $1\frac{1}{2}$ strongly inflated, rapidly enlarging whorls. Free edge of platform convex forward; reflected columellar edge not closely appressed, forming a relatively high umbilicuslike opening.

Maximum diameter 16 mm, height 6 mm (largest specimen).

Type: Apparently lost.

Type locality: Natural Well, N. Car., Duplin formation (late Miocene).

Specimens from the Culebra formation, identified as *Calyptraea* cf. *C. centralis*, are comparable in size and outline to *C. centralis*, but none shows the interior. All are molds, with the exception of one, which was collected at locality 108c and has much of the shell preserved.

The description is based on specimens from the lower part of the Gatun formation. The only large specimen, from locality 138, is imperfect. The interior of the only specimen from the middle part of the Gatun formation is inaccessible. It is listed as *Calyptraea* cf. *C. centralis*.

The Gatun fossils that show the interior agree closely with topotypes of *C. centralis* collected at Natural Well, N. Car. As pointed out by Dall and Gardner, Recent specimens are smaller than those from the Miocene. Recent specimens in the collection of the U. S. National Museum, representing localities from Cape Hatteras to the West Indies, are not more than a third the size of large Miocene fossils. Two large Recent shells, however, are exceptions. One, which has a maximum diameter of 11.5 millimeters, was cataloged at an early date and is labelled "West Indies." The other (maximum diameter 15.5 millimeters) was in the Henderson collection and is labelled "Marco, Florida." The reflected edge of the platform of both is closely appressed, like that of the western European *C. chinensis*, the type of the genus. They probably are specimens of that species with erroneous locality data. Should a name be desirable for the small Recent race, it may be designated *Calyptraea centralis candeana* (d'Orbigny), as indicated by Dall's synonymy. Pliocene fossils from the Caloosahatchee marl of Florida have a maximum diameter of 10 millimeters and therefore are intermediate in size.

The Recent Panamic *C. mamillaris* Broderip is larger than *C. centralis*, and has a thicker shell and mottled brown color pattern.

Occurrence: Culebra formation (early Miocene; *Calyptraea* cf. *C. centralis*), Gaillard Cut, localities 99b, 99c, 100, 108c, 110a. Lower and middle parts of Gatun formation (middle Miocene); lower part, localities 137, 138, 138a; middle part, eastern area, locality 147j, (*Calyptraea* cf. *C. centralis*). Early Miocene, Puerto Rico, ?Costa Rica, ?Brazil. Late Miocene(?), Trinidad. Miocene, Dominican Republic. Early to late Miocene, Maryland to Florida. Pliocene, Trinidad, Florida. Recent (small race) Cape Hatteras to West Indies.

Genus *Trochita* Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 57, 184, 1817.

Type (logotype, Rehder, Biol. Soc. Washington Proc., v. 56, p. 41, 1943): *Trochita spiralis* Schumacher (= *Trochus radians* Lamarck = *Turbo trochiformis* Born), Recent, Ecuador to Chile.

Trochita has a thick shell, distinct suture, and moderately strong to strong radial sculpture. The free edge of the platform is convex forward, except at the distal margin, where it bears a narrow indentation. The columellar edge of the platform is reflected only at its insertion. On adult shells this short reflected border is molded on the platform, like callus. The genus and its species were discussed by Rehder (1943) in the publication cited for the type designation.

Trochita heretofore has not been recorded from the Caribbean region. It is now extinct there, and in the western Atlantic is limited to the Falkland Islands and the coast of Argentina. Though it occurs in the Miocene and Pliocene of California, in the eastern Pacific it is now found only south of the equator. The survival of the genus in west African waters—a genus otherwise confined to the Peruvian, Magellanic, and South African provinces—is more readily understood in view of its occurrence in the Miocene of the Caribbean region and in the Pliocene and Pleistocene of west Africa. The West African species is considered conspecific with the Miocene Caribbean fossil and the Recent eastern Pacific species. It is an expectable fossil in the West African Miocene.

Trochita trochiformis (Born)

Plate 19, figures 11-14

Turbo trochiformis Born, Index Musaei Caesarei Vindobonensis, p. 355, 1778 (sole citation: Knorr, pt. 3, pl. 29, figs. 1, 2, 1768, "Antillean Islands").

Trochus radians Lamarck, Encyclopédie méthodique, Histoire naturelle des vers, t. 3, pl. 445, figs. 3a, b; Liste, p. 10, 1816. Lamarck, Histoire naturelle des animaux sans vertèbres, t. 7, p. 14, 1822 (Recent, "mer des Antilles").

Calyptrea (*Trochitella*) *trochiformis* (Gmelin), d'Orbigny, Voyage dans l'Amérique Méridionale, t. 5, pt. 3, p. 461, pl. 59, fig. 3, 1841 (Recent, Chile, Perú; *Calyptrea radians* in explanation of plate). Nicklès, Manuels Ouest-Africains, t. 2, p. 73, fig. 99, 1950 (Recent, Angola). Lecointre, Morocco Service Géologique, Notes et Mém. 99, t. 2, p. 108, pl. 25, figs. 1-4, 1952 (Pleistocene, Morocco).

Infundibulum trochiforme (Gmelin), d'Orbigny, Voyage dans l'Amérique Méridionale, t. 3, pt. 4 (Paléontologie), p. 158, 1842 (Pleistocene, Chile).

Trochita radians (Lamarck), Reeve, Conchologia Iconica, v. 11, *Trochita*, pl. 1, species 3, 1859 (Recent, Chile). Sowerby, Thesaurus Conchyliorum, v. 5, p. 64, pl. 451, figs. 95, 96, 99, 1883 (Recent, Chile). Rehder, Biol. Soc. Washington Proc. v. 56, p. 42, 1943 (Recent, Ecuador to Chile); see this publication for other citations and synonymy.

Calyptrea (*Trochita*) *trochiformis* (Gmelin), Grant and Gale, San Diego Soc. Natural History Mem., v. 1, p. 795, pl. 31, fig. 11, 1931 (Miocene and Pliocene, California; Recent—Panamá to Perú).

Trochatella trochiformis (Gmelin), Lecointre, Jour. Conchyliologie, t. 90, p. 240, unnumbered pl., fig. 2, 1950 (Pliocene, Pleistocene, Morocco).

Of medium size, moderately low spired or moderately high spired, apex broken. Sculpture consisting of heavy crude axial ribs. Platform broken back to insertion.

Maximum diameter 28.8 mm, height (incomplete) 10.7 mm (smaller figured specimen). Maximum diameter 43.5 mm, height (almost complete) 27 mm (larger figured specimen).

This calyptraeid is represented by two specimens from the lower part of the Gatun formation, both collected by T. F. Thompson. Though the interior of the larger specimen is inaccessible and the platform of the smaller is broken far back, they are identified with considerable confidence as *Trochita trochiformis*. The middle part of the Gatun formation in the western area at locality 151 yielded a worn thick-shelled apical fragment listed as *Trochita?* sp. Incomplete and poorly preserved fossils from the middle member of the Cairnito formation in the Gatun Lake area and the Culebra formation suggest that the lineage of *T. trochiformis* can be traced back to the late Oligocene. None of these Cairnito and Culebra fossils, however, is unequivocally identified.

Trochita trochiformis now ranges from Mantá, Ecuador, to Valparaíso, Chile. It is low spired to high spired. On low-spired shells the platform is almost flush with the base of the shell; on high-spired shells it is a considerable distance above the base. The heavy crude axial ribs are characteristic. The largest Recent specimen in the collection of the U. S. National Museum has a maximum diameter of 65 millimeters.

A small form of *Trochita trochiformis* (recorded as *T. radians*) occurs in formations of Pliocene age in California as far north as the Santa Maria district (Arnold and Anderson, 1907, p. 60, pl. 21, fig. 1; Woodring and Bramlette, 1950 [1951], p. 72, pl. 13, fig. 19), in Santa Barbara County. Early and middle Miocene forms from California have been identified as *Trochita costellata* Conrad (Eldridge and Arnold, 1907, p. 148, pl. 32, fig. 3; Loel and Corey, 1932, p. 268, pl. 63, fig. 11), and late Miocene forms have been named "*Calyptrea*" *diabloensis* Clark (1915, p. 485, pl. 70, fig. 9) and "*Calyptrea*" *martini* Clark (1915, p. 486, pl. 70, fig. 8). As suggested by Grant and Gale, these heavily ribbed Miocene forms, ranging in age from early to late Miocene, are probably to be referred to *Trochita trochiformis*. The inadequate type material of *Trochita costellata* Conrad (1857b, p. 195, pl. 7, fig. 3) consists of two molds showing traces of relatively fine ribs. Additional specimens from the type locality (Gaviota Pass in the western Santa Ynez Mountains, Santa Barbara

County, Calif.) have not been described and the age is still unknown.

I am indebted to R. T. Abbott for pointing out that Born's *Turbo trochiformis* is an earlier name for Lamarek's *Trochus radians*.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, localities 57 (*Trochita?* sp.), 57a (*Trochita* cf. *T. trochiformis*). Culebra formation (early Miocene), Gaillard Cut, localities 115a (*Trochita?* cf. *T. trochiformis*), 115b (*Trochita* cf. *T. trochiformis*), 116 (*Trochita* cf. *T. trochiformis*). Lower part of Gatun formation (middle Miocene), locality 136, 136a. Middle part of Gatun formation (middle Miocene), western area, locality 161c (*Trochita?* sp.). Miocene, California (identification doubtful). Pliocene, California, Morocco. Pleistocene, Chile, Cape Verde Islands, Morocco. Recent, Manta, Ecuador, to Valparaiso, Chile; Cape Verde Islands, Angola.

Genus *Crucibulum* Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 56, 182, 1817.

Type (logotype, Burch, Conchological Club Southern Calif. Proc., no. 56, p. 19, 1946): *Crucibulum planum* Schumacher (= *Patella auricula* Gmelin), Recent, Florida and West Indies.

J. E. Gray's (1847, p. 157) designation of *Patella auriculata* as the type of *Crucibulum* is not valid in the strict sense, as *Patella auriculata* was not mentioned by Schumacher. Schumacher, however, based *Crucibulum planum* on Chemnitz's *Patella auriculata* without mentioning it by name. Both *Crucibulum planum* and *Patella auriculata*, given binomial standing by Dillwyn in the year when Schumacher published the generic name *Crucibulum*, are synonyms of *Patella auricula* Gmelin.

The recent type designation by Burch, on the advice of Keen, appears to be the first valid designation. The question of possible virtual monotypy, raised by Keen, need not be considered. Whatever the status of *Crucibulum rugoso-costatum*, the only other species mentioned by Schumacher, may be, *Crucibulum* was not monotypic.

Unidentified molds from the Culebra formation, the Albajucla sandstone member of the Caimito formation, and the Chagres sandstone are listed as *Crucibulum* sp.

Subgenus *Crucibulum* s. s.

Crucibulum (*Crucibulum*) *chipolanum* Dall

Plate 19, figures 6, 7

Crucibulum auricula var. *chipolanum* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 349, 1892 (Miocene, Florida).

Crucibulum chipolanum Dall, Gardner, U. S. Geol. Survey Prof. Paper 142, p. 567, pl. 56, figs. 10, 11, 1947 (Miocene, Florida).

Of medium size, elliptical in ventral plan. Protoconch of about 1½ rapidly enlarging whorls. Shell smooth to diameter of 1½ to 3 mm. At that stage the shell is elliptical and the apex lies far to the rear. Sculpture consisting of closely spaced crudely roughened radial ribs, some of which bifurcate and a few of which unite as they extend outward. Right anterior border of cup sharply angulated, joined to side of shell at level far above ventral margin of cup.

Maximum diameter 27 mm, height 16.5 mm (figured specimen).

Type (lectotype, the specimen figured by Gardner): USNM 112783.

Type locality: USGS 2212, Tenmile Creek, Fla., Chipola formation (early Miocene).

Specimens from the middle part of the Gatun formation at the Gatun Third Locks excavation closely resemble *Crucibulum chipolanum* in characters of protoconch, sculpture, and cup. The right side of the cup of the figured specimen was uncovered, but the shell is too fragile to uncover the entire cup. Locality 155c yielded a worn incomplete specimen. It shows the same kind of cup and traces of radial ribs, but is only tentatively identified as *C. chipolanum*.

C. chipolanum was described as a variety of the Recent Caribbean *C. auricula* (Gmelin). Undoubtedly it is closely related to that species and to the Recent Panamic *C. spinosum* (Sowerby). The cups of all three are similar. The sculpture of *C. auricula* is weaker and more varied than that of *C. chipolanum*. As pointed out by Gardner, the protoconch whorls of *C. auricula* are wider and emerge more obtusely. Both *C. auricula* and *C. spinosum* are recorded from the Miocene of the Dominican Republic (Pilsbry, 1922, p. 385).

A species of *Crucibulum* from the Shoal River formation of Florida and its Oak Grove sand member, *C. chipolanum dodoneum* Gardner (1926-47, p. 567, pl. 56, figs. 18-20, 1947), has coarser sculpture than *C. chipolanum*. It presumably is not closely related, however, to *C. chipolanum*, as its cup is attached to the side of the shell at the level of the ventral margin of the cup.

Dall designated no type material for *C. chipolanum*. In his description he mentioned only one locality: the Chipola River, a mile below Baileys Ferry. He also examined and identified, however, specimens from the nearby Tenmile Creek locality, a mile west of Baileys Ferry. The specimen from the Tenmile Creek locality figured by Gardner is herewith designated the lectotype.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155, 155b, 155c (including a doubtfully identified worn specimen). Chipola formation (early Miocene), Florida.

Subgenus *Dispotaea* Say

Say, Acad. Nat. Sci. Phila. Jour., 1st ser., v. 4, p. 131, 1824. Type (logotype, Olsson and Harbison, Acad. Nat. Sci. Phila. Mon. 8, p. 276, 1953): *Calyptrea costata* Say, Miocene, Maryland.

After describing *Calyptrea grandis*, Say remarked that it does not properly belong in the genus *Calyptrea* and therefore proposed to place it in a new genus *Dispotaea*. He then assigned two other species to *Dispotaea*: *Dispotaea tubifera*, a new Recent species from South America, and his previously described *Calyptrea costata* (Say, 1820, p. 40; see p. 38 for locality data), a fossil species from Upper Marlborough, Maryland, associated with others now known to be Miocene. The types of these three species evidently are lost. So far as known *Dispotaea tubifera* has not been recognized. *Calyptrea costata* has been interpreted in different ways by Dall (1890-1903, pt. 2, p. 349, 1892) and Martin (1904, p. 244, pl. 58, figs. 7a, b). Dall thought it is the strongly costate *Crucibulum* that occurs in the St. Marys formation of Maryland and assigned it varietal rank under *Crucibulum auricula*, the type of *Crucibulum*. According to Martin, it is the weakly costate *Crucibulum* found in the Calvert formation of Maryland. Martin's interpretation is reasonable in view of the locality cited by Say and in view of Say's statement that the cup is attached by one side to the wall of the shell. At all events Martin's identification is accepted.

Olsson and Harbison, apparently not realizing that Say assigned the unequivocally identifiable *Calyptrea grandis* to *Dispotaea*, recently designated *Calyptrea costata* as the type of *Dispotaea*.

The cup of *Dispotaea* is attached by the right side, or part of the right side, to the interior of the shell. The type species has a wide attachment area; *Crucibulum grande* has an attachment area of varied width. The Recent *Crucibulum striatum* (Say) (Nova Scotia to Florida), which has been cited as the type of *Dispotaea* by several authors, has a consistently wide attachment area.

Crucibulum (*Dispotaea*) *springvaleense* Rutsch

Plate 19, figures 8-10

- ?*Capulus? gatunensis* Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 692, pl. 25, fig. 1, 1909 (Miocene, Canal Zone).
Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 360, 1911 (Toula's record).
Capulus? sp., Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 692, pl. 25, fig. 2, 1909 (Miocene, Canal Zone).
Crucibulum (*Dispotaea*) *gatunense* (Toula), Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 121, pl. 13, figs. 4-6, 1929 (Miocene, Canal Zone, Colombia).
Crucibulum? *springvaleense* Rutsch, Naturf. Gesell. Basel Verhandl., Band 54, p. 138, pl. 4, fig. 8, 1942 (Miocene, Trinidad).

Of medium size, circular to elliptical in ventral plan. Protoconch of $1\frac{1}{4}$ to $1\frac{1}{2}$ rapidly enlarging whorls. Shell smooth to a diameter of 3 to 6 mm. Shell at that stage circular and apex central or subcentral. Sculpture consisting of heavy widely spaced radial ribs, the interspaces bearing crude concentric lamellae, or consisting of closely spaced, generally narrower, roughened and pitted irregular ribs. Right side of cup widely attached to interior of shell.

Maximum diameter 19.2 mm, height 11 mm (figured specimen). Maximum diameter 24.5 mm, height 14 mm (largest specimen).

Type: 518/190 Basel Natural History Museum.

Type locality: Springvale quarry, Trinidad, Springvale formation (late Miocene).

Crucibulum springvaleense is widely distributed in the Gatun formation. Though the interior of the Trinidad specimens, on which this species was based, is unknown, the *Crucibulum* from Panamá is unequivocally identified. Coarsely sculptured specimens have the external characters of a topotype of *C. springvaleense* kindly forwarded by Dr. Rutsch. Some fossils from Panamá have only regular coarse sculpture, others only irregular generally finer sculpture, and still others, like the specimen figured, a combination of both.

This species has left no descendants in the Caribbean region. It appears to be allied, however, to the Recent Panamic *Crucibulum pectinatum* Carpenter, which has fewer ribs than the coarsely sculptured typical form of *C. springvaleense*. *C. pectinatum* ranges from the southern part of the Gulf of California to Panamá, possibly to Perú.

It is unlikely that *Crucibulum springvaleense* is the species Toula described as *Capulus? gatunensis*. At a diameter of 11.5 millimeters, the greatest diameter of the type of *Capulus? gatunensis*, it should show traces of strong sculpture, if it were the *Crucibulum*. According to a communication from Dr. Rutsch, who examined the types of Toula's Gatun gastropods, the type of *Capulus? gatunensis* is an unidentifiable mold retaining parts of the inner shell layer. In the text Toula cited figures 1 and 2 of plate 25 for *Capulus? gatunensis*. According to the explanation of the plate and the dimensions, however, figure 2 is his *Capulus?* sp. Figure 2 quite certainly represents a mold of the coarsely sculptured *Crucibulum* that occurs in the Gatun formation. Perhaps through this error in citation Anderson was led to use the name *Crucibulum gatunense* for that species.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 137, 137a, 138, 138a, 139. Middle part, eastern area, localities 146, 147b, 147e, 147f (identification doubtful, immature specimens only), 147g,

147h, 151, 152, 155, 155a, 155b, 155c, 159, 160 (*Crucibulum* cf. *C. springvaleense*); western area, locality 162a. Upper part, western area, locality 185. Springvale formation (late Miocene), Trinidad. Miocene, Bokvar, Colombia.

Family NATICIDAE

Subfamily NATICINAE

Genus *Natica* Scopoli

Scopoli, *Introductio ad historiam naturalem*, p. 392, 1777.

Type (logotype, Harris, *Catalogue of Tertiary Mollusca in the British Museum*; pt. 1, Australasian, p. 255, 1897); *Nerita vitellus* Linné, Recent, tropical western Pacific.

Anton (1839, p. 31) also designated *Nerita vitellus* as the type of *Natica* at a much earlier date than Harris. Anton's designation, however, is of doubtful validity, as it is a designation for *Natica* Lamarek.

Subgenus *Natica* s. s.?

Natica (*Natica*?) species

The collections from the marine member of the Bohio(?) formation at Vamos Vamos include two naticid opercula that have a narrow marginal rib, separated by a shallow groove from a wider second rib. They represent *Natica* s. s. or possibly some other subgenus that has a similar operculum. The larger specimen has a restored length of about 12 millimeters and a width of 7.5 millimeters. Small poorly preserved shells from locality 42 may represent this species.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), localities 40, 40d, 42 (identification doubtful).

Natica (*Natica*?) *bolus* Brown and Pilsbry

Plate 20, figures 1-3

Natica bolus Brown and Pilsbry, *Acad. Nat. Sci. Phila. Proc.*, v. 64, p. 508, pl. 22, fig. 9, 1913 (Miocene, Canal Zone).

Natica youngi Maury, *Bull. Am. Paleontology*, v. 5, no. 29, p. 135, pl. 23, figs. 11, 12, 1917 (Miocene, Dominican Republic). Pilsbry, *Acad. Nat. Sci. Phila. Proc.*, v. 73, p. 386, pl. 34, fig. 21, 1922 (Miocene, Dominican Republic). Maury, *Bull. Am. Paleontology*, v. 10, no. 42, p. 239, pl. 40, fig. 4, 1925 (Miocene, Trinidad). Mansfield, *U. S. Natl. Mus. Proc.*, v. 66, art. 22, p. 57, 1925 (Miocene, Trinidad).

Natica finitima Pilsbry and Johnson, *Acad. Nat. Sci. Phila. Proc.*, v. 69, p. 173, 1917 (Miocene, Dominican Republic).

Not *Natica youngi* Maury, *Li, Geol. Soc. China Bull.*, v. 3, p. 266, pl. 6, figs. 47, 47a, 1930 (Miocene, Panama Bay; = *Natica unifasciata* Lamarek, *Acad. Nat. Sci. Phila. Proc.*, v. 83, p. 432, 1931, Recent, Panamá Bay).

Not *Natica* (*Polinices*) cf. *youngi* Maury, *Trechmann, Geol. Mag.*, v. 72, p. 550, pl. 20, figs. 3-5, 1935 (Miocene, Carriacou); = *Polinices* sp.

Of medium size, thick-shelled, spire very low or moderately low, shoulder strongly or slightly inflated. Protoconch not clearly differentiated from remainder of shell, apical whorl large. Umbilicus wide, umbilical rib

narrow, ending in a small callus lobe bearing a shallow anterior depression. A narrow deep groove lies in front of umbilical rib and callus pad, separating them from umbilical border. Parietal callus thick, especially in front of junction with outer lip, where it forms a ridge. On immature shells anterior part of parietal callus relatively wider than on mature shells and roofing over posterior end of umbilicus as it extends forward to join umbilical lobe. Operculum assumed to represent this species bearing a narrow marginal rib, separated by a narrow groove from a second rib that is as narrow as the marginal rib or slightly wider.

Height 14.5 mm, diameter 15.2 mm (figured mature specimen). Height 9.7 mm, diameter 10.2 mm (figured immature specimen).

Type: Acad. Nat. Sci. Phila. 3846.

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

The type, the largest of 6 in the type lot, is a small immature shell (height 9 millimeters). On the type and other immature shells, such as that shown on plate 20, figure 3, the anterior part of the parietal callus is wide and roofs over the posterior end of the umbilicus. On mature shells more of the umbilicus is uncovered. The largest shell, which is incomplete, has a height of 19.5 millimeters. Very low-spined shells have an inflated shoulder, whereas shells that have a higher spire have a less inflated shoulder. Two small opercula assumed to represent *N. bolus* were found in association with shells at locality 155c and another of medium size at locality 172.

Though *Natica bolus* is fairly widespread in the Gatun formation, only a few specimens were collected at any locality, except locality 177b. *N. youngi*, from the Miocene of the Dominican Republic, reaches a somewhat larger size (height 24 millimeters), but has the umbilical and callus features, as well as the outline, of *N. bolus*. *N. youngi* from the Miocene of Trinidad has a narrower umbilicus and less conspicuous umbilical rib than *N. bolus*, but is considered conspecific. *N. youngi coelestana* Olsson (1922, p. 155, pl. 13, fig. 8; Miocene, Costa Rica), however, has a narrow umbilicus, weak umbilical rib, and narrower umbilical callus lobe, and evidently is not closely related. An early Miocene species from Costa Rica, *N. milleri* Gabb (1881, p. 338, pl. 44, fig. 3) has a higher spire and weaker umbilical rib. *N. castrenoides* Woodring (1928, p. 377, pl. 30, fig. 5; Miocene, Jamaica) and its Recent Caribbean analog, *N. castrensis* Dall (1889, p. 293), have a wider and weaker umbilical rib and thinner parietal callus. *N. bolus* appears to have no close living allies in either Caribbean or Panamic waters.

The strong, though narrow, umbilical rib indicates that *N. bolus* is not closely related to *N. vitellus*; it

probably is to be assigned to an unnamed subgenus. As pointed out by Powell (1933, p. 165), undue emphasis on opercular characters in effecting a classification of naticids may lead to artificial alliances.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138. Middle part, eastern area, localities 142, 144 (incomplete, identification doubtful), 147b, 147g, 155, 155a, 155b, 155c, 157, 159; western area, localities 161a, 161e, 161d. Upper part, eastern area, localities 172, 173, 175, 176a, 177, 177a (incomplete, identification doubtful), 177b, 178. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Springvale formation (late Miocene), Trinidad.

Subgenus *Naticarius* Duméril

Duméril, Zoologie analytique, p. 164, 1806; genus without species. Type (monotype, Froriep, C. Duméril's analytische Zoologie, p. 165, 1806; quoted from Iredale, Malacol. Soc. London Proc., v. 12, p. 83, 1916): *Nerita carrena* Linné, Recent, West Indies.

The status of Duméril's names, all of which end in "arius", will not be settled without a specific ruling, for they may be interpreted in various ways. According to Opinion 148 of the International Commission on Zoological Nomenclature, issued in 1943

A generic name published as an emendation of an earlier name of the same origin and meaning is to be rejected as a synonym of the earlier name, and the type of the genus bearing the emended name is automatically the same species as the type of the genus bearing the earlier name so proposed to be emended.

Duméril's names doubtless are emendations of earlier names of the same origin and meaning. All of them can be matched with earlier names that lack the "arius" termination. He probably emended the earlier names with the Latin suffix "arius" (pertaining to) as the name of the animal; *Naticarius*, for example, being the name of the animal "pertaining to" the shell *Natica*. His statement that "notre objet étoit de faire connoître les animaux et non les coquilles que les revêtent" supports that interpretation. In that event it could be argued that the names are to be rejected on the grounds that Duméril adopted a system that results in two names for shell-bearing mollusks. If the names are to be accepted and are emendations, and therefore synonyms, is *Naticarius* a synonym of *Natica* Scopoli or of *Natica* Lamarek? If it is a synonym of *Natica* Lamarek, it is available in place of that name, which is a homonym of *Natica* Scopoli. Duméril's names, however, were not admitted to be emendations when they were proposed. They therefore may be interpreted as entirely new names dating from his or Froriep's usage, depending on whether Duméril's usage is considered nude. For the time being the view that they are new names is arbitrarily adopted. In 1928 *Naticarius* was regarded as a substitute name for *Natica* Lamarek not Scopoli

(Woodring, 1928, p. 378). That view, which followed Iredale's (1916, p. 82) interpretation, is far fetched, but has the same nomenclatorial effect as the view adopted in the present report.

Natica s. s., or naticids having similar opercula, occur in the Eocene (Harris and Palmer, 1946-47, p. 247, pl. 29, figs. 1, 2, 1947; Wrigley, 1949, p. 11, 13, figs. 1, 2, 8-12). *Naticarius*, however, evidently does not antedate the late Oligocene. The late Eocene (Jackson) *Natica permaunda* Conrad, which has been referred to *Naticarius* (Harris and Palmer, 1946-47, p. 246, 1947), lacks the axial grooves of that subgenus, and has a less rapidly enlarging umbilical rib and correspondingly narrower umbilical callus lobe. *Naticarius* is now found in western Atlantic and eastern Pacific tropical and subtropical waters. The Mediterranean *N. mil-lepunctata* Lamarek has a multiribbed operculum, suggesting alliance with *Naticarius*, but the ribs are very narrow and the shell has a narrow umbilical rib. This species has been erroneously assigned to *Nacca* Risso.

An unidentified species of *Naticarius* occurs in the upper part of the Bohio formation and poorly preserved fossils from the middle member of the Caimito formation in the Gatun Lake area and the Culebra formation are identified as *Natica* (*Naticarius*?) sp. They have a relatively high spire and short axial grooves adjoining the suture. Their umbilical features and opercula are unknown.

Natica (*Naticarius*) *stenopa* Woodring, n. sp.

Plate 20, figures 4-6

Of medium size, thin shelled, moderately inflated, whorls enlarging at moderate rate, spire high. Protoconch of 2½ to 3 whorls, apical whorl small. End of protoconch marked by slight change in texture of shell and beginning of sculpture. Sculpture consisting of short closely spaced retractive axial grooves, parallel to growth lines, extending from suture and ending on shoulder on later whorls. Umbilicus moderately wide, umbilical rib rapidly enlarging, ending in a wide callus lobe, the anterior part of which is concave. A very narrow deep groove in front of umbilical rib and umbilical callus lobe. Parietal callus moderately thick. Operculum bearing a marginal rib and 4 or 5 wider flat ribs, all separated by deep grooves.

Height 15.2 mm, diameter 14.8 mm (type). Height 21.5 mm, diameter 19.5 mm (largest specimen).

Type: USNM 561340; paratype, USNM 561341; paratypes Stanford Univ.

Type locality: 177b (USGS 5854, Mount Hope, west side of Panama Railroad near oil tanks, Canal Zone), upper part of Gatun formation.

Natica stenopa is widespread and locally common in the Gatun formation, especially abundant in the upper

part of the formation in the eastern area. Eighteen of the 21 lots, however, consist only of immature specimens, up to a maximum of 115 immature shells in one lot. The largest shells are imperfect. A shell of medium size from locality 177c has an operculum in place (pl. 20, fig. 6). An incomplete operculum of medium size, not associated with shells, was found at locality 161. A small incomplete operculum, collected at locality 162, has three ribs, an indeterminate number of other lower ribs being covered with a glaze of enamel. The identification of this operculum is uncertain. The axial grooves disappear on the body whorl of an incomplete doubtfully identified shell from locality 147h.

Though Brown and Pilsbry (1913, p. 508) recorded *N. canrena* from the Gatun formation and though Olsson (1922, p. 155, pl. 13, fig. 9) figured a specimen of that Recent Caribbean species from the Gatun formation near Gatun, that species is not represented in the Gatun collections of the U. S. National Museum or Stanford University. *N. stenopa* is of medium size and has a high spire, small apical whorl, closely spaced axial grooves, and 5 or 6 ribs on the operculum. *N. canrena*, on the contrary, is much larger and has more inflated and more rapidly enlarging whorls, low spire, large apical whorl, more widely spaced axial grooves, more rapidly enlarging umbilical rib and correspondingly larger umbilical callus lobe, and 8 or 9 ribs on the operculum.

On the basis of shell characters *N. stenopa* is closely related to a Recent Panamic species identified by Dall as *N. limacina* Jousseau (1874, p. 14, pl. 2, figs. 7, 8). Jousseau's description and illustrations suggest that the identification is erroneous. The operculum of *N. limacina* is unknown and the type locality is indefinite: "West Indies(?)". Dall's *N. limacina* is represented in the collections of the U. S. National Museum by one shell dredged in Panamá Bay at a depth of 33 fathoms. *N. stenopa* has a somewhat thinner shell, narrower groove in front of the umbilical rib and umbilical callus lobe, and wider umbilical opening back of the umbilical rib. *Naticarius* opercula, having 7 to 9 ribs, are represented by 2 lots from Panamá Bay, and also by lots dredged in the Gulf of California off Guaymas and La Paz, but it is not known that the opercula are to be associated with Dall's *N. limacina*. They agree with the operculum of *N. colima* Strong and Hertlein (1937, p. 174, pl. 35, figs. 12, 13, 16), dredged near Manzanillo, Mexico. *N. colima*, however, is thin shelled and has a very narrow umbilical rib and small umbilical callus lobe.

Natica canrena or allied forms are widespread in the Caribbean region in formations of Miocene and Pliocene

age. *N. precanrena* F. Hodson (Hodson, Hodson, and Harris, 1927, p. 68, pl. 36, figs. 2, 6, 9), a small Venezuelan early Miocene species (height 6.8 millimeters), has a high spire, small initial whorl, and closely spaced axial grooves. It has, however, a higher spire and a wider umbilicus than small specimens of *N. stenopa*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136, 137, 137a, 138, 138a. Middle part, eastern area, localities 146, 147b, 147g, 147h (incomplete, identification doubtful), 151, 155, 155c, 157; western area, localities 161, 161a, 161e, 161d, 170, 170a. Upper part, eastern area, localities 175, 176a, 177b, 177c; western area, localities 183, 185.

Genus *Stigmaulax* Mörch

Mörch, *Catalogus conchyliorum* *** Comes de Yoldi, pt. 1, p. 133, 1852.

Type (logotype, Harris, *Catalogue of Tertiary Mollusca in the British Museum*; pt. 1, Australasian, p. 262, 1897): *Natica sulcata* Born (*Nerita sulcata* Born), Recent, West Indies.

Stigmaulax, like *Naticarius*, lives in American tropical and subtropical waters on both sides of Central America. It is found in the late Tertiary of the same region, the earliest species being of early Miocene age.

Stigmaulax guppiana (Toula)

Plate 20, figures 11-16

Natica guppiana Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 696, pl. 25, fig. 6, 1909 (Miocene, Canal Zone). Hodson, Hodson, and Harris, *Bull. Am. Paleontology*, v. 13, no. 49, p. 67, pl. 36, figs. 1, 4, 1927 (Miocene, Venezuela).

Natica guppiana Toula, Engerrand and Urbina, *Soc. Geol. Mexicana Bol.*, v. 6, p. 130, pl. 60, figs. 53, 54, 55 (reproduction of Toula's illustration), 1910 (Miocene, Mexico). Brown and Pilsbry, *Acad. Nat. Sci. Phila. Proc.*, v. 63, p. 360, 1911 (Miocene, Canal Zone). Olsson, *Bull. Am. Paleontology*, v. 9, no. 39, p. 156, pl. 13, figs. 13-15, 1922 (Miocene, Panamá, Costa Rica). Anderson, *California Acad. Sci. Proc.*, 4th ser., v. 18, no. 4, p. 123, 1929 (Miocene, Colombia). Tucker and Wilson, *Bull. Am. Paleontology*, v. 18, no. 65, p. 13, pl. 2, figs. 3, 4, 1932 (Miocene, Florida). Mansfield, *Florida Dept. Conservation, Geol. Bull.* 12, p. 10, 13 (lists), 1935 (Miocene, Florida).

Natica (Stigmaulax) sulcata guppiana Toula, Rutsch, *Schweizer. Palaeont. Gessel. Abh.*, Band 54, no. 3, p. 51, pl. 1, fig. 15 (type), 1934 (Miocene, Canal Zone).

Natica (Naticarius) guppiana Toula, Oinomikado, *Geol. Soc. Japan Jour.*, v. 46, p. 621, pl. 29, fig. 18, 1939 (Miocene, Colombia).

Natica (Stigmaulax) guppiana Toula, Gardiner, *U. S. Geol. Survey Prof. Paper* 142, p. 546, pl. 59, fig. 9 (reproduction of Toula's illustration), 1947 (Miocene, Florida).

Natica (Stigmaulax) guppiana toulana Gardner, *idem*, p. 547, pl. 59, figs. 7, 8, 1947 (Miocene, Florida).

Natica (Stigmaulax) guppiana Toula, Marks, *Bull. Am. Paleontology*, v. 33, no. 139, p. 98, 1951 (Miocene, Ecuador).

Operculum (sp.?), Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 511, pl. 31, fig. 26, 1911 (Miocene, Canal Zone).

Not *Natica guppyana* Toulou, Li, Geol. Soc. China Bull., v. 3, p. 266, pl. 6, fig. 46, 1930 (Miocene, Panama Bay; = *Natica elenae* Récluz, fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 432, 1931, Recent, Panama Bay).

Large, thick shelled, spire low, whorls strongly inflated and rapidly enlarging. Protoconch of $2\frac{1}{4}$ to $2\frac{1}{2}$ whorls, apical whorl small. Sculpture of relatively widely spaced retractive axial grooves, parallel to growth lines, extending away from suture and generally ending at or above periphery. On some shells they extend to umbilical region, but not on last half of body whorl of large shells. Umbilicus very wide, umbilical rib rapidly enlarging, ending in a moderately wide callus lobe, the anterior part of which is concave on large shells and strongly excavated on shells of small and medium size. On shells of large and medium size a more or less distinct supplementary rib lies on umbilical rib at its posterior border and may modify outline of callus lobe. Groove in front of umbilical rib and umbilical callus lobe moderately wide on large shells, narrow on others. Parietal callus very thick. Operculum dominated by very wide thick warty central rib. Marginal rib very narrow, denticulate. Several minor ribs, two of which generally are undercut along their inner margin, lie between marginal and central ribs. Outermost minor rib irregularly roughened.

Height 33.5 mm, diameter 30.5 mm (figured large specimen with short axial grooves). Height 30.5 mm, diameter 29 mm (figured large specimen with axial grooves extending from suture to umbilical region on first half of body whorl).

Type: Tech. Hochschule, Vienna (temporarily at Geol. Inst., Univ. of Berne, Switzerland).

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

Stigmaulax guppyana is the most widespread and most abundant of the Gatun naticids and was found in the Chagres sandstone at the mouth of Río Indio. All of the numerous large shells and many of medium size have one or more healed breaks on the body whorl. The more widely spaced axial grooves and the excavated umbilical callus lobe differentiate very young shells from very young shells of *Natica stenopa*. The sculpture is variable. Shells of large and medium size on which the axial grooves extend to the umbilical region are common only in the upper part of the Gatun formation in the eastern area. Locality 155c is the only locality in the middle part of that formation where all the specimens collected have grooves extending to the umbilical region. No large shell has grooves extending to the umbilical region on the later half of the body whorl. Though the body whorl of some large shells shows indistinct microscopic spiral lineation, like that on some specimens of *Natica canrena*, there is no gross

spiral sculpture. The supplementary umbilical rib is of variable strength, but is visible on shells of large and medium size.

Opercula are not rare. They were collected at 11 localities, as many as 10 at a locality. A large shell having the operculum in place (pl. 20, fig. 18) was collected by T. F. Thompson. The only other in place is in a minute shell, which has a height of 1.5 millimeters (locality 147b). Details of opercular sculpture are variable, especially the number of minor ribs. The fine denticles on the very narrow marginal rib are obscure on some large opercula. That the thick callus of the warty central rib conceals flat minor ribs, like those adjoining the central rib on some opercula, is shown by the mergence of such ribs on 2 large opercula, (pl. 20, figs. 13, 18). Toulou described a small operculum without realizing that it belongs to a species he had named.

Forms of *Stigmaulax* closely related to the Recent Caribbean *S. sulcata* (Born) are found in Miocene formations in Jamaica, Haiti, the Dominican Republic, Puerto Rico, and Brazil. *S. guppyana*, however, is not one of them. It lacks gross spiral sculpture and is more closely allied to the Recent Panamic *S. broderipiana* (Récluz), as pointed out by Olsson (1932, p. 207). *S. broderipiana* is smaller and has a less depressed suture. The opercula of the two species are similar, but the central rib of *S. broderipiana* has a narrow crest. *S. elenae* (Récluz), also a Recent Panamic species, is another close ally. It also has a less depressed suture and its axial grooves are in general more closely spaced. The single available operculum has a narrower central rib. The color pattern, however, is the most distinctive feature of *S. elenae*.

S. guppyana is found in the Gurabo formation of the Dominican Republic. A close ally of *S. sulcata* also occurs in the Gurabo formation, but not at the same localities. This close ally of *S. sulcata* was recorded as *S. vererugosum* (Cossmann) (Woodring, 1928, p. 383) and has been named *Natica sulcata gurabensis* by Rutsch (1934, p. 52, pl. 2, fig. 10). *S. guppyana* also occurs in deposits of middle and late Miocene age in Florida. The collection from Shell Bluff on Shoal River (USGS 3742) consists of numerous specimens, all smaller than large shells from the Canal Zone. The collection also includes 3 opercula which agree with opercula of *S. guppyana*. Two specimens from locality 3742 that have short axial grooves were named *Natica guppyana toulouana* by Gardner. This is the common form in the lower and middle parts of the Gatun formation, and the numerous Gatun collections show gradation in the length of the grooves. The single specimen (height 22 millimeters) from Vaughan Creek (USGS 12046) agrees closely with Gatun shells

of medium size that have grooves extending to the umbilical region. According to Tucker and Wilson, *S. guppiana* occurs in upper Miocene deposits at Acline, Florida.

A large *Stigmaulax* from the late Miocene Punta Gavilán formation of Venezuela has been described as *Natica (Stigmaulax) sulcata beaumonti* Rutsch (1934, p. 50, pl. 2, figs. 6-8, pl. 3, fig. 5). I am indebted to Dr. Rutsch for two topotypes of this form. It is allied to *S. guppiana* and may be considered a subspecies of *S. guppiana*. It is considerably larger than *S. guppiana* proper (height 42 millimeters), but even on these large shells the axial grooves continue to the umbilical region almost to the outer lip. This large form, *S. guppiana beaumonti*, and the typical form of *S. guppiana* in the Chagres sandstone are the last Caribbean allies of *S. broderipiana*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part localities 137, 137a, 138, 138a. Middle part, eastern area, localities 142, 146, 147 (identification doubtful), 147b, 147f, 147g, 147h, 150a, 151, 153, 153a, 155, 155b, 155c, 156, 157, 158 (identification doubtful); western area, localities 161, 161c, 161d. Upper part, eastern area, localities 172, 175, 176, 176a, 177a, 177b, 177c, 178; western area, localities 182, 182a, 183, 185. Chagres sandstone (early Pliocene), locality 208. Miocene, Falcón, Venezuela. Middle Miocene, Bolívar and Chocó, Colombia. Daule formation (middle Miocene), Ecuador. Middle Miocene, northeastern Panamá and Costa Rica. Miocene, Chiapas, Mexico. Shoal River formation (middle Miocene), Florida. Late Miocene deposits at Acline, Florida.

Genus *Tectonatica* Sacco

Sacco, Mus. Zoologia Anatomia Comparata R. Univ. Torino Bol., v. 5, no. 86, p. 33, 1890.

Type (monotype): *Tectonatica tectula* Bors. (error for Bon.) (*Natica tectula* Bonelli), Miocene and Pliocene, Italy.

Though the name *Tectonatica* has been used for small tropical American species (Woodring, 1928, p. 384), that usage was not entirely satisfactory, because no specimens of the type species were examined. Through the kindness of John Q. Burch, of Los Angeles, a specimen of *Natica tectula* identified by Sacco is now available. It is larger than the small tropical American species (height 7 millimeters; maximum height 12 millimeters, according to Sacco) and the umbilical callus lobe does not completely fill the umbilicus, leaving a narrow unfilled space, comparable to the narrower space of varying width on the small American "*Natica*" *pusilla* Say. In his later description of *Tectonatica*, Sacco (1891, p. 81) described the operculum as calcareous. He evidently was relying on allied Recent species, as in his description of *Natica tectula* the

operculum is not mentioned. Though the operculum of that species evidently is still unknown, there is no reasonable doubt that *Tectonatica* is an appropriate name for the small American species. The type of *Cryptonatica* (Dall, 1890-1903, p. 362, 1892; type (logotype, Dall, 1909, p. 85): *Natica clausa* Broderip and Sowerby) is a large arctic and boreal species, on which the umbilical callus lobe completely fills the umbilicus. Like the small species, it has a smooth calcareous operculum. When the anatomy of the large arctic and small tropical species is known, both names (*Tectonatica* and *Cryptonatica*) may be found to be useful.

Tectonatica has been recognized in the Eocene of England (Wrigley, 1949, p. 14).

Tectonatica species

Two imperfect specimens record the occurrence of a small inflated species of *Tectonatica* in the late Eocene or early Oligocene strata of Trinidad Island. The umbilical callus lobe is preserved on the smaller specimen, but is absent (presumably dissolved) on the larger. The larger specimen has a more strongly bulging body whorl than *T. agna* of the Gatun formation. *T. floridana* (Dall) (1890-1903, pt. 2, p. 366, pl. 17, fig. 5, 1892), of the early Miocene Tampa limestone of Florida, is more than three times as large and is more elongate. Heretofore *T. floridana* was the earliest recorded east American species.

The larger specimen has the following dimensions: height 2.4 mm, diameter 2.6 mm.

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

Tectonatica agna Woodring, n. sp.

Plate 17, figure 46

Very small, strongly inflated, spire low or moderately low. Protoconch not clearly differentiated from remainder of shell, apical whorl small. Umbilical callus lobe thick, completely filling umbilicus, bearing a shallow central depression. Edge of umbilical callus lobe raised above level of umbilical border. Parietal callus thick. Operculum unknown.

Height 2.8 mm, diameter 2.4 mm (type).

Type: USNM 561348; paratypes, Stanford Univ.

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

This minute *Tectonatica*, like many other small species from the Gatun formation, is abundant at locality 147b, the type locality. The shallow, but distinct, depression on the umbilical callus lobe is its