

grooves. Very faint microscopic lineation apparent in grooves of body whorl. Siphonal fasciole strongly inflated, sculptured with narrow spiral threads of irregular width. Outer lip not preserved. Columellar lip and parietal wall unarmed.

Height (not quite complete) 30 mm, diameter 16.8 mm (figured specimen).

A small, evidently immature, tonnid in a Stanford University collection, found by T. F. Thompson in the middle part of the Gatun formation at the Gatun Third Locks site, may represent *Malea* or *Tonna* (Brünnich, 1771, p. 248; type (logotype, Suter, 1913, p. 314): *Buccinum galea* Linné, Recent, West Indies, western Atlantic and western Pacific Oceans; see Opinion 237, International Commission on Zoological Nomenclature). The unarmed aperture indicate *Tonna*, but the small shell probably is an immature *Malea* in an unarmed state following absorption of the apertural armature. The outline suggests the Recent Caribbean *Tonna* generally known as *T. perdia* (Linné), but now designated *T. maculosa* (Dillwyn) (Turner, 1948, p. 169). The Recent species, however, has a less inflated siphonal fasciole, no suggestion of a shoulder, and fainter microscopic sculpture. The widely distributed *T. galea* (Linné), the only other Recent Caribbean species, has an inflated siphonal fasciole and microscopic sculpture comparable to that of the Canal Zone fossil, but the entire shell is greatly inflated and low spired. If the fossil is a *Malea*, it is allied to the relatively slender high spired *M. elliptica*, already mentioned in the discussion of *M. camura*.

*Tonna* is unknown in the Miocene of America and Europe. Böse's undescribed Mexican *Dolium* cf. *galea* (Linné) (Böse, 1906, p. 87), which he assigned to the Pliocene, appears to be the only Tertiary Caribbean record. d'Orbigny's Cuban *Dolium perdia* "Lamarck" (d'Orbigny, 1852(?), p. 34, pl. 3, figs. 2, 3) and *Dolium sagrae* d'Orbigny (Idem, p. 34, pl. 3, figs. 4, 5), which evidently is *Tonna galea*, presumably are Pleistocene.

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

#### Family FICIDAE

##### Genus *Ficus* Röding

Röding, Museum Boltenianum, p. 148, 1798.

Type (tautotype and logotype, Winckworth, Malacological Soc. London, Proc., v. 26, p. 140, 1945): *Ficus variegata* Röding (= *Bulla ficus* Gmelin = *Bulla ficus* Linné), Recent, western Pacific Ocean.

Röding cited *Bulla ficus* under *F. communis* and *F. variegata*. The gender of *Ficus* is feminine.

It has long been recognized that the Miocene species of *Ficus* in the Caribbean region may be classified in

two groups: the group of *F. communis* Röding—formerly known as *F. papyratia* (Say)—and the group of *F. ventricosa* (Sowerby). The primary spirals of the *F. communis* group are moderately strong and relatively closely spaced, whereas those of the *F. ventricosa* group are strong and widely spaced. The patterns of the two end members (the species for which the groups are named) stand in marked contrast, but some fossil species have an intermediate pattern. The *F. communis* group survived in the western Atlantic Ocean, the *F. ventricosa* group in the eastern Pacific Ocean.

In the Canal Zone and adjoining parts of Panamá the two groups are represented as early as late Oligocene time and the *F. ventricosa* group survived as late as early Pliocene time. The late Eocene or early Oligocene deposits contain a species that may belong in a group of high-spired late Eocene and Oligocene species typified by *F. mississippiensis* Conrad.

#### ?Group of *Ficus mississippiensis*

##### *Ficus* cf. *F. mississippiensis* Conrad

Hill collected at Vamos Vamos a poorly preserved incomplete small ficid (height of body whorl less part of siphonal canal 15 mm). The primary spirals are strong and relatively widely spaced and the secondary spirals evidently are very fine. There is a suggestion of fine nodes at the intersection of primary spirals and poorly preserved axial threads. The spire is not preserved.

The degree of inflation and the sculptural pattern, so far as it can be made out, suggest the high-spired *Ficus mississippiensis* Conrad, which occurs in the Vickshurg group and has close allies in the upper Eocene of Southeastern United (Harris and Palmer, 1946-47, p. 322-326) and in the upper Eocene or lower Oligocene of Perú (*F. chiraensis* Olsson, 1931, p. 97, pl. 18, figs. 10, 12).

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

#### Group of *Ficus communis*

##### *Ficus* cf. *F. pilsbryi* (B. Smith)

*Pyrula* near *papyratia* Say, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 356, 1911 (Miocene, Canal Zone).

Small, strongly inflated, spire rising well above body whorl. Protoconch consisting of about two whorls, initial whorl small. Protoconch and early part of first sculptured whorl slightly tilted. Earliest axial threads closely spaced, strongly retractive. Primary spirals relatively closely spaced. Secondary spirals consisting of one rank almost as strong as primaries and forming almost evenly reticulate sculpture with axial threads, or consisting of two slightly different

ranks. Spirals faintly noded by the narrow axial threads. Siphonal canal broken.

Height (incomplete) 34.5 mm, diameter (increased by crushing) 27 mm (largest specimen).

Two incomplete specimens from the Caimito formation on Barro Colorado Island and one from the upper part of the Gatun formation in the eastern area, all of which retain only patches of shell, are identified as *Ficus* cf. *F. pilsbryi* (B. Smith). They are too imperfect for certain identification. Though it is doubtful whether the fossils from the two formations represent the same form, their protoconch and sculptural pattern are similar and they evidently are members of the same lineage. The early retractive threads are converted into threads of axial trend after about a half whorl on the form from the Caimito formation and after about a quarter whorl on the form from the Gatun formation, which presumably also is represented by the mold, now unavailable, mentioned by Brown and Pilsbry.

These fossils have a slightly higher spire than *F. pilsbryi* (Woodring, 1928, p. 313, pl. 20, fig. 9, pl. 21, figs. 1, 2) and the initial whorl of their protoconch is smaller. *F. pilsbryi* occurs in the Bowden formation of Jamaica and the Cercado formation of the Dominican Republic. The fossils from the Canal Zone may be more closely related to the lower Miocene Brazilian *F. paraensis* White, which, according to Maury's illustration, has a higher spire than *F. pilsbryi* (Maury, 1925a, p. 123, pl. 5, figs. 10, 12).

The upper part of the Caimito formation in Madden basin at locality 77 (a submerged locality probably representing the calcareous sandstone member) yielded a small mold listed as *Ficus* sp. The primary spirals are closely spaced, suggesting that this *Ficus* is a member of the *F. communis* group, possibly another representative of the lineage just described.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, localities 54h, 54i. Middle part of Gatun formation (middle Miocene), eastern area (Brown and Pilsbry's record). Upper part of Gatun formation (middle Miocene), eastern area, locality 177b.

#### Group of *Ficus ventricosa*

##### *Ficus* species

The occurrence of a *Ficus* of the *F. ventricosa* group in deposits of late Oligocene age is shown by part of a body-whorl mold from the middle member of the Caimito formation in the Gatun Lake area and a similar mold from the Caimito in the Río Caraba area. The primary spirals are very strong and very widely spaced. They are stronger and more widely spaced than those of molds from the lower part of the Caimito in Madden

basin (mentioned under *F. carbasa micronematica*), also of late Oligocene age, and more widely spaced than on specimens of *F. carbasa micronematica* and *F. carbasa carbasa* of the same size.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 56. Caimito formation (late Oligocene), Río Caraba area, locality 60.

#### *Ficus carbasa carbasa* (Guppy)

Plate 36, figures 10, 13

- Ficula carbasa* Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 580, pl. 26, fig. 7, 1866 (Miocene, Trinidad, Anguilla). Guppy, Agricultural Soc. Trinidad and Tobago Proc., v. 10, p. 456, 1910 (reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 152, 1921) (Miocene, Trinidad).
- Ficus mississippiensis* Conrad, Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 223, 1873 (Miocene, Dominican Republic).
- Ficus mississippiensis* (Conrad), Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 525, 1876 (Miocene, Dominican Republic).
- ?*Pyrula papyratia* Say, Böse, Inst. Geol. México Bol. 22, p. 26, 37, pl. 4, figs. 11-13, 1906 (Miocene, México).
- Ficula* (*Pyrula*) sp. cf. *Ficula condita* Brongniart, Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 699, 1909 (Miocene, Canal Zone).
- Pyrula carbasa* (Guppy), Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 364, 1922 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 224, pl. 41, fig. 5, 1925 (Miocene, Trinidad).
- Pyrula trinitaria* Maury, idem, p. 222, pl. 41, figs. 9, 12, 1925 (Miocene, Trinidad).
- Ficus colombiana* Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 143, pl. 13, figs. 1, 2, 1929 (Miocene, Colombia).
- Ficus carbasa* (Guppy), Vokes, Am. Mus. Novitates, no. 988, p. 26, 1938 (Miocene, Trinidad). Rutsch, Naturforschenden Gesell. Basel Verh., Band 54, p. 144, 1942 (Miocene, Trinidad).
- Ficus* aff. *ventricosa* (Sowerby), Rutsch, Schweizer. Palaeont. Gesell. Abh., Band 54, p. 62, pl. 3, fig. 8, text fig. 8, 1934 (Miocene, Venezuela).

Moderately large, strongly inflated, spire low. Protoconch consisting of about 1½ whorls, initial whorl moderately small. Protoconch and early part of first sculptured whorl slightly tilted. Earliest axial threads relatively widely spaced, strongly retractive. Primary spirals strong, widely spaced. Three to seven secondary spirals between primaries. Secondary spirals generally of equal width in sets of three, a middle one slightly wider than others in sets of more than three. Spirals faintly noded by narrow axial threads. Siphonal canal broken.

Height (incomplete) 53 mm, diameter 34.5 mm (figured specimen).

Type: USNM 115509.

Type locality: Savanetta [Savaneta], Trinidad, Caroni series [Savaneta River, about 5.6 kilometers northeast of Forres Park, Springvale formation].

Ficids found in the Alhajuella sandstone member of

the Caimito formation, the middle part of the Gatun formation in the eastern area, the upper part of the Gatun in the western area, and the Chagres sandstone are referred to *Ficus carbasea carbasea*. Though 13 specimens are available, only four (all in collections from the upper part of the Gatun) are more or less complete shells. The others are molds or molds that include some shell material. The molds, however, show at least some sculpture. The largest, a little larger than the figured specimen, were found in the Alhajuela sandstone member of the Caimito and the Chagres sandstone. The strength and spacing of primary and secondary spirals are variable. The early axial threads are preserved on two shells, both from the upper part of the Gatun. They are more widely spaced than those on a specimen from Springvale Quarry, Trinidad. The first sculptured whorl of the type is poorly preserved.

Toula's *Ficula (Pyrula)* sp. cf. *F. condita* is small and incomplete (height 10 mm, diameter 12 mm), but shows the sculpture of the *Ficus ventricosa* group and is identified as an immature specimen of *F. carbasea carbasea*.

The type locality of *F. carbasea* is "Savanetta," Trinidad. According to a communication from H. G. Kugler, "Savanetta" evidently is the locality where the fossiliferous sandstone near the top of the Springvale formation crosses Savaneta River, about 5.6 kilometers northeast of Forres Park. In other words, the type locality is at or near the Brechin Castle Estate locality shown by Rutsch in his account of Springvale fossils (Rutsch, 1942, fig. 1, p. 150; according to Kugler, Couva River of fig. 1 should read Savaneta River). *F. carbasea* was found at the Brechin Castle Estate locality (Rutsch, 1942, p. 144). The type has an ocherous color and ocherous, shelly, granule sandstone matrix, like fossils from Springvale Quarry, which is 1.6 kilometers northeast of Forres Park, where the same fossiliferous sandstone is exposed.

The type is exceptional in one feature: the body whorl is sharply angulated at the posteriormost primary spiral near the suture, as shown in Guppy's illustration. The sharpest angulation was formed later than what appears to be a break in the shell and therefore may be a deformity. The angulation is not shown by four topotypes forwarded by H. G. Kugler or by 11 other specimens from the Springvale formation at other localities.

*F. trinitaria* (type locality Springvale Quarry), was named on the grounds that it has five or seven secondary spirals between primaries, whereas *F. carbasea* has three. The specimen illustrated by Maury as her figure

12 is designated the lectotype (Paleontological Research Inst. 1088). Both the lectotype and Maury's other illustrated specimen have three to seven secondary spirals, but if more than three are present, three generally are stronger than the others. Rutsch has already pointed out that single specimens from the Springvale formation bear three to seven—the range shown by the fossils from the Canal Zone and nearby localities in Panamá.

Guppy's record of *F. carbasea* in the Anguilla formation of the island of Anguilla needs confirmation. A few fragments from the Cercado formation of the Dominican Republic without much doubt represent *F. carbasea carbasea* and a specimen in better condition is in the Gabb collection of fossils from that country. Böse's illustrations of his *Pyrula papyratia* strongly suggest *F. carbasea carbasea*. The type of *Ficus colombiana* is poorly preserved, but the paratype has the outline and sculpture of *F. carbasea carbasea*.

*F. carbasea carbasea* is very similar to *F. ventricosa* (Sowerby), which ranges from southern Baja California to Ecuador. *F. ventricosa* is twice as large and the anterior half of the body whorl of immature shells of the same size as *F. carbasea carbasea* is more strongly constricted. A species of the *F. ventricosa* group has been recognized in the upper Miocene of Florida (Olsson and Harbison, 1953, p. 259).

Occurrence: Alhajuela sandstone member of Caimito formation (early Miocene), Madden basin, locality 88. Middle and upper parts of Gatun formation (middle and late Miocene). Middle part, eastern area, localities 146 (identification doubtful), 147a, 160. Upper part, western area, localities 182, 185. Chagres sandstone (early Pliocene), localities 199, 201. Middle Miocene, southeastern México (identification doubtful). Miocene, Dominican Republic. Middle Miocene, Colombia. Punta Gavilán formation (late Miocene), Venezuela. Springvale formation (late Miocene), Trinidad.

*Ficus carbasea micronematica* (Brown and Pilsbry)

Plate 27, figures 1, 3

*Pyrula micronematica* Brown and Pilsbry, Acad. Nat. Sci. Phila.

Proc., v. 64, p. 507, pl. 22, fig. 8, 1913 (Miocene, Canal Zone).

*Pyrula peruviana* Spieker, Johns Hopkins Univ., Studies in Geol., no. 3, p. 54, pl. 2, figs. 5, 6, 1922 (Miocene, Perú).

Small, moderately inflated, spire low. Protoconch not preserved. Primary spirals moderately strong and moderately widely spaced. Three to seven (generally three) secondary spirals between primaries. Spirals faintly noded by narrow axial threads. Siphonal canal broken.

Height (incomplete) 35 mm, diameter 27.5 mm (largest specimen). Height (incomplete) 25.8 mm, diameter 21.5 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3833.

Type locality: *Pecten* bed in Culebra Cut near Tower N, Las Cascadas, Canal Zone [Emperador limestone member of Culebra formation].

*Fiscus carbacea micronematica* is represented by 15 specimens from the Culebra formation proper and one from the Emperado limestone member. All, like the type, are poorly preserved. This unsatisfactory material indicates that *F. micronematica* is a small subspecies of *F. carbacea* and that arrangement is adopted, although the protoconch and early sculpture are unknown. Most of the specimens are not as slender as that figured. The upper part of the spire of the figured specimen appears to be bulbous, but the spire is damaged and the shell material of the tip is replaced and worn. Three molds from the upper Oligocene part of the Caimito formation in Madden basin, which are in even poorer condition than the fossils from the Culebra formation, are identified as *Ficus* cf. *F. carbacea micronematica*.

No features are apparent to distinguish *F. peruviana* from *F. carbacea micronematica*. The protoconch of the type (and only specimen) of *F. peruviana* is slightly tilted and consists of two whorls. *F. woodringi* Olsson (1931, p. 98, pl. 18, fig. 8), which occurs in the upper Oligocene Heath formation of Perú, may be the predecessor of *F. carbacea micronematica*. The anterior part of the shell of *F. woodringi* is more constricted and a central secondary spiral is stronger than the other secondary spirals.

*Ficus* cf. *F. carbacea micronematica* (upper Oligocene), *F. carbacea micronematica* (early part of lower Miocene), *F. carbacea carbacea* (later part of lower Miocene to lower Pliocene), and *F. ventricosa* (Pliocene, Ecuador, and Recent) are reasonably interpreted as a lineage and are graded in size. Lineages of a duration from late Oligocene to early Pliocene are unusual in the faunas studied for the present report.

Occurrence: Limestone lenses in pyroclastic-clay member, lower part of Caimito formation (early Oligocene), Madden basin, localities 71, 73 (*Ficus* cf. *F. carbacea micronematica*, both localities). Culebra formation (early Miocene), localities 99c, 99d, 99f, 99g, 99h, 102, 111b, 114, 115a. Emperador limestone member of Culebra formation (early Miocene), locality 120. Lower part of Zorritos formation (early Miocene), Perú.

#### Genus *Gonysycon* Woodring, n. gen.

Type: *Gonysycon epomis* Woodring, n. sp., Oligocene, Canal Zone.

Small, outline *Ficus*-like but shouldered, spire low. Protoconch unknown. Spire whorls sculptured with narrow axial ribs gradually reduced on body whorl and disappearing on later half of body whorl. Closely spaced axial threads conspicuous on body whorl. Spiral threads overriding ribs, on later half of body whorl combined with the narrower and more closely spaced axial threads to form *Ficus*-like reticulate sculpture. Spiral threads faintly noded by axial threads. Anterior part of body whorl strongly constricted. Siphonal canal apparently relatively short.

The outline and late sculpture indicate that *Gonysycon* is a small, shouldered, low-spired, axially ribbed fid. The axial ribs, however, are lost on the later half of the body whorl, which has *Ficus*-like reticulate sculpture. Though only three poorly preserved specimens are available, the combination of characters seems to be distinctive. The low spire, shoulder and strong constriction of the anterior part of the body whorl distinguish *Gonysycon* from *Fulgurofiscus* Sacco (1891, p. 41; type (orthotype): *Pyruca burdigalensis* Sowerby, Miocene, Southwestern Europe). The typical form of the type species of *Fulgurofiscus* is noded on and below the shoulder. The combination of nodes and high spire of *Fulgurofiscus* recall the noded species of the Eocene high-spined, more slender genus *Ficopsis* Conrad (1866, p. 100; type (logotype, Stewart, 1927, p. 375): *Hemifiscus remondii* Gabb, Eocene, California). Both *Fulgurofiscus burdigalensis* and the noded species of *Ficopsis* have axial ribs on the early whorls, whereas the sculpture of the early whorls of the large and very heavily noded genus *Trophosycon* Cooper (1894, p. 53; type (monotype): *Agasoma?* (*Trophosycon*) *kennerlyanum* Cooper, Miocene, California) is *Ficus*-like.

#### *Gonysycon epomis* Woodring, n. sp.

Plate 26, figures 9, 13-15

Field, n. gen., Woodring, Smiths. Misc. Coll., v. 135, no. 3, p. 15 (list), 1957 (Oligocene, Canal Zone).

Penult whorl sculptured with about 13 axial ribs, some of which are not preserved. Tip of siphonal canal missing. For other features see description of genus.

Height (incomplete 26.2 mm, diameter 17.3 mm (type).

Type material: Type, USNM 562566; paratype USNM 562567.

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.

The two specimens of this species—the type and the more strongly shouldered paratype—are incomplete and much of the shell material is missing. No closely related species, other than the next species, has been recognized.

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

*Gonysycon* cf. *G. epomis* Woodring, n. sp.

An incomplete specimen (spire and posterior part of body whorl) of another species of *Gonysycon* was found in the Bohio formation on Barro Colorado Island, but not in association with *G. epomis*. It is in poorer condition than the specimens of *G. epomis*. Only traces of axial ribs remain on the spire whorls and none is visible on the body whorl, which has a diameter of 17.5 mm. This species is not as strongly shouldered as *G. epomis*.

Occurrence: Bohio formation (late Oligocene), locality 42g.

Family MURICIDAE

Subfamily MURICINAE

Fragmentary remains from the marine member of the Bohio(?) formation, and the Bohio and Culebra formations probably represent muricine genera.

Genus *Murex* Linné

Linné, Systema naturae, 10th ed., p. 746, 1758.

Type (logotype, Montfort, Conchologie systématique, v. 2, p. 619, 1810): *Murex pecten* Montfort (= *M. tribulus* Linné), Recent, western Pacific Ocean.

Subgenus *Murex* s. s.

*Murex* (*Murex*) *recurvirostris recurvirostris* Broderip

Plate 35, figures 5, 8, plate 36, figures 11, 12

*Murex recurvirostris* Broderip, Zool. Soc. London Proc., 1832, p. 174 (Recent, Gulf of Nicoya, Costa Rica). Ratsch, Schweizer. Pal. Gesell. Abh., Band 54, p. 64, pl. 4, fig. 1, 1934 (Miocene, Venezuela).

*Murex messorius* Sowerby, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 353, 1911 (Miocene, Canal Zone).

*Murex* (*Murex*) *recurvirostris* Broderip, Woodring, Carnegie Inst. Washington Pub. 385, p. 288, pl. 17, figs. 7, 8, 1928 (Miocene, Jamaica; additional citations). Hertlein and Strong, Am. Mus. Nat. History Bull. 107, p. 252, 1955 (Recent, Pacific coast of Panamá).

*Murex* (*Murex*) *woodringi* Clench and Pérez Farfante, Johnsonia, v. 1, no. 17, p. 9, pl. 4, figs. 1-3, 1945 (Recent, Jamaica, northern South America).

*Murex woodringi* Clench and Pérez Farfante, Aguayo, Soc. Malacológica Carlos de la Torre Revista, v. 6, p. 63 (list), 1948 (Miocene, Cuba).

Of medium size, moderately spinose. Protoconch slender, consisting of  $2\frac{3}{4}$  whorls, initial whorl small;

or consisting of  $1\frac{3}{4}$  whorls, initial whorl large. End of protoconch, as in all muricine gastropods, marked by narrow varix. Sculpture of early post-protoconch whorls consisting of closely spaced, wide axial ribs, three spiral threads, and a very narrow spiral thread near posterior suture. First varix appearing on third or fourth sculptured whorl. Varices strongly pinched, a little ahead of corresponding varix on preceding whorl. At first two axial ribs between varices, later three, and still later three to five; generally four. On largest shell ribs of body whorl narrow and suppressed, the number indefinite, but more than five. On late whorls primary and secondary spirals alternating. Primary spiral on shoulder forming short backward-bent spine on varices; another spine at base of varices on spire whorls. Body whorl varices bearing four to six spines. Spines generally more or less broken. Edge of outer lip scalloped by elongate interior denticles. Siphonal canal moderately long, narrow, straight, tip broken, outer side bearing one spine. Inner lip weakly denticulate or smooth. Parietal wall bearing an elongate posterior denticle.

Height (incomplete) 45.8 mm, diameter (including terminal varix and its broken shoulder spine) 27.5 mm (largest specimen, figured).

Type locality: Gulf of Nicoya, Costa Rica, Recent.

*Murex recurvirostris recurvirostris* occurs in the lower, middle, and upper parts of the Gatun formation, but is nowhere abundant. It is represented by 10 specimens. The larger figured specimen (the largest of the fossils) has exceptionally suppressed axial ribs on the body whorl. The apertural face of the smaller figured specimen is greatly worn. The roof of the siphonal canal, leaving only a narrow slit open, is well preserved on one shell (locality 157). A  $2\frac{3}{4}$ -whorled acutely tapering protoconch is preserved on two of the fossils from the middle part of the Gatun, whereas the single specimen from the upper part of the formation has a  $1\frac{3}{4}$ -whorled blunt protoconch. The two kinds of protoconch, however, are not correlated with differences at later growth stages.

*M. recurvirostris* is another example of a species that appeared in the Miocene and survived on both sides of Central America. It is widely distributed in the Miocene of the Caribbean region. A relatively small and light-colored Recent form, found along the coasts of Florida and the Bahamas, and apparently southward to Yucatan and eastward to Hispaniola, is now known as *M. recurvirostris rubidus* F. C. Baker (Clench and Pérez Farfante, 1945, p. 6, pl. 3; figs. 1-7). A small-apertured light-colored form dredged off Yucatan has been named *M. recurvirostris sallasi* Rehder and Abbott (1951, p. 58, pl. 9, figs. 7, 8). Clench and Pérez Farfante

(1945, p. 9) thought that a worn dark-colored shell from Santa Marta, Colombia, may be *M. recurvirostris recurvirostris*. The collections of the U. S. National Museum contain numerous more or less dark-colored shells from British Honduras, Panamá, Colombia, and Trinidad. These shells appear to be indistinguishable from the eastern Pacific *M. recurvirostris recurvirostris*. It is doubtful whether *M. woodringi* Clench and Pérez Farfante (1945, p. 9, pl. 4, figs. 1-3; type locality Jamaica) can be distinguished from the shells ranging from Central America to Trinidad. Clench and Pérez Farfante suggested that the Miocene Jamaica *Murex* described as *M. recurvirostris* is *M. woodringi*. The Jamaican fossils are indeed very similar to Jamaican Recent shells. The number of ribs between varices, emphasized in the description of *M. woodringi*, is variable in fossils and in Recent shells from both sides of Central America, ranging from two to five, or even more. *M. antillarum* Hinds, with which Rutsch suggested the Jamaican fossil form should be compared, is larger, more spinose, and has a longer bent siphonal canal.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a. Middle part, eastern area, localities 155, 155b, 157. Upper part, eastern area, locality 176. Quebradillas limestone (early Miocene), Puerto Rico. Pirabas formation (early Miocene), Brazil. Cereado formation (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Middle Miocene, Costa Rica, Cuba. Deposits of late Miocene age, northeastern Panamá. Punta Gavilán formation (late Miocene), Venezuela. Pliocene, eastern and western Costa Rica. Pleistocene, western Costa Rica. Recent, Jamaica, St. Thomas, British Honduras to Trinidad; Mazatlan, México, to southern Ecuador.

***Murex (Murex?) cf. M. polynematicus* Brown and Pilsbry**

Two poorly preserved, relatively small specimens (restored height about 40 mm, restored diameter about 20 mm) from the uppermost part of the Culebra formation, including the transition zone between the Culebra and Cucaracha formations, are identified as *Murex* cf. *M. polynematicus*. The shell material is corroded on one, and what remains on the other is replaced by secondary calcite. The varices, axial ribs, and spiral sculpture, so far as shown, suggest a species comparable to *M. polynematicus*, the next species described.

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

***Murex (Murex?) polynematicus* Brown and Pilsbry**

Plate 36, figures 2, 3, plate 37, figures 6, 9

*Murex polynematicus* Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 353, pl. 26, fig. 1, 1911 (Miocene, Canal Zone).

Moderately large, strongly shouldered, moderately spinose. Protoconch consisting of three acutely tapering whorls. Early post-protoconch whorls not shouldered, sculptured with axial ribs and three spiral threads. First varix appearing on third or fourth sculptured whorl or delayed until about sixth. Varices moderately pinched, well ahead of corresponding varix on preceding whorl. At first two or three strong axial ribs, extending from suture to suture, between varices; later two and finally on body whorl generally one, swollen and extended on shoulder but not reaching suture. Spiral sculpture of late whorls consisting of closely spaced threads of different rank. All except earliest post-protoconch whorls also sculptured with faint irregular axial swellings and microscopic irregularly spaced axial threads. Varices bearing a short erect spine at shoulder and on body whorl a blunt projection or low spine below shoulder. One or two slender spines present or absent on pillar on the two varices preceding terminal varix. Edge of outer lip scalloped; interior bearing elongate denticles well within aperture. Siphonal canal moderately long, narrow, slightly bent backward, tip broken. Basal part of inner lip bearing elongate denticles.

Height (incomplete) 54.5 mm, diameter (including terminal varix and its broken shoulder spine) 33.7 mm (largest specimen, figured). Height (incomplete) 48.7 mm, diameter (including terminal varix and its shoulder spine) 29.7 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 1719.

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

Though *Murex polynematicus* is found in the lower, middle, and upper parts of the Gatun formation, and in both eastern and western areas in the upper part, it is by far most abundant in the lower part (13, two, one, and four specimens, respectively). On all the specimens from the lower part the earliest varix appears at an early stage, but on one from the middle part and all from the upper part it appears at a late stage. The axial ribs are greatly reduced on the last two whorls of the specimen from the middle part that has a late-appearing varix (only a terminal varix at a height of 88 mm on 4½ preserved whorls).

*M. polynematicus* is related to the Recent *M. chryso-stoma* Sowerby (Clench and Pérez Farfante, 1945, p. 10, pl. 5, figs. 1, 2), which has a limited range from Venezuela and Barbados southward probably to Brazil.



mation (early Miocene), Brazil. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Middle Miocene, Costa Rica. Middle Miocene, Falcón, Venezuela. Springvale formation (late Miocene), Trinidad. Deposits of Pliocene age, Venezuela. Pliocene, Florida. Recent, southern Florida to northern South America.

**Genus Paziella Jousseume**

Jousseume, Le Naturaliste, 2nd year, no. 42, p. 335, 1180.

Type (monotype): *Murex pazi* Crosse, Recent, West Indies.

The subgenus *Paziella* s.s., characterized by long slender spines on the shoulder and siphonal fasciole and by very weak spiral sculpture, is unknown as a fossil. As suggested by Rehder (1946, p. 143), it may be a deep-water offshoot from the subgenus *Dallimurex*.

**Subgenus Panamurex Woodring, n. subgen.**

Type: *Murex (Phyllonotus) gatunensis* Brown and Pilsbry, Miocene, Canal Zone.

Of medium size, strongly shouldered. Axial sculpture consisting of sharp-edged varices, which bear a short, slender, erect spine on spiral cord at shoulder. Spiral sculpture strong, consisting of cords and threads. Interior of outer lip bearing strong elongate denticles or ridges. Siphonal canal moderately long, bent backward. Basal part of inner lip bearing three to five elongate denticles.

The strong spiral sculpture, strong elongate denticles or ridges on the interior of the outer lip, and the elongate denticles on the basal part of the inner lip distinguish *Panamurex* from the subgenus *Dallimurex* Rehder (1946, p. 142; type (orthotype): *Murex nuttingi* Dall (Clench and Pérez Farfante, 1945, p. 49, pl. 25, fig. 5), Recent, Florida Keys).

Both *Dallimurex* and *Panamurex* appeared in late early Miocene time. They are associated in the Chipola formation of Florida: *Paziella (Dallimurex) lychnia* Gardner (1926-47, p. 523, pl. 53, figs. 12, 13, 1947) and *Paziella (Dallimurex) fusinoides* Gardner (idem, p. 524, pl. 52, figs. 39, 42), respectively. "*Muricopsis*" *lacopoia* Gardner (idem, p. 529, pl. 52, figs. 40, 41), which occurs with *P. fusinoides*, evidently is that species.

*Dallimurex* is the group of muricine gastropods for which the name "*Muricopsis*" has been used (Woodring, 1928, p. 291), although it was realized that name is unsuitable. Species of *Dallimurex*, all of which have very weak to moderate spiral sculpture, are fairly widespread in the middle and upper Miocene of the Caribbean region: "*Murex*" *collatus* Guppy (Woodring, 1928, p. 291, pl. 17, figs. 10, 11; Jamaica), "*Trophon*" *dominicensis* Gabb (Pilsbry, 1922, p. 354, pl. 28, figs. 2, 3; Dominican Republic), "*Murex (Trophon)*" *wernerii*

Toula (1911, p. 479, pl. 29, fig. 9; Tehuantepec), "*Muricopsis*" sp. (Woodring, 1928, p. 292, pl. 18, fig. 1; Jamaica), and an undescribed slender, high-whorled species from Tehuantepec (USGS locality 10361). In addition to the type species, dredged at depths of 15 to 100 fathoms near Key West, Fla., *Dallimurex* survives in Caribbean waters, where it is represented by three small, moderately deep-water species: "*Murex*" *hystri-cinus* Dall (Clench and Pérez Farfante, 1945, p. 45, pl. 24, figs. 4-7; south of Cuba and Lesser Antilles, 148 to 254 fathoms) "*Eupleura*" *stimpsonii* Dall (1889, p. 204; Barbados, 100 fathoms), and "*Murex (Murexul)*" *car-nicolor* Clench and Pérez Farfante (1945, p. 48, pl. 25, figs. 1-4; Lesser Antilles, 88 to 103 fathoms). *Panamurex*, on the contrary, is rare and is not known to have survived beyond late middle Miocene time.

**Paziella (Panamurex) gatunensis (Brown and Pilsbry)**

Plate 35, figures 6, 7, 9, 10

*Murex (Phyllonotus) gatunensis* Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 354, pl. 26, fig. 2, 1911 (Miocene, Canal Zone). Brown and Pilsbry, Idem, v. 64, p. 503 (list), 1913 (Miocene, Canal Zone).

*Murex gatunensis* Brown and Pilsbry, Pilsbry and Brown, idem, v. 69, p. 34 (list), 1917 (Miocene, Colombia).

Relatively large, strongly shouldered, strongly sculptured spirally. Protoconch slender, consisting of 2½ whorls. End of protoconch marked by narrow varix. Sculpture of first post-protoconch whorl consisting of narrow varices. Two wide, but weak, spiral cords appear on second whorl. Varices and spiral cords gradually strengthened. Late whorls bearing seven sharp-edged varices, strong spiral cords, and narrow spiral threads between them. Varices bearing a short, slender, erect spine on spiral cord at shoulder and forward-directed extensions (generally more or less damaged) on four or five body-whorl spiral cords below shoulder. Edge of outer lip frilled by the spine and extensions; interior bearing strong, elongate denticles or longer ridges well within aperture. Siphonal canal moderately long, wide at insertion, bent backward. Siphonal fasciole sculptured with a row of lamellar spines aligned with varices. Basal part of inner lip bearing three to five strong, elongate denticles.

Height (incomplete) 35 mm, diameter (incomplete, including terminal varix and its shoulder spine) 23 mm, restored diameter about 26 mm (largest specimen, figured). Height 27 mm, diameter (including terminal varix and its shoulder spine) 14.7 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 1720.

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



*Paziella gatunensis* is found in the middle part of the Gatun formation, in both eastern and western areas, and in the upper part in the eastern area. The 12 specimens are damaged or fragmentary, with the exception of three immature shells from locality 155c, one of which is illustrated (pl. 35, figs. 9, 10). In 1913 Brown and Pilsbry identified this species in a collection from the Emperador limestone member of the Culebra formation, and Pilsbry and Brown later listed it from middle Miocene deposits in Colombia. These specimens were not found during a recent visit at the Academy of Natural Sciences of Philadelphia, although they doubtless are still in the Academy's collections. A somewhat worn specimen is in a collection of middle Miocene fossils from the Darién area (USGS locality 8477). The weaker spirals of the Darién specimen presumably are the result of wear.

A very closely related undescribed species, more slender than *P. gatunensis* and not quite so strongly sculptured, occurs in the Gurabo formation of the Dominican Republic (USGS locality 8544). *P. gatunensis* is larger, more inflated, and more strongly shouldered than the late early Miocene *P. fusinoides* Gardner, and has more numerous minor spirals. The early lower Miocene "*Murex spinulosa*" Heilprin (1887, p. 108, pl. 15, fig. 41; Tampa limestone, Florida; not *Murex spinulosus* Deshayes, 1835), with which Brown and Pilsbry compared *P. gatunensis*, evidently represents a different muricine genus.

Occurrence: Emperador limestone member of Culebra formation (early Miocene; Brown and Pilsbry's record). Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 155, 155b, 155c, 157; western area locality 161a. Upper part, eastern area, localities 163, 173, 175, 176. Middle Miocene, Darién area, Panamá. Middle Miocene, Colombia (Pilsbry and Brown's record).

#### Genus *Yasila* Olsson

Olsson, Bull. Am. Paleontology, v. 17, no. 62, p. 59, 1930.  
Type (orthotype): *Yasila paytensis* Olsson, Eocene, Perú.

The genus *Yasila* embraces small, or moderately small, early Tertiary species that have a short siphonal canal, heavy axial ribs, and a low columellar fold at the insertion of the siphonal canal. The columellar fold is similar to that of some other muricid genera and of genera in other families, notably buccinid and nassarid genera. The only species of the genus so far recognized are found in the Eocene of Perú and the Canal Zone and the Eocene or Oligocene of Perú.

#### *Yasila* aff. *Y. paytensis* Olsson

Plate 24, figures 4, 5

Moderately small, strongly inflated, moderately shouldered, whorls constricted between shoulder and slightly swollen band adjoining suture. Protoconch not preserved. Axial ribs wide, swollen, less swollen between shoulder and suture; nine on body whorl. Axial threads narrow, subdued on ribs. Primary spiral threads narrow, secondary threads poorly preserved. Edge of outer lip broken; interior bearing weak ridges near edge of lip. Siphonal canal short, tip broken. Siphonal fasciole moderately swollen. Columella bearing a low fold at insertion of siphonal canal.

Height (incomplete) 18.5 mm, diameter 12.5 mm (figured specimen).

*Yasila* aff. *Y. paytensis* is larger than *Y. paytensis* Olsson (1930, p. 60, pl. 11, figs. 11, 16-18; upper Eocene, Perú) and *Y. chiraensis* Olsson (1931, p. 104, pl. 14, figs. 9, 11; upper Eocene or lower Oligocene, Perú) and its whorls are constricted above the shoulder. It is a new species, but no suitable type material is available. That the figured specimen is immature is shown by a fragment, which is the only other specimen. The fine sculpture is not well reproduced by the granular silica replacing the shell.

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

#### Genus *Eupleura* H. and A. Adams

H. and A. Adams, The genera of Recent Mollusca, v. 1, p. 107, 1853.

Type (logotype, Baker, Chicago Acad. Sci. Bull., v. 2, p. 176, 1895): *Eupleura caudata* (Say) (*Ranella caudata* Say), Recent, Massachusetts to Florida, Louisiana, Bahamas, and northwestern Cuba.

In his widely used volumes of the Handbuch der Paläozoologie covering the prosobranch gastropods, Wenz placed *Eupleura* in the subfamily Drupinae (the group for which the family name Thaididae is used in the present report) of the family Muricidae. *Eupleura* is muricine in shell and opercular characters. The radular dentition, however, is like that of *Urosalpinx* and *Ocenebra* (Troschel, 1866-91, pl. 11, figs. 13, 14, 20, 1869).

#### *Eupleura thompsoni* Woodring, n. sp.

Plate 36, figures 6-9

Relatively large, strongly inflated, distinctly but not strongly shouldered. Protoconch blunt-tipped, 2½-whorled, smoothly tapering; a narrow spiral thread at anterior suture on last 1½ whorls. First post-proto-

conch whorl sculptured with narrow axial lamellae—the first strongly arcuate, the others moderately arcuate—and two low spiral cords. Lamellae slightly overlapping last protoconch whorl. Lamellae gradually widening, but remaining as sharp-edged lamellae up to first varix, which appears on penult or preceding whorl of mature shells. Two varices to a whorl, almost directly opposite each other, but each one later than corresponding varix on preceding whorl. Original lamellae transformed between varices into low swollen ribs, not reaching posterior suture and on body whorl disappearing below periphery. Three or four ribs between varices, generally three, and invariably three between last two varices of mature shells. A rib between early varices rarely has a lamellar edge of outer shell material. Body whorl of mature shells sculptured with seven main spiral cords, the posteriormost faint between last two varices, and as many as five somewhat narrower spiral threads on pillar, fading out anteriorly. Posteriormost spiral cord forming short spine on outer lip; others forming blunt spines or projections; spines generally more or less broken. Interior of outer lip bearing six strong denticles well within aperture. Siphonal canal moderately long, narrow, slightly bent backward; tip broken. Next to last varix forming low lamella on siphonal fasciole.

Height (not quite complete) 45.7 mm, diameter (including last two varices) 29.5 mm (largest specimen, type).

Type: USNM 562587.

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

*Eupleura thompsoni* is abundant in the lower part of the Gatun formation, which yielded 38 specimens. Two immature specimens, one of which shows the protoconch (the only shell showing that growth stage), were found in the middle part in the eastern area. It is represented in all except one of the collections from the lower part along the Transisthmian Highway. The largest number of specimens in a collection is 18, collected by T. F. Thompson at the type locality. It also occurs, but is rare, in deposits of middle Miocene (USGS locality 11325) and late(?) Miocene (USGS localities 8101 and 10158; identification doubtful for 10158) age in northeastern Colombia.

This is the first described Tertiary *Eupleura* from a locality south of Florida. It would be remarkable if it were closely related to *E. caudata*, the type of the genus and the only species in the western Atlantic Ocean and adjoining waters. *E. caudata* ranges from Cape Cod, Mass., to the Florida Keys, the Bahamas

and the north coast of western Cuba, and westward in the Gulf of Mexico to Louisiana; that is, it is restricted to waters cooler than the Caribbean Sea. It is a serious pest on oyster beds, except in water of low salinity (Galtsoff, Prytherch, and Engle, 1937). As a matter of fact, *E. thompsoni* is more closely related to the eastern Pacific *E. muriciformis* (Broderip) (Hertlein and Strong, 1955, p. 258). It is, however, more inflated than *E. muriciformis*, and has stronger spiral sculpture and less shouldered early whorls. (A form of *E. muriciformis* dredged in the Gulf of California is thin-shelled and has high thin varices.) *E. muriciformis* is a Panamic species ranging from Cedros Island, Baja California, to northern Perú. It occurs in the Pliocene of Ecuador (Pilsbry and Olsson, 1941, p. 37) and during late Pleistocene time ranged far northward to the San Pedro district, California. The markedly different temperature tolerances of the two species of *Eupleura* on the Atlantic and Pacific coasts of America illustrate the uncertainty that may be involved in paleoecologic interpretations at the generic level.

The earliest *Eupleura* now known in the Caribbean region is a small specimen from deposits of early Miocene age in Colombia (USGS locality 11641). The genus gained only a temporary footing in the Caribbean Sea and now is extinct there. "*Eupleura*" *stimpsonii* Dall, dredged off Barbados, is a small *Paziella* of the subgenus *Dallimurea* (p. 217). There also is no species on the coast of California. "*Eupleura*" *grippi* Dall (1911, p. 87; San Diego, 15 fathoms) evidently is a thaidid, not a muricid. The type is the only specimen.

*Eupleura caudata* appears in the upper Miocene of southeastern United States. The early Miocene *E. pterina* Gardner (1926-47, p. 532, pl. 53, fig. 6, 1947; Chipola formation, Florida) is the earliest species of the genus. The type (and only specimen) may be immature (height 14.7 mm). No varix precedes the terminal varix and that varix is preceded by only one nonlamellar axial rib. The slightly earlier, small "*Murea*" *sexangula* Dall (1915, p. 74, pl. 13, fig. 11; Tampa limestone, Florida), which was assigned to *Eupleura* by Mansfield (1937, p. 132), lacks heavy varices, even a heavy varix at the outer lip, and lacks strong denticles on the interior of the outer lip. It is not a *Eupleura*.

*Eupleura thompsoni* is named for T. F. Thompson, formerly Chief of the Geological Section, Special Engineering Division, Panama Canal Company, who collected many of the fossils from the Gatun formation described in the present series of report, including species not represented in collections other than his.

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

locality 155. Deposits of middle and late(?) Miocene age, northeastern Colombia.

#### Subfamily TYPHINAE

Keen's 1944 review is an indispensable starting point for a study of typhine gastropods.

#### Genus *Typhis* Montfort

Montfort, *Conchylologie systématique*, v. 2, p. 615, 1810.

Type (orthotype): *Typhis tubifer* (Roissy) (*Murex tubifer* Roissy) = *Purpura tubifer* Bruguière, Eocene and Oligocene, Western Europe.

Winckworth (1945, p. 143-144) and Clench (1947, p. 63-64) have discussed the action by the International Commission on Zoological Nomenclature that may be needed to validate *Purpura* Bruguière, 1789, with *Buccinum persicum* Linné as the type. Otherwise it may be argued that *Typhis* is an objective synonym of *Purpura* Bruguière, 1792, (monotype, *Purpura tubifer* Bruguière).

Wrigley (1930, p. 112) thought that *Typhis tubifer* should take the trivial name of "*Murex*" *pungens* Solander, described at an earlier date. On the basis of Solander's illustration, that view was rejected by Keen (1944, p. 53). Wrigley's *T. pungens* doubtless is *T. tubifer*. According to his records, it occurs in the middle Eocene of the Paris basin, the upper Eocene and lower Oligocene of England, and the entire Oligocene of Germany.

#### Sugenus *Pilsbrytyphis* Woodring, n. subgen.

Type: *Typhis gabbi* Brown and Pilsbry, Miocene, Canal Zone.

Five varices to a whorl. Tubes midway between varices, slightly bent backward. All except earliest whorls bearing irregular axially wrinkled and pitted sculpture. Aperture small. Siphonal canal short, moderately bent.

According to Keen's arrangement (1944, p. 52), *Typhis gabbi* keys out to the subgenus *Typhina* (Jousseaume, 1880, p. 335; type (orthotype): *Typhis belcheri* Broderip, Recent, West Africa). She allowed considerable latitude in assigning species to *Typhina*, a view that has to be adopted to avoid numerous monotypic, or almost monotypic, groups. Of the six species grouped with the type species, none has the long strongly bent siphonal canal of the type species and only two (*Typhis dentatus* Conrad, upper Eocene, Mississippi, and *T. bivaricatus* Verco, Recent, South Australia) have varices slightly frilled by weak spirals, like the type species. One of those two, *T. bivaricatus* has an exceptional feature: double varices. Though a conservative attitude in delimiting the subgenera of *Typhis* is commendable, the remarkable peanut-shell

sculpture (minus the cross bars) of *T. gabbi* cannot be compared with that of any other typhine gastropod. The subgeneric name *Pilsbrytyphis* is proposed for it. It is unlikely that a species like *T. gabbi* arose from *Typhina* in a single step. Indeed, an undescribed weakly sculptured species represents an intermediate stage, but it is of the same age as *T. gabbi*.

The name *Pilsbrytyphis* is a tribute to the late Dr. Henry A. Pilsbry, of the Academy of Natural Sciences of Philadelphia, a friend and wise counselor for 40 years. He adequately described the sculpture of the type species.

#### *Typhis* (*Pilsbrytyphis*) *gabbi* Brown and Pilsbry

Plate 32, figures 2, 3, 5, 7

*Typhis gabbi* Brown and Pilsbry, *Acad. Nat. Sci. Phila. Proc.*, v. 63, p. 354, pl. 26, fig. 6, 1911 (Miocene, Canal Zone). Keen, *Jour. Paleontology*, v. 18, p. 65, 1944 (assigned to subgenus *Typhina*).

Of medium size, slender, strongly turreted, whorls strongly channeled adjoining posterior suture. Protoconch narrow, blunt-tipped, 1½-whorled. End of protoconch marked by change in texture of shell. First post-protoconch whorl bearing five low, swollen axial ribs, corresponding to varices of later whorls. First spine-bearing varix and first tube appearing on next whorl. Five spine-bearing varices to a whorl. Tubes midway between varices, slightly bent backward. Spines and tubes generally broken. Irregular axially wrinkled and pitted sculpture beginning on fourth post-protoconch whorl, thereafter covering entire whorl, except channel adjoining posterior suture, siphonal canal, and siphonal fasciole. Aperture small, narrowly ovate. Siphonal canal short, moderately bent away from siphonal fasciole.

Height (practically complete) 20.6 mm, diameter 11 mm (larger figured specimen).

Type: Acad. Nat. Sci. Phila. 1722.

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

The type of *Typhis gabbi* and an immature specimen were recovered from the middle part of the Gatun formation in the eastern area, and 18 specimens were found in the upper part in the eastern area. All are quite uniform. Except for the sculpture, this species is remotely similar to *T. harrisi* Olsson (Mansfield, 1930, p. 83, pl. 11, fig. 6), a late Miocene species from Florida, but is more slender, and has a deep channel, instead of a shelf, adjoining the suture and a smaller aperture.

An undescribed more weakly sculptured species—the only other species of *Pilsbrytyphis* now known—occurs in the middle Miocene of the Darién area in eastern Panamá (USGS locality 8477).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, localities 147g, Gatun Locks excavation (Brown and Pilsbry's record). Upper part, eastern area, localities 175, 176, 176a, 177b.

#### Subgenus *Talityphis* Jousseume

Jousseume, Rév. Mag. Zoologie, 42nd year, 3rd ser., v. 7, p. 338, 1879 [1881(?)].

Type (orthotype): *Typhis expansus* Sowerby, Recent, locality unknown (presumably West Indies).

The region where *Typhis expansus* occurs was unknown until Olsson collected at Monte Cristi, on the north coast of the Dominican Republic, specimens closely resembling Sowerby's illustration (Keen, 1943, p. 53). Until then it was thought that *Talityphis* is extinct in the Caribbean region.

*Talityphis* appeared in Florida and Haiti in late early Miocene time; reached its widest distribution in the middle Miocene: Florida, Jamaica, Dominican Republic, Trinidad, Colombia, and California; and survives in the Caribbean and Panamic regions.

#### *Typhis (Talityphis) alatus obesus* Gabb

Plate 31, figures 3, 4

*Typhis obesus* Gabb, Am. Philos. Soc. Trans., n. s., v. 15, p. 203, 1873 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 73, p. 354, pl. 28, figs. 5, 6, 1922 (Miocene, Dominican Republic). Keen, Jour. Paleontology, v. 18, p. 66, 1944 (assigned to subgenus *Talityphis*).

*Typhis alatus* Sowerby, Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 354, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 132, pl. 10, fig. 15, 1922 (Miocene, northwestern Panamá).

*Typhis alatus obesus* Gabb, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 1, p. 151, 1890 (Miocene, Florida).

*Typhis (Talityphis) alatus obesus* Gabb, Woodring, Carnegie Inst. Washington Pub. 385, p. 294, pl. 18, figs. 3, 4, 1928 (Miocene, Jamaica). Keen, San Diego Soc. Nat. History Trans., v. 10, no. 2, p. 53, 56, pl. 3, figs. 13, 18, 22 (Miocene, northwestern Panamá). Gardner, U. S. Geol. Survey Prof. Paper 142, p. 527, pl. 53, figs. 15, 16, 1947 (Miocene, Florida). not *Typhis alatus obesus* Gabb, Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 214, pl. 36, figs. 6, 9, 1925 (Miocene, Trinidad).

Moderately large, greatly inflated, strongly shouldered, spire moderately low. Protoconch relatively large, consisting of about 1½ whorls. Whorls bearing four or five lamellar varices, ending on shoulder in blunt hollow spine. Tubes almost midway between varices, but closer to preceding varix. Suture extending from aboral side of varix to base of whorl. Another suture extending from spine of preceding varix to aboral side of tube and along adoral side of low partition abutting against preceding whorl. Tubes and spines generally

broken to base. Spiral sculpture absent on spire, except for pinching at shoulder. Body whorl below shoulder bearing four weak spiral threads, most conspicuous on flank of terminal varix. Aperture moderately large. Terminal varix greatly expanded, its edge strongly frilled by the four spiral threads; basal part bearing three other weak frills. Siphonal canal evidently short, tip broken.

Height (not quite complete) 29.4 mm, diameter 22.3 mm (figured specimen).

Type: Acad. Nat. Sci. Phila. 3251.

Type locality: Dominican Republic, Miocene.

A relatively large specimen of *Typhis alatus obesus* was found in the lower part of the Gatun formation and the same form was recorded from the middle part in the eastern area by Brown and Pilsbry as *T. alatus*. The suture extending from a tube to the preceding varix is almost obliterated on the specimen from the lower part of the formation.

The status of *T. alatus* Sowerby (1850, p. 48, pl. 10, fig. 4) and *T. obesus* still is as uncertain as it was when the matter was discussed in 1928 (Woodring, 1928, p. 294). For the time being *T. obesus* is treated as an inflated relatively low-spined subspecies of *T. alatus*, as was done by Dall in 1890. Both forms were collected in the Dominican Republic. Though they presumably occur in the Cercado or Gurabo formations, they were not found by the Maury or U. S. Geological Survey expeditions in either.

The *Typhis* from the lower Miocene Chipola formation of Florida, identified by Dall and Gardner as *T. alatus obesus*, is smaller than middle and late Miocene Caribbean specimens and has somewhat weaker spiral sculpture, but agrees in essential features. *T. pterinus* Gardner (1926-47, p. 528, pl. 53, fig. 14, 1947), from the middle Miocene Shoal River formation of Florida, is small, slender, and high spired. It probably is closely related to *T. alatus*. Maury's *T. alatus obesus*, found in the Manzanilla formation of Trinidad, has a higher spire and stronger spiral sculpture than *T. alatus obesus* of the present report.

*T. alatus obesus* closely resembles the Recent Panamic *T. latipennis* Dall (Keen, 1943, p. 53, pl. 3, figs. 17, 21, 24, 25), but has stronger spiral sculpture.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part locality 136. Middle part, eastern area (Brown and Pilsbry's record). Chipola formation (early Miocene), Florida. Bowden formation (middle Miocene), Jamaica. Miocene (presumably middle), Dominican Republic. Deposits of late Miocene age, northwestern Panamá.

Subgenus *Laevityphis* Cossmann

Cossmann, Essais de paléonchologie comparée, pt. 5, p. 59, 1903.  
Type (orthotype): *Typhis coronarius* Deshayes, Eocene, Paris basin [= *T. muticus* (J. de C. Sowerby)].

According to Wrigley (1930, p. 113), *Typhis coronarius*, a rare species in the Cuisian of the Paris basin, is the same as *T. muticus*, which occurs in the London clay of England.

*Laevityphis* has a range of Eocene to Recent. In the Caribbean and nearby regions it is found in deposits of late Eocene, late Eocene or early Oligocene, and early and middle Miocene age.

*Typhis* (*Laevityphis*) aff. *T. curvirostratus* Conrad

Plate 24, figures 2, 6

Of medium size, slender, strongly turreted. Early whorls missing. Body whorl bearing four or five swollen varices forming blunt spines on shoulder. Partitions extending up from varices and forming flattened scales on preceding whorl. Tubes broken, located almost halfway between varices, but closer to succeeding varix, seated on adoral side of low, swollen axial ribs. Siphonal canal broken.

Height (incomplete) 12.6 mm, diameter 9.6 mm (figured specimen).

The one specimen of this species, from the marine member of the Bohio (?) formation at the submerged Vamos Vamos locality, is incomplete but shows the essential features. It probably is a new species and is closely related to *T. curvirostratus* Conrad (1848, p. 116, pl. 11, fig. 29), an Oligocene species found in Mississippi and northeastern Mexico. It is distinguished from Conrad's species by its heavier axial ribs extending down from the aboral side of the tubes and by the stronger flattening of the posterior part of the partitions extending upward from the varices. The species from the Canal Zone also has stronger tube-bearing axial ribs than *T. thagus* Olsson (1930, p. 58, pl. 12, fig. 6), which is found in the upper Eocene Talara formation of Perú.

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

## Family THAIDIDAE

Genus *Thais* Röding

Röding, Museum Boltenianum, p. 54, 1798.

Type (logotype, Stewart, Acad. Nat. Sci. Phila. Proc., v. 78, p. 386, 1927): *Thais lena* Röding (= *Murex fucus* Gmelin = *Murex neritoideus* Linné = *Nerita nodosa* Linné), Recent, eastern Atlantic Ocean.

Though Iredale's (1915, p. 472) designation of "*T. neritoides* = *M. fucus* Gmel." as the type species has the same effect as Stewart's, *Murex neritoideus* was not

mentioned by Röding. *Murex neritoideus* has been discussed recently by Dodge (1957, p. 131).

Subgenus *Stramonita* Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 226, 1817.

Type (logotype, Gray, Zool. Soc. London Proc., p. 138 (*Stamonita* by error), 1847: *Buccinum haemastoma* Linné, Recent, eastern and western Atlantic Ocean, eastern Pacific Ocean.

*Thais* (*Stramonita*) aff. *T. haemastoma* (Linné)

Plate 28, figures 13, 14

Small (immature), strongly shouldered. Early whorls worn. Body whorl bearing a row of low, blunt nodes on shoulder and a row of smaller, lower nodes below shoulder. Spiral sculpture consisting of narrow bands and threads of variable width. Outer lip broken back.

Height (incomplete) 20 mm, diameter 13.2 mm. (figured specimen).

A worn, incomplete, immature specimen of *Thais*, the only representative of the genus in the Gatun formation, was collected from the *Turritella*-bearing siltstone at locality 155c, at the top of the Gatun Third Locks excavation (unit 12b of section on page 44 of chapter A). Though it is poorly preserved, it evidently is closely related to *T. haemastoma* (Linné) (Clench, 1947, p. 73, pl. 36, figs. 1-6), a Recent species occurring in the Caribbean region, as well as in the eastern Atlantic and the eastern Pacific Oceans. Perhaps, however, it is more closely related to *T. rustica* (Lamarck) (Clench, 1947, p. 80, pl. 39, figs. 4-6, 8, 10), also a Recent species found throughout the Caribbean region. Those two Recent species themselves are closely related. As pointed out by Clench (1947, p. 82), *T. rustica* generally is smaller, is more strongly noded, and generally has an inner set of ridges on the interior of the outer lip well within the aperture. The fossil from the Gatun formation is immature and its outer lip is broken back. Therefore its closest affinities are indeterminable. In view of the occurrence of *T. haemastoma* on both sides of Central America, that species is expectable as a Miocene fossil in the Caribbean region.

Both *T. haemastoma* and *T. rustica* are intertidal species and live on rocks or reefs. Like other intertidal rock-dwelling mollusks, the genus is rare in the Miocene deposits of the Caribbean region. At locality 155c the worn broken specimen is associated with a large fauna indicating deposition at a depth considerably greater than shallow water.

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

Subgenus *Vasula* Mörch

Mörch, Malakozoologische Blätter, Band 7, p. 99, 1860.

Type (monotype): *Purpura* (*Vasula*) *melones* Duclos (*Purpura melones* Duclos), Recent, Mexico to Perú and Galápagos.

*Thais* (*Vasula*) aff. *T. melones* (Duclos)

Of medium size, greatly inflated, spire low, shoulder rounded. Early whorls missing. Intermediate whorls worn, but showing low, small nodes, which disappear on late whorls. Intermediate and late whorls too worn to show spiral sculpture. Outer lip broken back and aperture filled with hard limestone.

Height (incomplete) 39.5 mm, diameter (incomplete) 26 mm.

The coralliferous limestone at the base of the La Boca marine member of the Panamá formation on Río Masambí in the Gaillard Cut area yielded a poorly preserved, incomplete, squat, round-shouldered specimen of *Thais*. It is greatly worn and partly covered with a calcareous crust, except the intermediate whorls on one side. Despite its imperfections, the fossil evidently is allied to the Recent Panamic *T. melones* (Duclos) (Hertlein and Strong, 1955, p. 260), also known as *T. crassa* (Blainville). *T. melones* ranges from Mexico to Perú and the Galápagos. Many specimens that reach museums are almost, or quite, as worn as the fossil, as the species lives in the intertidal zone on rocks or under stones.

There is no analog of *T. melones* in Caribbean waters.

Occurrence: La Boca marine member of Panamá formation (early Miocene), locality 123.

Genus *Cymia* Mörch

Mörch, Malakozoologische Blätter, Band 7, p. 97, 98, 1860. Substitute name for *Cuma* Swainson, A treatise on malacology, p. 87, 307, 1840, not *Cuma* Milne Edward, 1828.

Type (monotype of *Cuma* Swainson): *Cuma sulcata* Swainson = *Buccinum tectum* Wood, Recent, Panamá to Perú.

Mörch cited Humphrey's anonymous usage of *Cuma* on page 35 of the Museum Calonnianum, published in 1797, and also Swainson's usage. Although he did not state that he rejected Humphrey's names, his proposal of *Cymia* as a substitute name for *Cuma*, invalidated by Milne Edward's usage in 1828, could refer only to Swainson's *Cuma*. The type of *Cymia* therefore is the monotype of Swainson's *Cuma*. As a matter of fact, the Museum Calonnianum was rejected as a basis for any nomenclatural work in Opinion 51, issued by the International Commission on Zoological Nomenclature in 1912.

*Cymia* is one of the numerous genera formerly widely distributed in the Caribbean region and elsewhere in Atlantic waters, but now surviving only in the eastern Pacific Ocean. Miocene species of *Cymia* s.s. are found

in Hispaniola, Venezuela, Colombia, Panamá, Perú and Baja California, as well as in New Jersey, southwestern France and Italy. The youngest eastern Atlantic species occurs in strata at Point Courbaril in southwestern Trinidad near the Pitch Lake. Though the fossiliferous strata at Point Courbaril have been referred to the Oligocene (Maury, 1912, p. 25) and to the Pliocene (Maury, 1925, p. 17), they probably are of early Pliocene age (Kugler, 1953, p. 55). *C. woodi* (Gabb), which is found in the middle Miocene of New Jersey—far north of the expected range of the genus—is the only species of *Cymia* s.s. from eastern North America. *C. caloosana* Tucker and Wilson (1933, p. 9, pl. 2, fig. 8), a Pliocene species from Florida, evidently is a species of a buccinid genus. Despite records of fossil and Recent species of *Cymia* from the western Pacific Ocean, *C. tectum*, the type of the genus, is the only surviving species. Its radula has been described by A. H. Cooke (1919, p. 107, fig. 31).

In both America and Europe small species of the genus appeared during Oligocene time. "*Triton*" *subalveatum* Conrad (1849, p. 207), found in the Vicksburg group of Mississippi, is the monotype of *Tritonopsis* Conrad (1865, p. 20), a subgenus of *Cymia* characterized by a slightly notched siphonal canal, slightly swollen siphonal fasciole, the persistence of reticulate sculpture to a late stage, and the absence of spines. The Stampian European *Cymia monoplex* (Deshayes) (Cossmann, 1903, p. 74, pl. 3, fig. 16) and the Oligocene Mexican *Cymia* sp. (Gardner, 1945, p. 186) have the deeply notched siphonal canal and strongly swollen siphonal fasciole of *Cymia* s.s. Though the columella of the Mexican species was not exposed when Gardner identified it, it has the columellar fold of *Cymia*. The status of *C. berryi* Olsson (1931, p. 105, pl. 18, fig. 6), an Oligocene Peruvian species is uncertain, as the columella is unknown.

Subgenus *Cymia* s.s.

*Cymia* (*Cymia*) *cheloma* Woodring, n. sp.

Plate 28, figures 12, 15

Large, whorls strongly angulated, strongly spinose at angulation, body whorl relatively loosely coiled. Protoconch missing. Earliest preserved post-protoconch whorls angulated near anterior suture, sculptured with three spiral cords and narrower axial threads, forming a reticulate network. Later whorls bearing strong, blunt spines at angulation and sculptured with closely spaced narrow spiral cords and growth lines that are finely, or microscopically, lamellar. Below angulation some spiral cords wider and heavier than others. Trace of anal fasciole on body whorl (as outlined by lamellar growth lines) progres-

sively more deeply notched near outer lip. Edge of outer lip not preserved. Interior of outer lip bearing short, strong ridges. Siphonal canal deeply notched. Siphonal fasciole swollen, strongly lamellar. Columellar fold strong even at aperture.

Height (almost complete) 76.7 mm, diameter (including spines) 51.5 mm (type).

Type: USNM 562590; two paratypes, Stanford University.

Type locality: 136 (USGS 16912, north side of Transisthmian Highway, knoll about 30 meters north of highway, 1.2 kilometers northwest of Sabanita, Panamá), lower part of Gatun formation.

*Cymia cheloma* is represented by six specimens, all from the lower part of the Gatun formation at localities 136 and 136a. (Those two localities actually are two collections from the same locality, or practically the same locality.) This species is one of the most conspicuous of the fossils found in the lower part of the Gatun, but not in other parts of the formation; in fact, the genus itself was not found in other parts of the formation. It belongs to a group of large or moderately large, strongly spinose species that have a deep anal notch at maturity and a relatively loosely coiled body whorl. This group of species is found in the southern part of the Caribbean region and in the eastern Pacific region: Trinidad, Venezuela, Colombia, the Canal Zone, the Darién area of Panamá, Perú and Baja California. These species, with the exception of one from Trinidad—*Cymia brightoniana* Maury (1925, p. 215), now considered of early Pliocene age, the youngest species of *Cymia* in western Atlantic waters—are of early and middle Miocene age. The anal notch is much deeper than that of the type species of the genus. Were it not for the variable depth of the notch in other smaller Miocene Caribbean species, a subgeneric name would be justified for this group of species.

*C. cheloma* is most closely related to *C. buchivacoana* H. K. Hodson (Hodson and Hodson, 1931, p. 38, pl. 18, fig. 4, pl. 22, fig. 2), which occurs in the middle Miocene of Venezuela and in deposits of the same age in the Darién area of Panamá (USGS localities 8433, 8477). The spines of the Gatun species are not as strongly compressed in a plane parallel to the angulation of the whorl and the spiral cords above the angulation are narrower.

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

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PLATES 24–38

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PLATE 24

FIGURE 1. 8, 9, 11. *Oostrombus* aff. *O. chiraensis* Olsson (p. 188).

Locality 38. Gatuncillo formation, middle Eocene. USNM 562547.

1. Height (incomplete) 40.2 mm, diameter (incomplete) 24.5 mm.

8. Fragment showing upper part of outer lip. Height 17.5 mm, diameter 25 mm.

9. Height (incomplete) 25 mm, diameter (incomplete) 32.8 mm.

11. Height (incomplete) 17.9 mm, diameter 11.4 mm.

2, 6. *Typhis* (*Laevityphis*) aff. *T. curvirostratus* Conrad (p. 222).

Height (incomplete) 12.6 mm, diameter 9.6 mm. Locality 40d. Marine member of Bohio(?) formation.

USNM 562555.

3, 7. *Cerithium* (*Theridium*) *mimeticum* Woodring, n. sp. (p. 171).

Locality 42d. Bohio formation.

3. Paratype. Height (not quite complete) 15 mm, diameter 4.6 mm. USNM 562565.

7. Type. Height (incomplete) 18.5 mm, diameter 6.7 mm. USNM 562564.

4, 5. *Yasila* aff. *Y. paytensis* Olsson (p. 218).

Height (incomplete) 18.5 mm, diameter 12.5 mm. Locality 38. Gatuncillo formation, middle Eocene.

USNM 562555.

10, 12-14 *Diroderithium wechesense* Stenzel, n. sp. (p. 175).

Roadcut on abandoned county road adjoining new Marquez-Centerville road (State Highway 7), .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 [Weches greensand member of Mount Selman formation], middle Eocene. Collection of H. B. Stenzel.

10. Paratype. Height (almost complete) 36 mm, diameter 13 mm.

12, 13. Type. Height (incomplete) diameter 58 mm, 24 mm.

14. Paratype. Height (almost complete) 15 mm, diameter 5.8 mm.

15-18. *Dirocerithium ame* Woodring, n. sp. (p. 175).

Locality 38. Gatuncillo formation, middle Eocene.

15. Type. Height (incomplete) 52 mm, diameter 26 mm. USNM 562545.

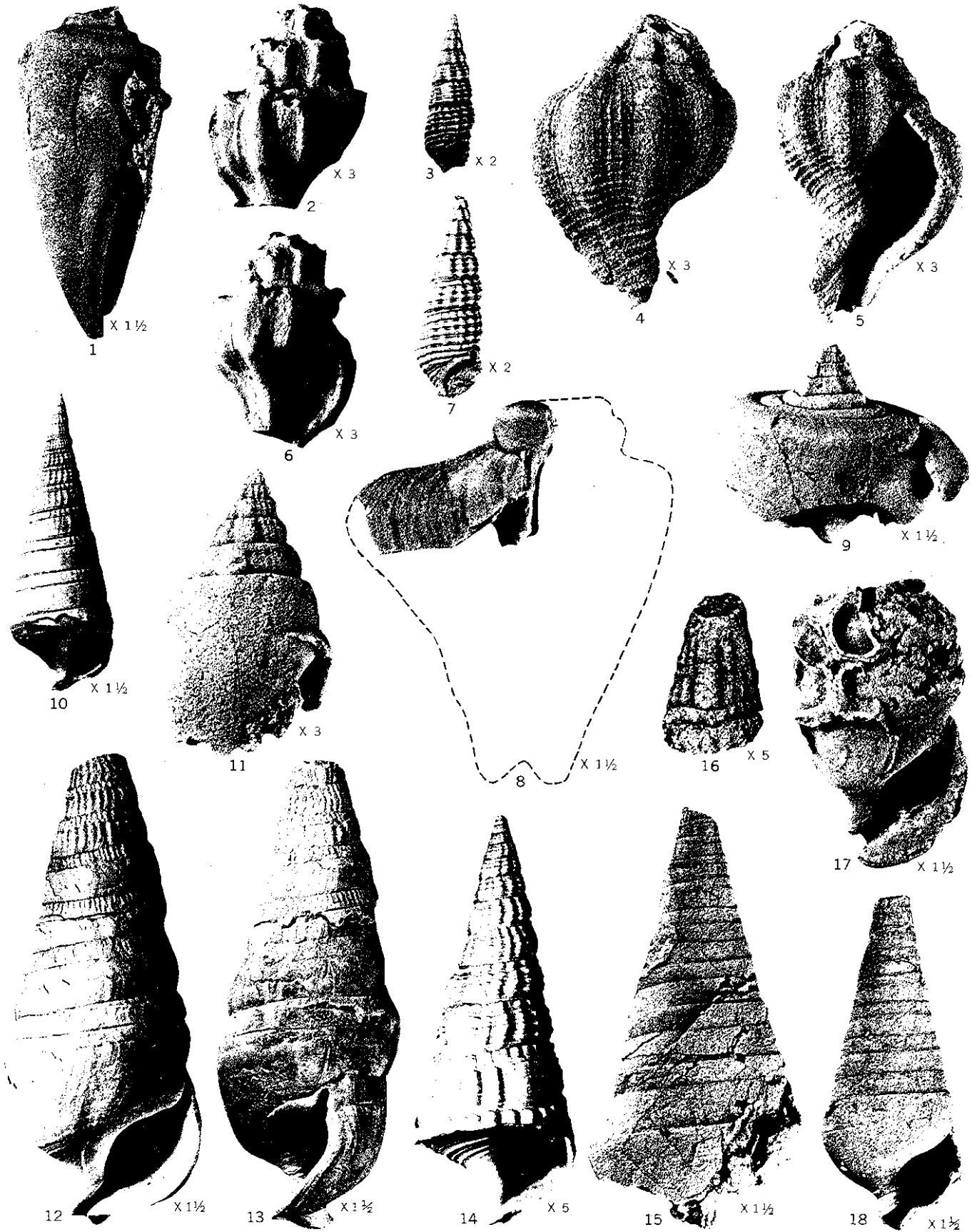
16-18. Paratypes USNM 562546.

16. Height (incomplete) 5.9 mm, diameter 3.9 mm.

17. Height (incomplete) 34.0 mm, diameter 21 mm.

18. Height (incomplete) 40.5 mm, diameter 17.5 mm.





MIDDLE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION AND TEXAS, LATE EOCENE OR EARLY OLIGOCENE MOLLUSK FROM MARINE MEMBER OF BOHIO(?) FORMATION, AND LATE OLIGOCENE MOLLUSK FROM BOHIO FORMATION



PLATE 25

FIGURE 1-4, 9, 10. *Hemisinus (Longiverena) oeciscus* Woodring, n. sp. (p. 157).

Locality 42f. Bohio formation.

1, 3, 4, 9. Paratypes. USNM 562559.

1, 4. Height (incomplete) 15.2 mm, diameter (slightly increased by crushing) 8 mm.

3, 9. Height (incomplete) 13 mm, diameter (slightly increased by crushing) 7 mm.

2, 10. Type. Height (incomplete) 12 mm, diameter (slightly increased by crushing) 6.5 mm. USNM 562558.

5, 7. *Terebellum (Terebellum) procerum* Merian? (p. 192).

Locality 12. Gatuncillo formation, late Eocene. USNM 562548.

5. Height (incomplete) 29.5 mm, diameter (slightly increased by crushing) 14 mm

7. Height (incomplete) 43.7 mm, diameter (slightly increased by crushing) 16.5 mm.

6. *Terebellum (Seraphs) belemnium* Palmer? (p. 192).

Height (incomplete) 37.3 mm, diameter 14.5 mm. Locality 38. Gatuncillo formation, middle Eocene. USNM 562549.

8, 14-16. *Ectinochilus* cf. *E. gaudichaudi* (d'Orbigny) (p. 193).

Gatuncillo formation, late Eocene.

8, 14. Height (incomplete) 26 mm, diameter 12.8 mm. Locality 11. USNM 562550.

15. Height (incomplete) 21 mm, diameter 9.5 mm. Locality 9. USNM 562551.

16. Height (incomplete) 7.1 mm, diameter 5.7 mm. Locality 34. USNM 562552.

11, 17. *Morum* ("Oniscidia") sp. (p. 202).

Height (incomplete) 21 mm, diameter (incomplete) 13.5 mm. Locality 38. Gatuncillo formation, middle Eocene. USNM 562554.

12, 13. *Morum* ("Oniscidia") cf. *M. antiquum* (Bayan) (p. 203).

Height (incomplete) 21.5 mm, diameter 18.3 mm. Locality 40a. Mariue member of Bohio(?) formation, late Eocene or early Oligocene. USNM 135212.

18, 19. *Galeodea?* cf. *G. nodosa* (Solander) (p. 197).

Height (incomplete) 46 mm, diameter (modified by crushing) 40 mm. Locality 27. Gatuncillo formation, late Eocene. USNM 562553.

PLATE 26

FIGURE 1, 6, 7. *Turritella listrota* Woodring, n. sp. (p. 160).

Locality 42d. Bohio formation.

1. Paratype. Height (incomplete) 18.5 mm, diameter 6.5 mm. USNM 562562.

6. Type. Height (incomplete) 35 mm, diameter 11 mm. USNM 562561.

7. Height (incomplete) 4.7 mm, diameter 2.2 mm. USNM 562563.

2, 3. *Solariella ephnidia* Woodring, n. sp. (p. 156).

Type. Height 3.5 mm, diameter 3.6 mm. Locality 42d. Bohio formation. USNM 562557.

4, 5, 10. *Architectonica (Architectonica) rhicna* Woodring, n. sp. (p. 164).

Type. Height 9.5 mm, diameter 17.7 mm. Locality 56. Middle member of Caimito formation. USNM 562569.

8, 12. *Semicassis (Echinophoria)* sp. (p. 199).

Middle member of Caimito formation.

8. Height (incomplete) 30 mm, diameter (incomplete) 23.5 mm. Locality 54j. USNM 562572.

12. Height (incomplete) 27.7 mm, diameter (incomplete) 24.3 mm. Locality 54h. USNM 562571.

9, 13-15. *Gonysycon epomis* Woodring, n. sp. (p. 213).

Locality 42d. Bohio formation.

9, 15. Paratype. Height (incomplete) 23 mm, diameter 18.3 mm. USNM 562567.

13, 14. Type. Height (incomplete) 26.2 mm, diameter 17.3 mm. USNM 562566.

11, 17. *Semicassis (Echinophoria) apenes* Woodring, n. sp. (p. 198).

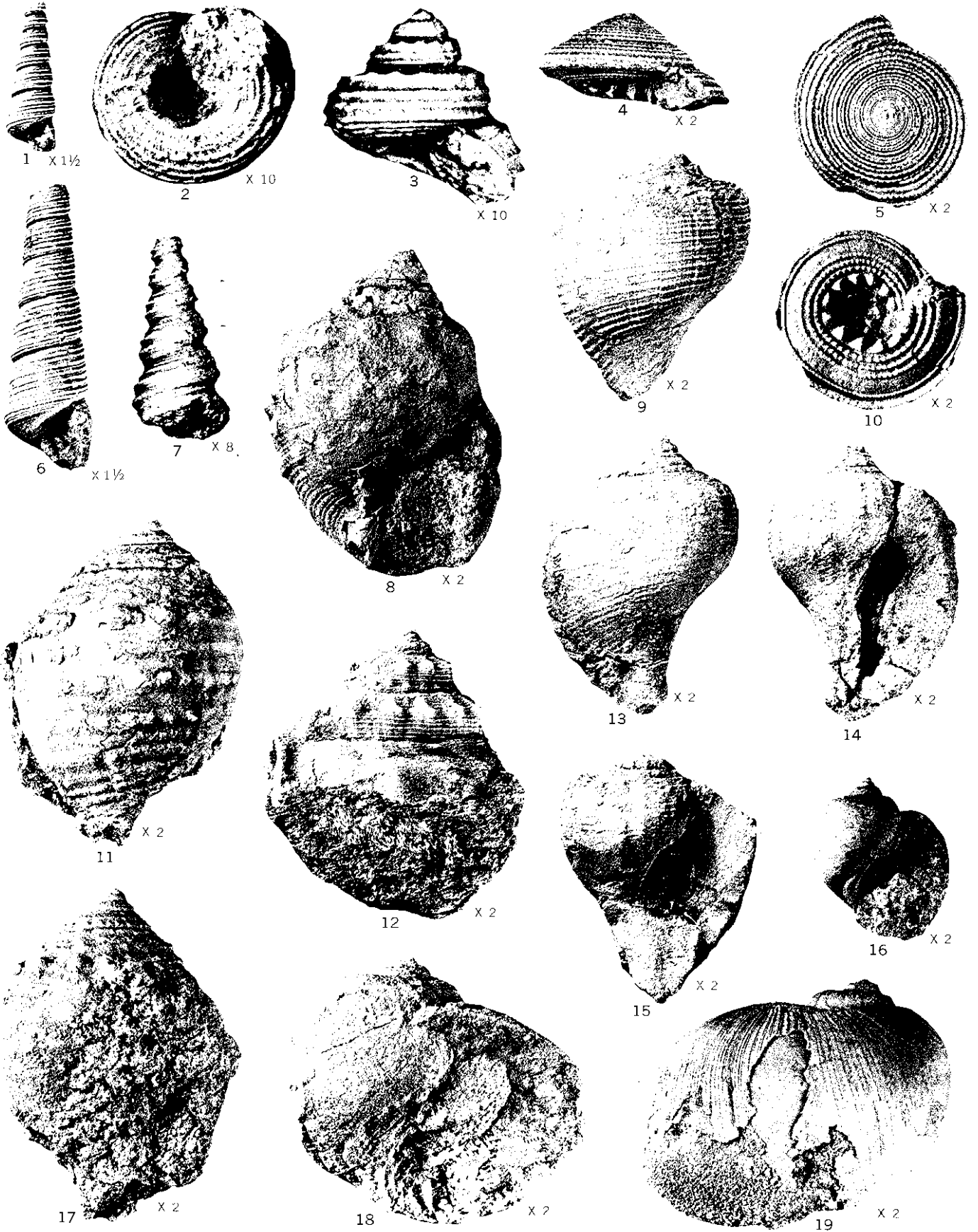
Type. Height (almost complete) 31 mm, diameter (incomplete) 22 mm. Locality 56. Middle member of Caimito formation. USNM 562570.

16, 18, 19. *Globularia (Globularia)* aff. *G. fischeri* (Dall) (p. 158).

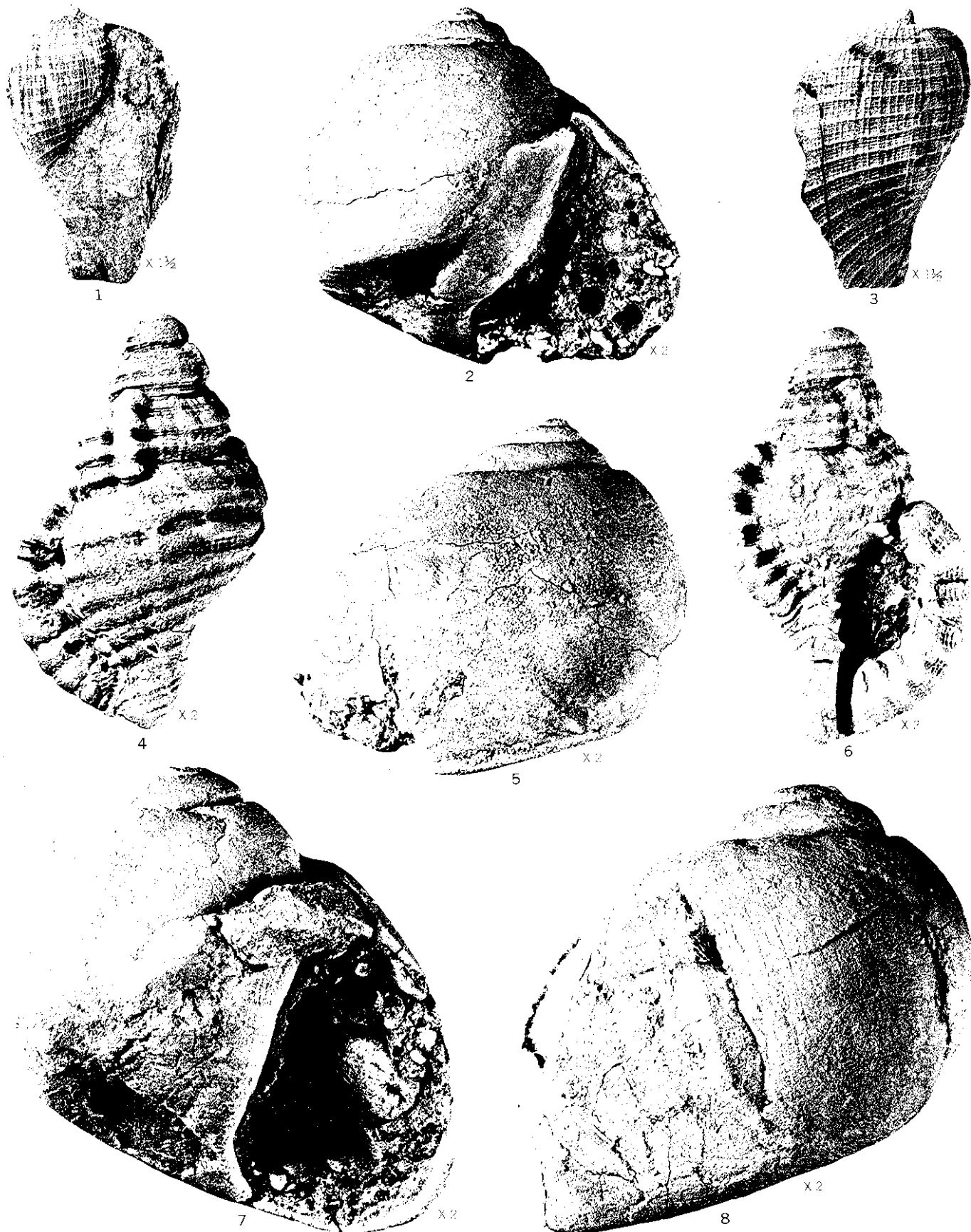
Locality 42d. Bohio formation. USNM 562560.

16. Height 15.3 mm, diameter 13 mm.

18, 19. Height 27 mm, diameter 28 mm.



LATE OLIGOCENE MOLLUSKS FROM BOHIO FORMATION AND MIDDLE MEMBER OF CAIMITO FORMATION  
IN GATUN LAKE AREA



LATE OLIGOCENE MOLLUSKS FROM MIDDLE MEMBER OF CAIMITO FORMATION IN GATUN LAKE AREA AND EARLY MIOCENE MOLLUSK FROM CULEBRA FORMATION

PLATE 27

FIGURE 1, 3. *Ficus carbasea micronematica* (Brown and Pilsbry) (p. 212).

Height (incomplete) 25.8 mm, diameter 21.5 mm. Locality 99d. Culebra formation. USNM 562577.

2, 5, 7, 8. *Ampullinopsis spenceri* (Cooke) (p. 159).

Locality 55b. Middle member of Caimito formation. USNM 562568.

2, 5. Height (practically complete) 36.5 mm, diameter (almost complete) 36.5 mm.

7, 8. Height (practically complete) 47.5 mm, diameter (incomplete) 42.5 mm.

4, 6. *Cymatium (Septa) ogygium* Woodring, n. sp. (p. 204).

Type. Height (almost complete) 40 mm, diameter 23 mm. Locality 55b. Middle member of Caimito formation.  
USNM 562573.

PLATE 28

FIGURE 1, 2, 7, 8. *Bursa (Colubrellina) caelata amphitriles* Maury (p. 207).

Middle part of Gatun formation.

1, 2. Height 29.6 mm, diameter 20 mm. Locality 157. USNM 562609.

7, 8. Height (almost complete, tip of siphonal canal broken) 45 mm, diameter 30 mm. Locality 155b. USNM 562608.

3-6. *Potamides suprasulcatus* (Gabb) (p. 176).

Culebra formation.

3, 5, 6. Height (incomplete) 30 mm, diameter (including varicose outer lip) 17 mm. Locality 104a. USNM 562574.

4. Height (incomplete) 21.8 mm, diameter (somewhat increased by crushing; including upper part of varicose outer lip) 14.3 mm. Locality 115b. USNM 562575.

9. *Epitonium* ("Depressiscala") *eucteanum* Woodring, n. sp. (p. 183).

Type. Height (incomplete) 28.3 mm, diameter (slightly increased by crushing) 7.8 mm. Locality 206b. Chagres sandstone. USNM 562637.

10, 11. *Bittium scotti* Brown and Pilsbry (p. 178).

Locality 100a. Culebra formation. USNM 562576.

10. Height (practically complete) 7.2 mm, diameter 2.7 mm.

11. Height (not quite complete) 8 mm, diameter 3 mm.

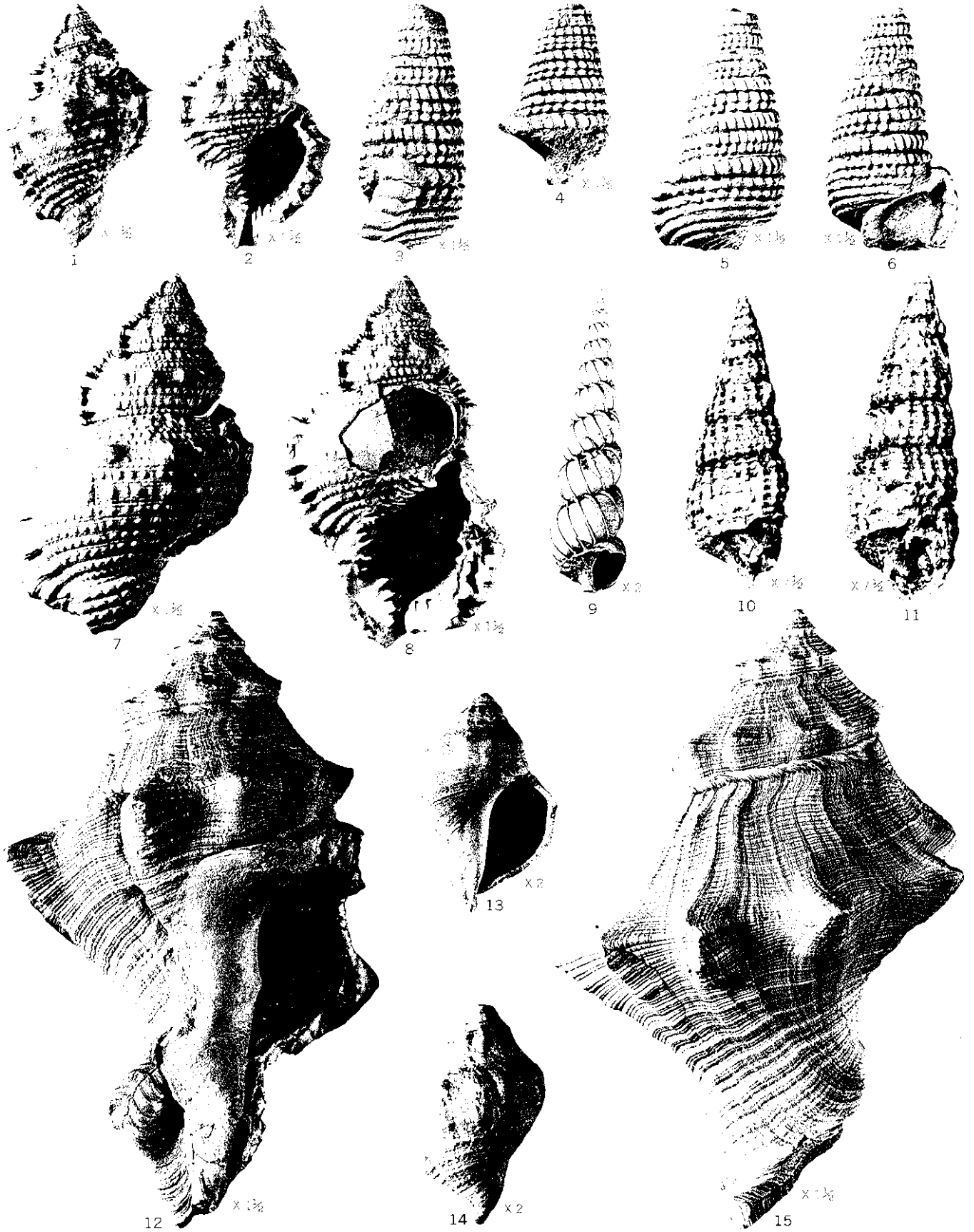
12, 15. *Cymia (Cymia) cheloma* Woodring, n. sp. (p. 223).

Type. Height (almost complete) 76.7 mm, diameter (including spines) 51.5 mm. Locality 136. Lower part of Gatun formation. USNM 562590.

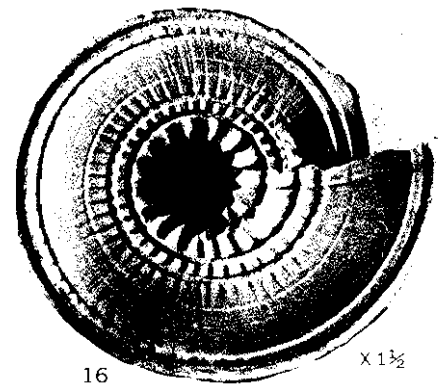
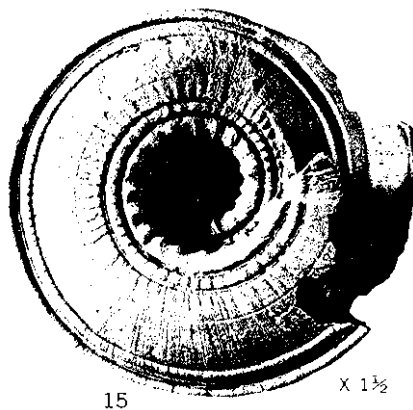
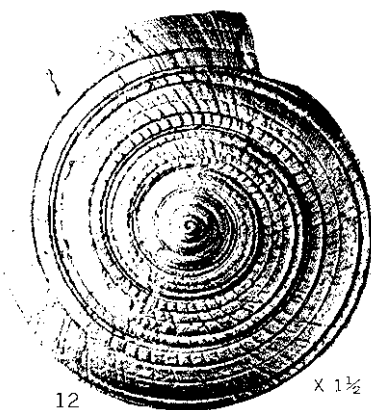
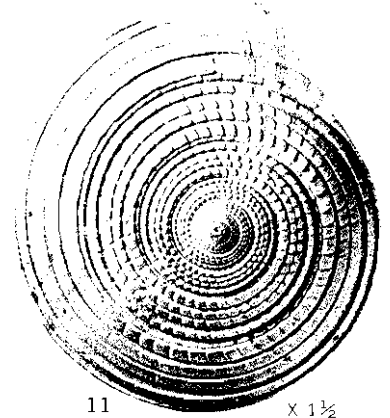
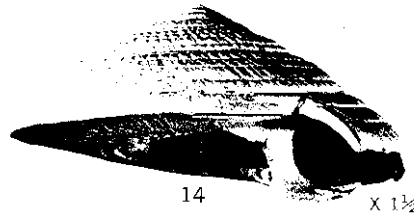
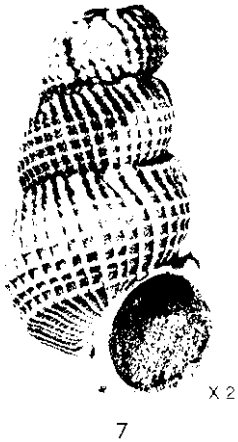
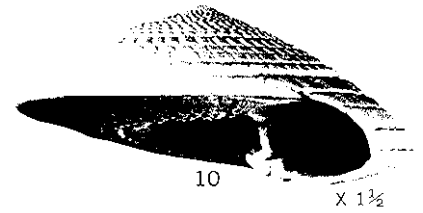
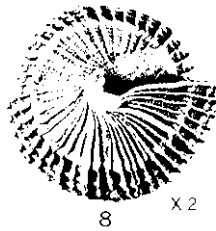
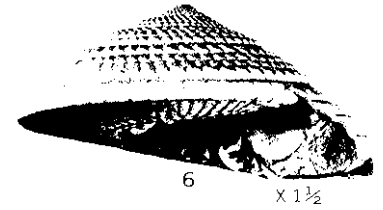
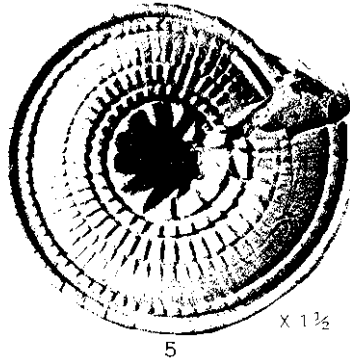
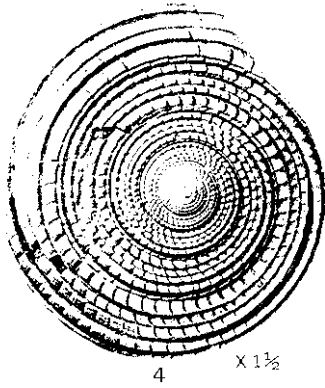
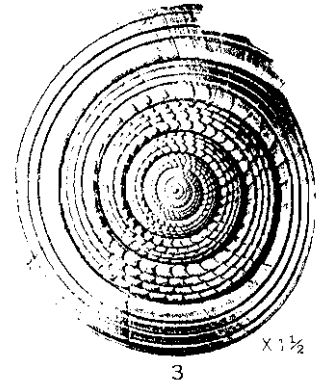
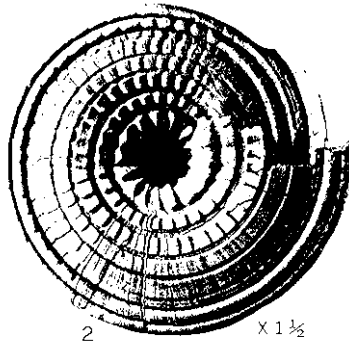
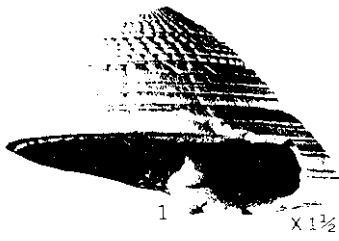
13, 14. *Thais (Stramonita)* aff. *T. haemastoma* (Linné) (p. 222).

Height (incomplete) 20 mm, diameter 13.2 mm. Locality 155c. Middle part of Gatun formation. USNM 562618.





EARLY MIOCENE MOLLUSKS FROM CULEBRA FORMATION, MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY PLIOCENE MOLLUSK FROM CHAGRES SANDSTONE

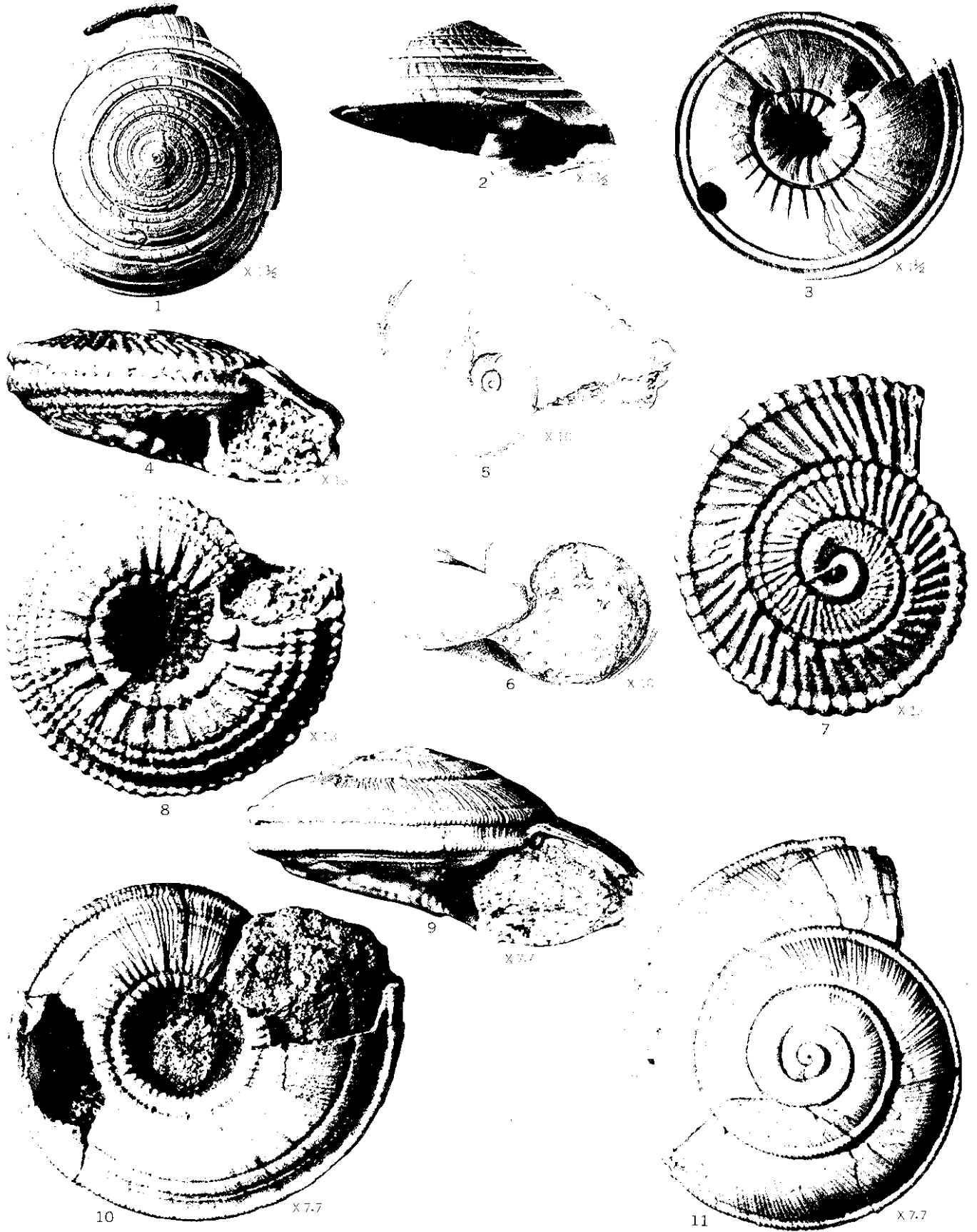


MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY PLIOCENE MOLLUSKS FROM CHAGRES SANDSTONE

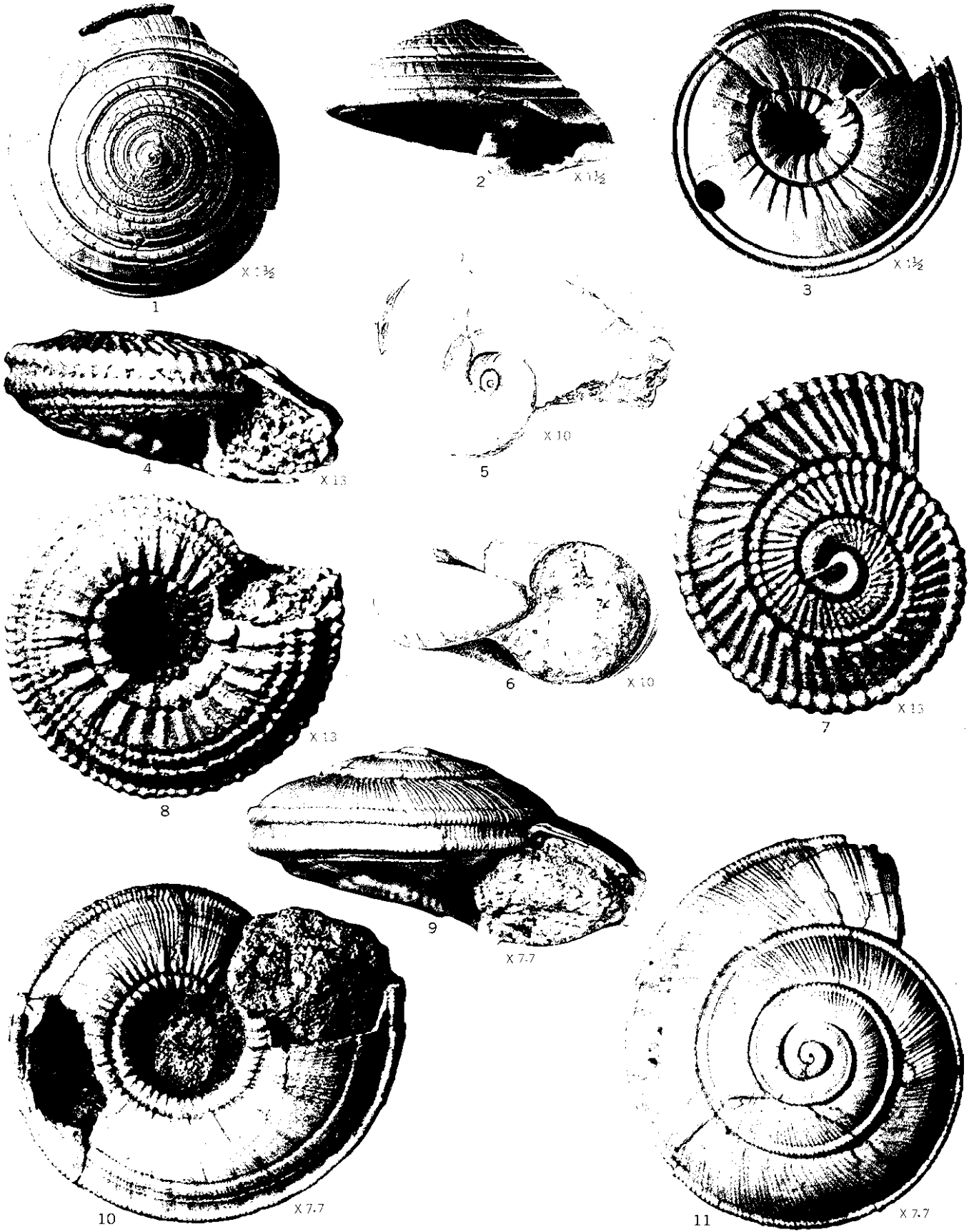
PLATE 29

FIGURE 1-6, 10-12, 14-16. *Architectonica (Architectonica) nobilis nobilis* Röding (p. 165).

- 1-3. Height 19 mm, diameter 31 mm. Locality 175. Upper part of Gatun formation, eastern area, middle Miocene. USNM 562620.
  - 4-6. Height 16 mm, diameter 31.3 mm. Locality 157. Middle part of Gatun formation, middle Miocene. USNM 562598.
  - 10, 11, 16. Height 16.5 mm, diameter 36.5 mm. Locality 155b. Middle part of Gatun formation, middle Miocene. USNM 562597.
  - 12, 14, 15. Height 18 mm, diameter 35.8 mm. Locality 183. Upper part of Gatun formation, western area, late Miocene. USNM 562629.
- 7, 8. *Scalina weigandi* (Böse) (p. 187).  
Chagres sandstone.
- 7. Height (incomplete) 26.5 mm, diameter 14.5 mm. Locality 206a. USNM 562641.
  - 8. Height (incomplete) 19.7 mm, diameter 14 mm. Locality 206. USNM 562642.
9. *Petalococonchus* aff. *P. floridanus* Olsson and Harbison (p. 161).  
Height of coil 22 mm, greatest diameter of tube 6 mm. Locality 155b. Middle part of Gatun formation, middle Miocene. USNM 562596.
13. *Serpulorbis papulosus* (Guppy) (p. 161).  
Length 16 mm, greatest diameter 8.8 mm. Locality 155c. Middle part of Gatun formation, middle Miocene. USNM 562595.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY PLIOCENE MOLLUSK FROM CHAGRES SANDSTONE



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY PLOCENE MOLLUSK FROM CHAGRES SANDSTONE



PLATE 31

FIGURE 1. *Meioceras amblyoceras* Woodring, n. sp. (p. 163).

Type. Length 2.1 mm, diameter of aperture 0.5 mm. Locality 155a. Middle part of Gatun formation, middle Miocene. USNM 562591.

2, 5. *Malea?* cf. *M. elliptica* Pilsbry and Johnson (p. 209).

Height (not quite complete) 30 mm, diameter 16.8 mm. Locality 155. Middle part of Gatun formation, middle Miocene. USNM 562610.

3, 4. *Typhis (Talityphus) alatus obesus* Gabb (p. 221).

Height (not quite complete) 29.4 mm, diameter 22.3 mm. Locality 136. Lower part of Gatun formation, middle Miocene. USNM 562589.

6-10. *Cypraea (Muracypraea) henekeni* Sowerby (p. 194).

6-8. Locality 159b. Middle part of Gatun formation, middle Miocene. USNM 562603.

6, 7. Height 55.3 mm, lateral diameter 40.8 mm, dorsoventral diameter 29.3 mm.

8. Height (not quite complete) 48 mm, lateral diameter 39 mm, dorsoventral diameter 27.7 mm.

9, 10. Height 55.7 mm, lateral diameter 44 mm, dorsoventral diameter 32.5 mm. Locality 182a. Upper part of Gatun formation, western area, late Miocene. USNM 562633.

PLATE 32

FIGURE 1, 4, 6, 9. *Cypraea* (*Muracypraea*) *henkeni* Sowerby (p. 194).

Lower part of Gatun formation.

1, 4. Height (incomplete) 53 mm, lateral diameter 44 mm, dorsoventral diameter 31 mm. Locality 136a. USNM 562581.

6, 9. Height (not quite complete) 45.3 mm, lateral diameter 36.5 mm, dorsoventral diameter 24.5 mm. Locality 138a. USNM 562582.

2, 3, 5, 7. *Typhis* (*Pilsbrytyphis*) *gabbi* Brown and Pilsbry (p. 220).

Upper part of Gatun formation, eastern area.

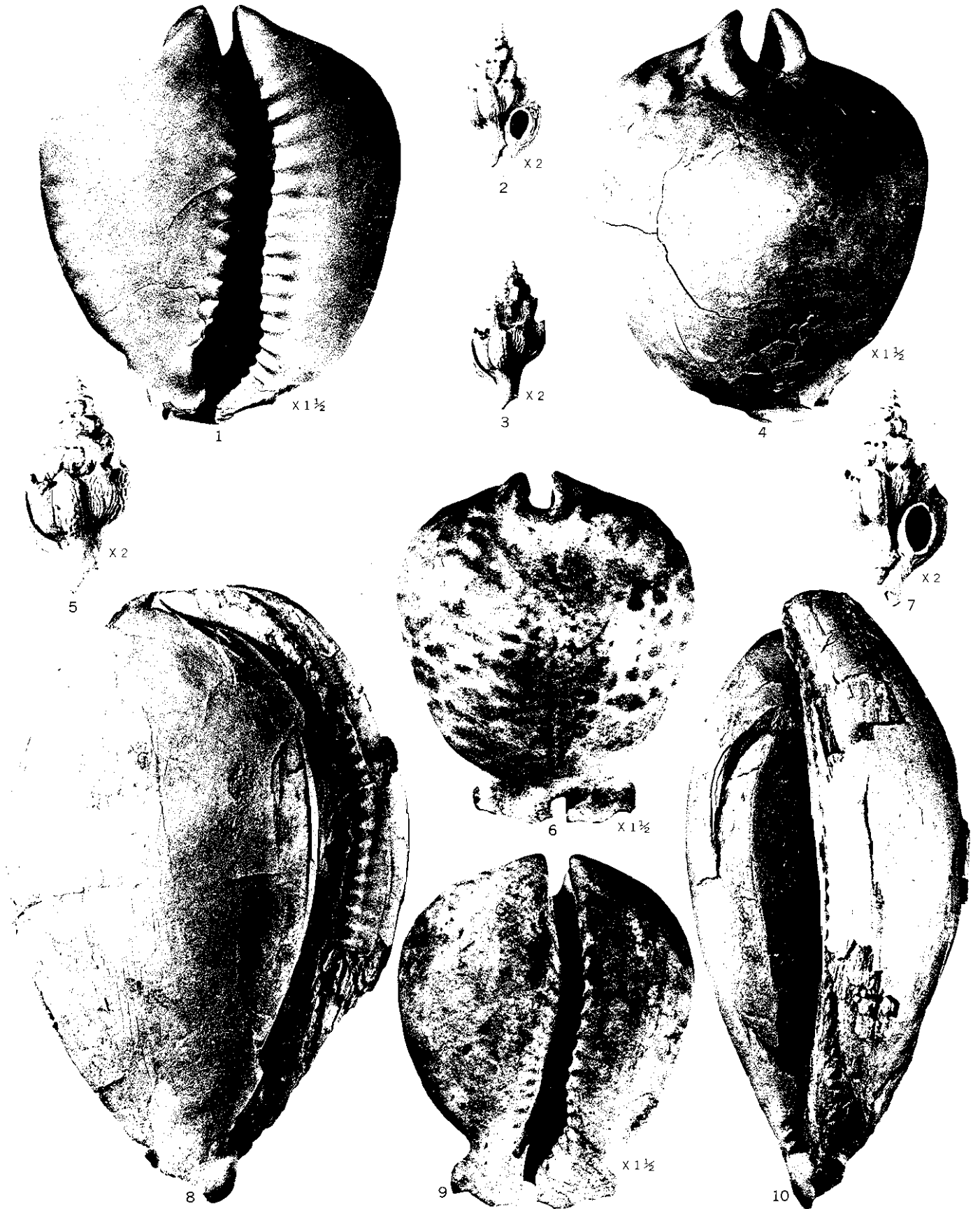
2, 3. Height 9.5 mm, diameter 7.8 mm. Locality 176. USNM 562628.

5, 7. Height (practically complete) 20.6 mm, diameter 11 mm. Locality 175. USNM 562627.

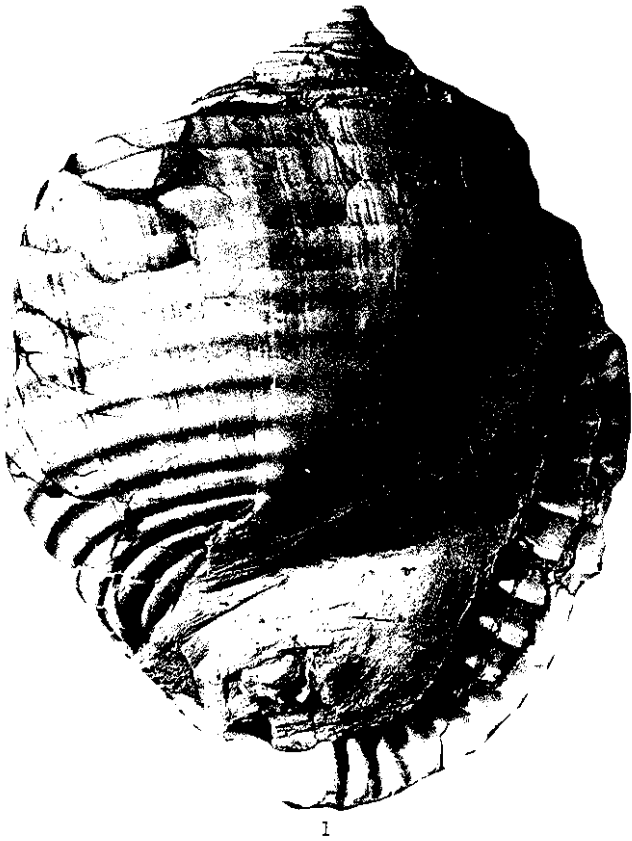
8, 10. *Eocypraea* (*Apiocypraea*?) *keenae* Woodring, n. sp. (p. 196).

Type. Height (not quite complete) 115 mm, lateral diameter (increased by dorsoventral crushing) 76 mm, dorsoventral diameter (diminished by dorsoventral crushing) 56 mm. Locality 155. Middle part of Gatun formation. USNM 562604.

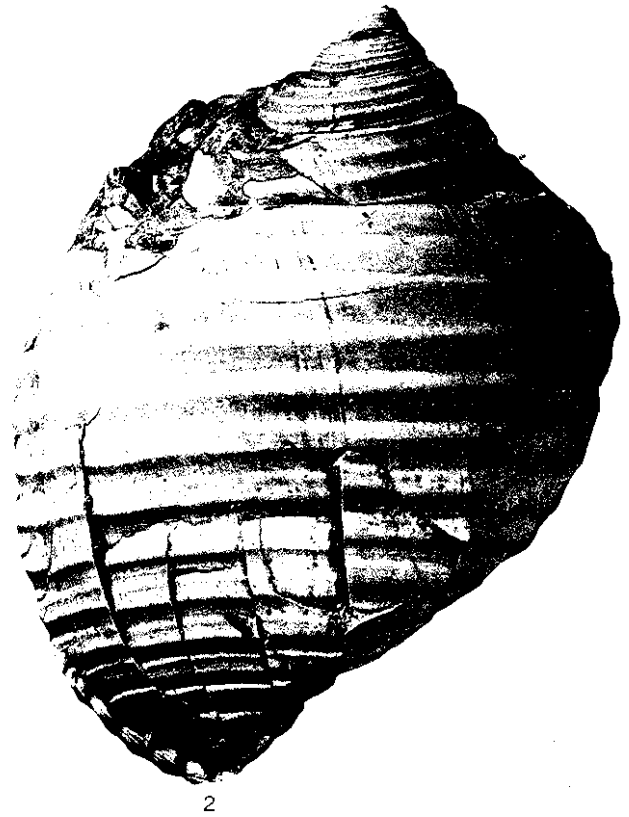




MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION



1



2



X 1 1/2

3



X 1 1/2

4

MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 33

Figure 1-4. *Malea camura* Guppy (p. 208).

- 1, 2. Height (slightly reduced by crushing) 105 mm, diameter (increased by crushing) 83 mm. Locality 159b. Middle part of Gatun formation, middle Miocene. USNM 562611.
- 3, 4. Height (incomplete) 75 mm, diameter 56 mm. Locality 182. Upper part of Gatun formation, western area, late Miocene. USNM 562634.

PLATE 34

FIGURE 1, 4-6. *Semicassis (Tylocassis) reclusa* (Guppy) (p. 200).

1, 4. Height (incomplete) 25.3 mm, diameter (incomplete) 23 mm. Locality 136a. Lower part of Gatun formation. USNM 562583.

5, 6. Height (incomplete) 34.5 mm, diameter (incomplete) 30 mm. Locality 147h. Middle part of Gatun formation. USNM 562605.

2, 3. *Sthenorytis pernobilis* (Fischer and Bernardi)? (p. 184).

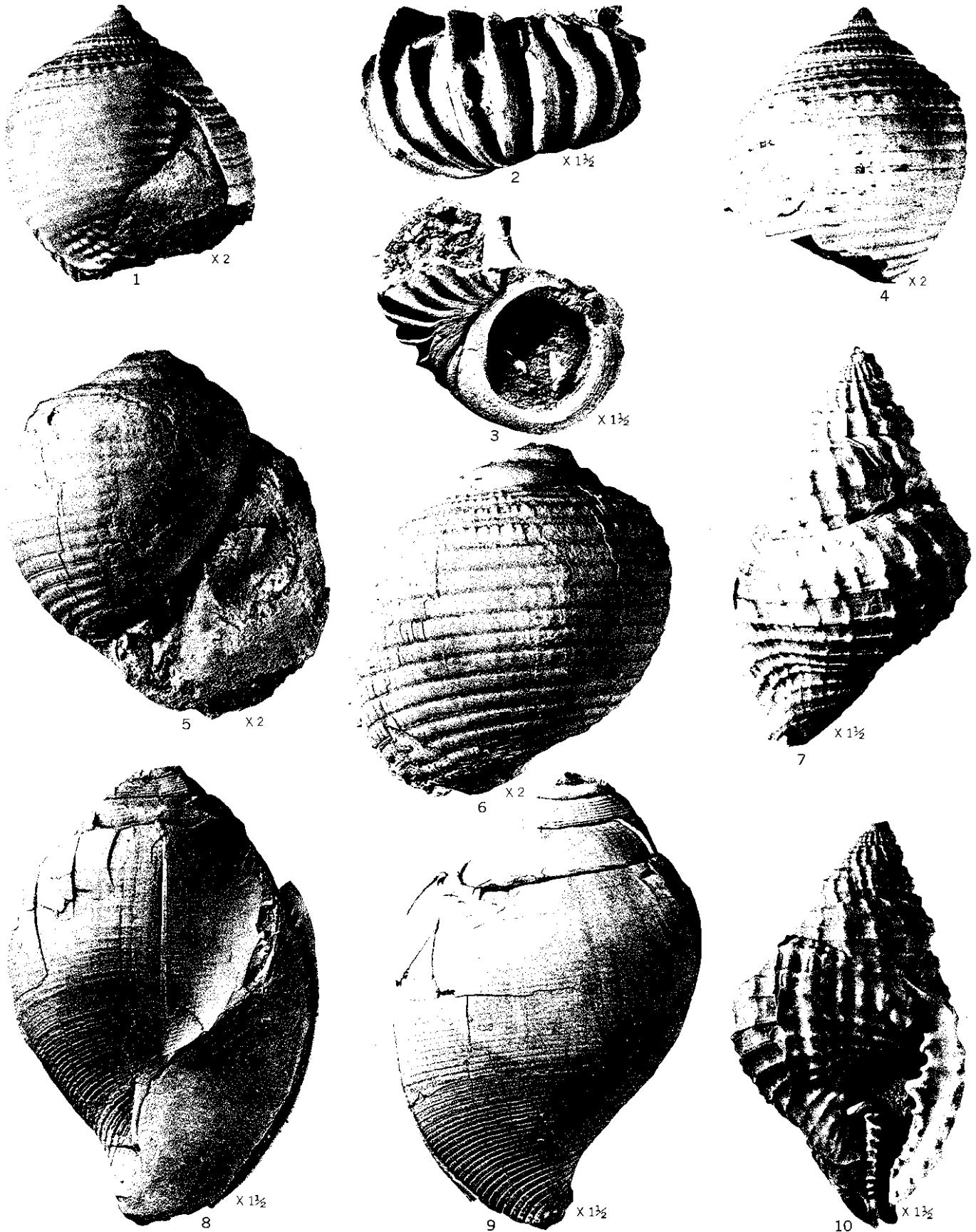
Height (incomplete) 31 mm, diameter 31.5 mm. Locality 186. Toro limestone member of Chagres sandstone. USNM 214346.

7, 10. *Distorsio (Rhysema) decussata gatunensis* Toula (p. 205).

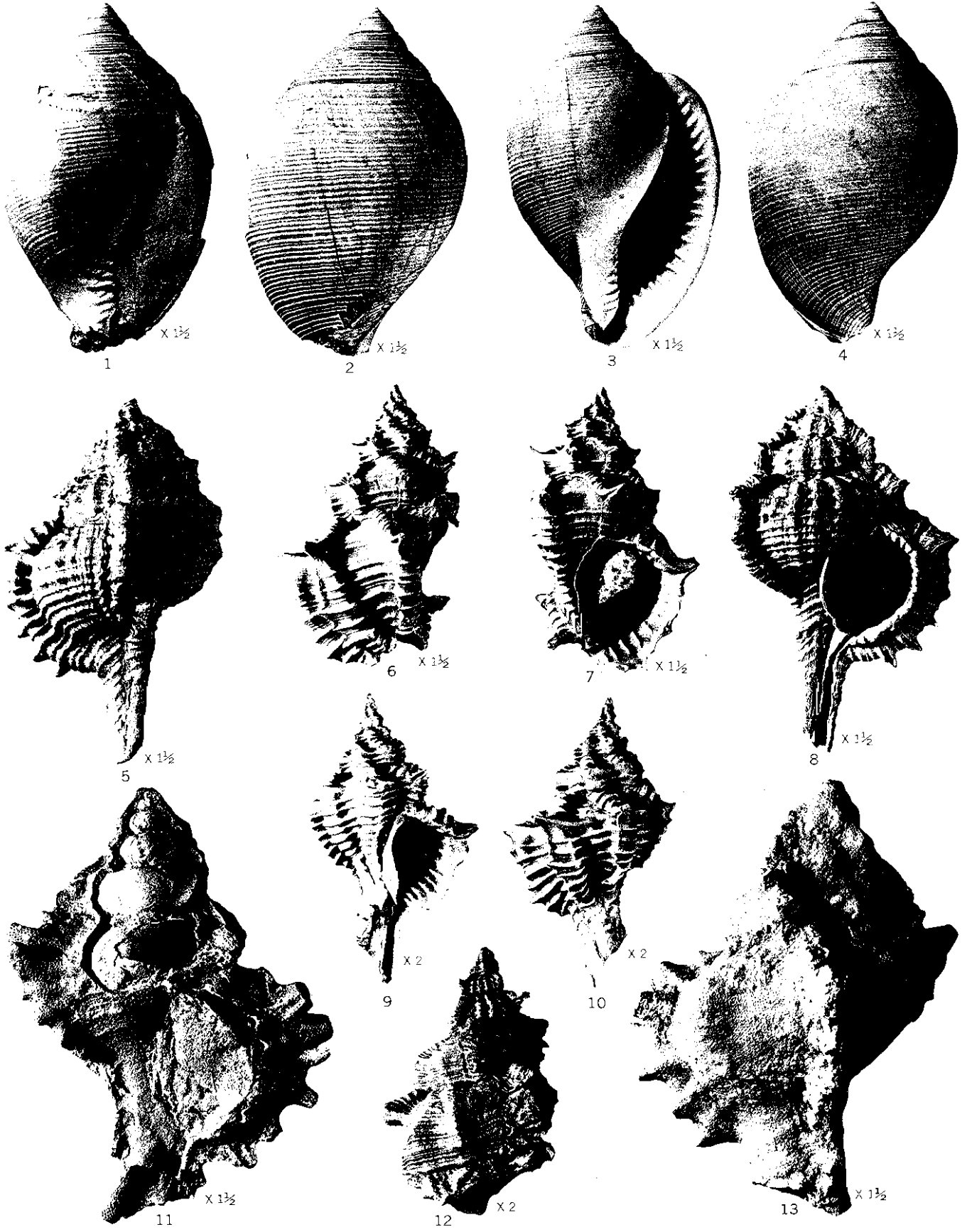
Height (almost complete) 50.5 mm, diameter 30.3 mm. Locality 155. Middle part of Gatun formation. USNM 562607.

8, 9. *Sconsia laevigata sublaevigata* (Guppy) (p. 201).

Height (incomplete) 57 mm, diameter (modified by crushing) 37.5 mm. Locality 175. Upper part of Gatun formation, eastern area. USNM 562625.



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND EARLY PLIOCENE MOLLUSK FROM TORO LIMESTONE MEMBER OF CHAGRES SANDSTONE



MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 35

FIGURE 1-4. *Sconsia laevigata sublaevigata* (Guppy) (p. 201).

1, 2. Height (incomplete) 43.8 mm, diameter (incomplete) 27 mm. Locality 173. Upper part of Gatun formation, eastern area. USNM 562624.

3, 4. Height 42 mm, diameter 26.5 mm. Locality 155b. Middle part of Gatun formation. USNM 562606.

5, 8. *Murex (Murex) recurvirostris recurvirostris* Broderip (p. 214).

Height (incomplete) 45.8 mm, diameter (including terminal varix and its broken shoulder spine) 27.5 mm. Locality 155. Middle part of Gatun formation. USNM 562612.

6, 7, 9, 10. *Paziella (Panamurex) gatunensis* (Brown and Pilsbry) (p. 217).

Middle part of Gatun formation.

6, 7. Height (incomplete) 35 mm, diameter (including terminal varix and its shoulder spine) 23 mm. Locality 155b. USNM 562616.

9, 10. Height 27 mm, diameter (including terminal varix and its shoulder spine) 14.7 mm. Locality 155c. USNM 562617.

11-13. *Murex (Chicoreus) brevifrons* Lamarck (p. 216).

Middle part of Gatun formation

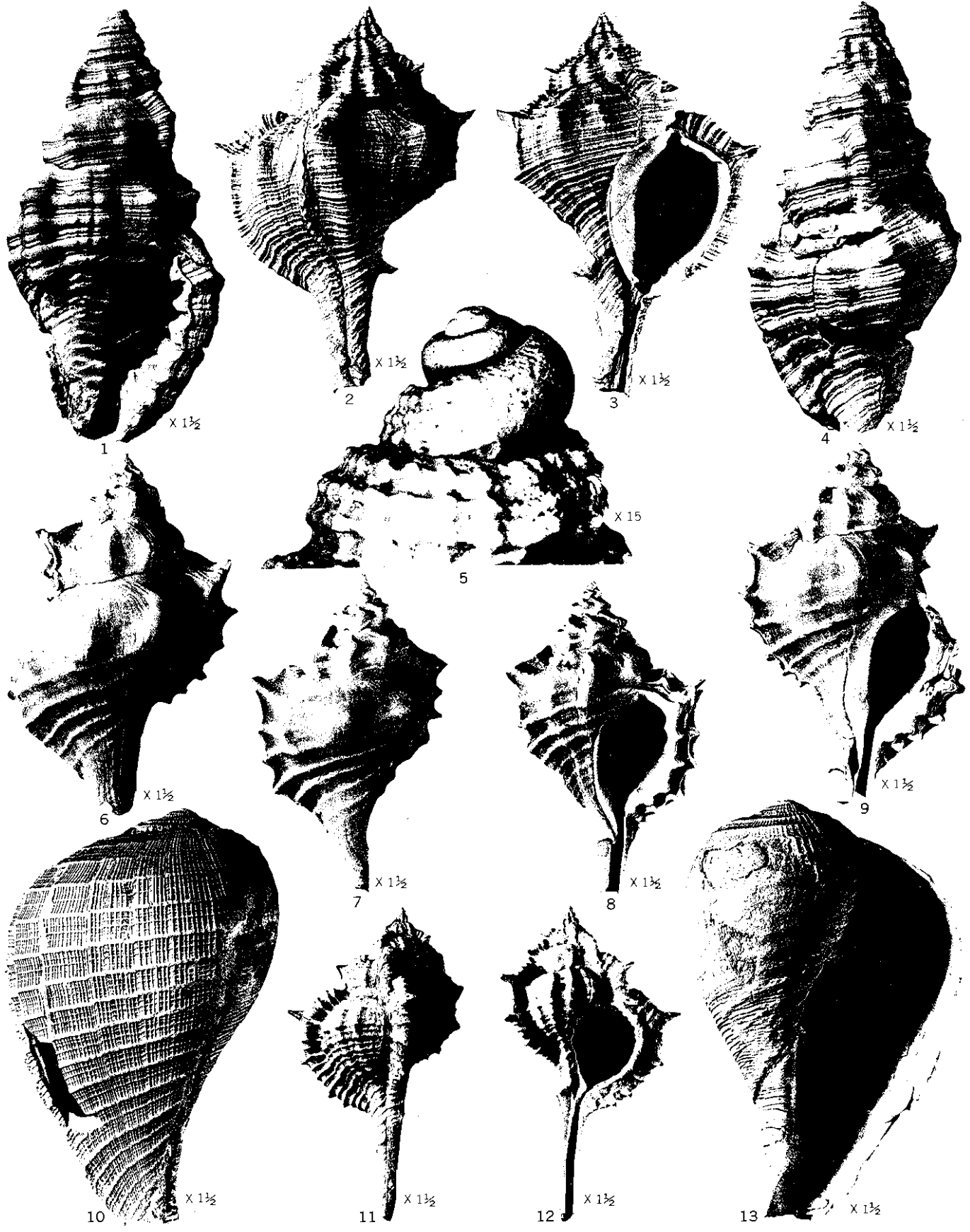
11, 13. Height (incomplete) 54.5 mm, diameter (including terminal varix and broken spine) 35.5 mm. Locality 155.

12. Height (incomplete) 25.3 mm, diameter (incomplete) 18.5 mm. Locality 155b.

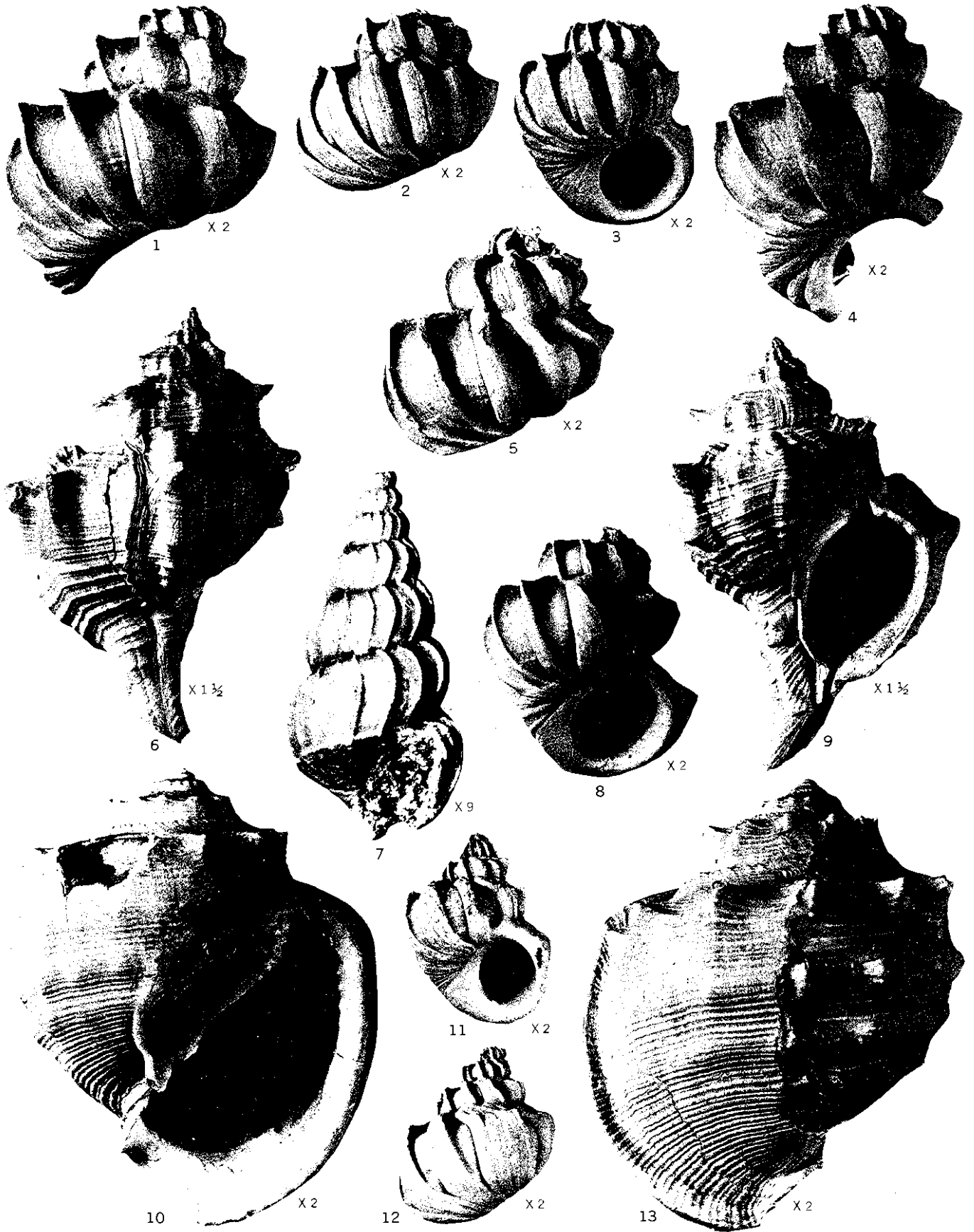
PLATE 36

- FIGURE 1, 4. *Cymatium (Septa) pileare henicum* Woodring, n. subsp. (p. 204).  
Type. Height (incomplete) 53.5 mm, diameter 28 mm.  
Locality 136a. Lower part of Gatun formation, middle Miocene. USNM 562584.
- 2, 3. *Murex (Murex?) polynematicus* Brown and Pilsbry (p. 215).  
Height (incomplete) 48.7 mm, diameter (including terminal varix and its shoulder spine) 29.7 mm. Locality 138a.  
Lower part of Gatun formation, middle Miocene. USNM 562586.
5. *Distorsio (Rhysema) decussata gatunensis* Toulou (p. 205).  
Protoconch. Height 1.6 mm, diameter 2 mm. Locality 142. Middle part of Gatun formation, middle Miocene.  
Locality 142. Stanford Univ.
- 6-9. *Eupleura thompsoni* Woodring, n. sp. (p. 218).  
Locality 136a. Lower part of Gatun formation, middle Miocene.  
6, 9. Type. Height (not quite complete) 45.7 mm, diameter (including last 2 varices) 29.5 mm.  
7, 8. Height (almost complete) 40 mm, diameter (including last 2 varices) 24.3 mm.
- 10, 13. *Ficus carbacea carbacea* (Guppy) (p. 211).  
Height (incomplete) 53 mm, diameter 34.5 mm. Locality 182. Upper part of Gatun formation, western area,  
late Miocene. USNM 562635.
- 11, 12. *Murex (Murex) recurvirostris recurvirostris* Broderip (p. 214).  
Height (not quite complete) 38.8 mm, diameter (including terminal varix and its broken shoulder spine) 21.3 mm.  
Locality 157. Middle part of Gatun formation, middle Miocene.





MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION



MIDDLE MIOCENE MOLLUSK FROM GATUN FORMATION AND EARLY PLIOCENE MOLLUSKS FROM CHAGRES SANDSTONE AND ITS TORO LIMESTONE MEMBER

PLATE 37

FIGURE 1, 4, 5, 8. *Sthenorytis toroensis euthyanta* Woodring, n. subsp. (p. 185).

Locality 205. Chagres sandstone.

1, 4. Type. Height (incomplete) 29.5 mm, diameter (incomplete) 24 mm. USNM 562639.

5, 8. Paratype. Height (incomplete) 23.2 mm, diameter 20.6 mm. USNM 562640.

2, 3, 11, 12. *Sthenorytis toroensis toroensis* (Dall) (p. 184).

Locality 186. Toro limestone member of Chagres sandstone. USNM 214345.

2, 3. Type. Height (incomplete) 19.2 mm, diameter 17.3 mm.

11, 12. Paratype. Height (not quite complete) 17.8 mm, diameter 14.3 mm.

6, 9. *Murex (Murex?) polynematicus* Brown and Pilsbry (p. 215).

Height (incomplete) 54.5 mm, diameter (including terminal varix and its broken shoulder spine) 33.7 mm.

Lower part of Gatun formation. USNM 562585.

7. "*Epitonium*" sp. (p. 184).

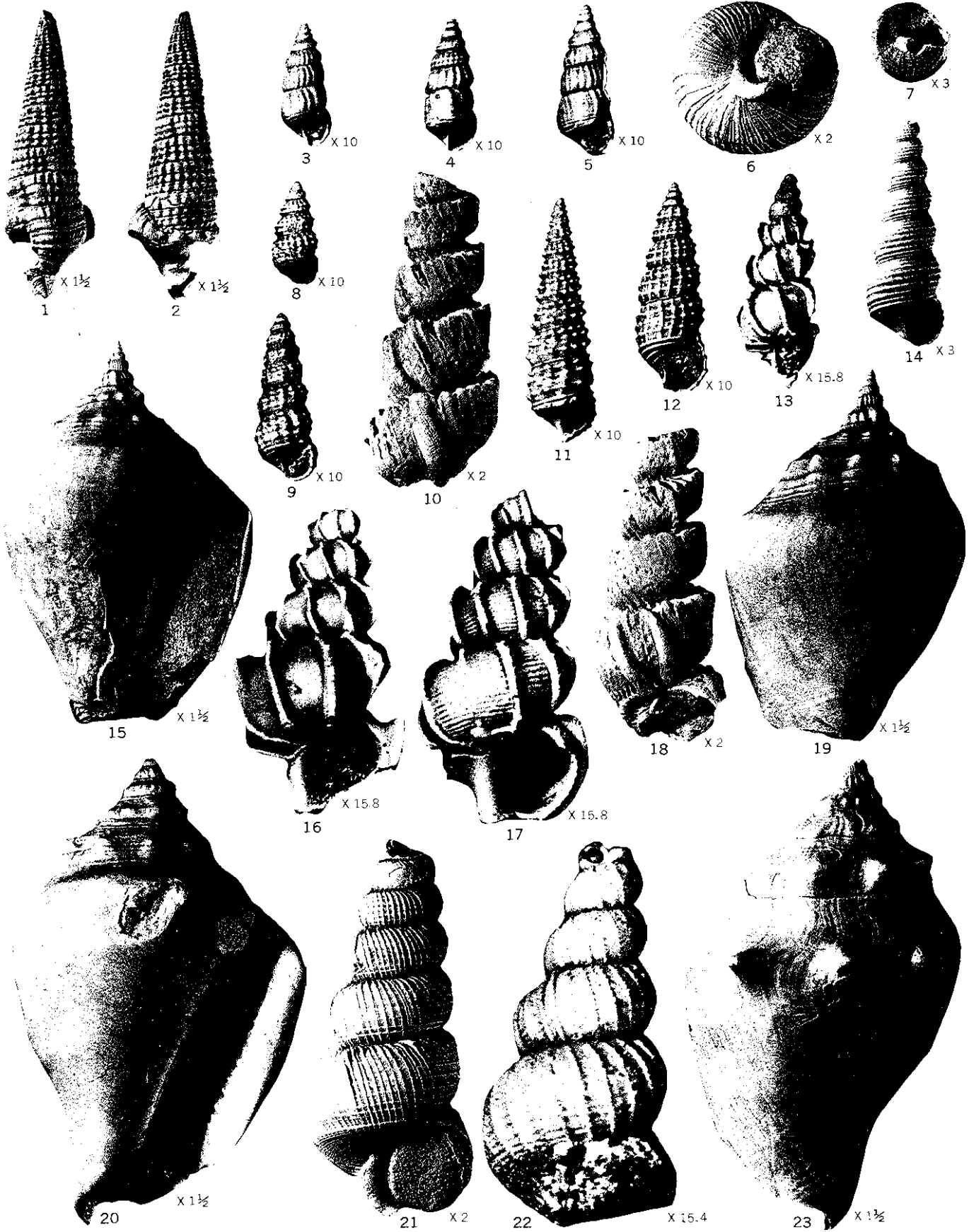
Height (incomplete) 7.5 mm, diameter 3.7 mm. Locality 206. Chagres sandstone. USNM 562638.

10, 13. *Bathygalea (Miogalea) hadra* Woodring and Olsson (p. 198).

Type. Height 43.7 mm, diameter 33.6 mm. Locality 208. Chagres sandstone. USNM 562268.

PLATE 38

- FIGURE 1, 2. *Rhinoclavis (Ocheloclava) costaricana canabina* Woodring, n. subsp. (p. 171).  
 Type. Height (incomplete) 35.5 mm, diameter 11.5 mm. Locality 115b. Middle part of Gatun formation, middle Miocene. USNM 562599.
- 3-5. *Alabina asperoides canaliculata* (Gabb) (p. 180).  
 3. Height 2.3 mm, diameter .8 mm. Locality 170a. Middle part of Gatun formation, middle Miocene. USNM 562619.  
 4. Height 2.4 mm, diameter 1 mm. Locality 138a. Lower part of Gatun formation, middle Miocene. USNM 562594.  
 5. Height 2.5 mm, diameter 1 mm. Locality 147b. Middle part of Gatun formation, middle Miocene. USNM 562601.
- 6, 21. *Scalina pseudoleroyi* (Maury) (p. 187).  
 Height (incomplete) 35 mm, diameter 16 mm. Locality 175. Upper part of Gatun formation, eastern area, middle Miocene. USNM 562623
- 7, 14. *Scalina* cf. *S. brunneopicta* (Dall) (p. 188).  
 Height (incomplete) 14 mm, diameter 5.2 mm. Locality 179. Upper part of Gatun formation, western area, late Miocene. USNM 562631.
- 8, 9. *Alabina asperoides asperoides* (Gabb) (p. 180).  
 Locality 138a. Lower part of Gatun formation, middle Miocene. USNM 562593.  
 8. Height 1.8 mm, diameter .9 mm.  
 9. Height 3.1 mm, diameter 1.1 mm.
- 10, 18. *Cirsotrema (Cirsotremopsis, cf. C. arcella* Rehder (p. 186).  
 Height (incomplete) 29 mm, diameter (incomplete) 13 mm. Locality 153. Middle part of Gatun formation, middle Miocene. USNM 562580.
11. *Bittium pericallum* Woodring, n. sp. (p. 179).  
 Type. Height 4.5 mm, diameter 1.3 mm. Locality 177c. Upper part of Gatun formation, eastern area, middle Miocene. USNM 562622.
12. *Bittium nugatorium* Brown and Pilsbry (p. 179).  
 Height 4 mm, diameter 1.4 mm. Locality 155c. Middle part of Gatun formation, middle Miocene. USNM 562600.
- 13, 16. *Epitonium (Epitonium) cf. E. foliaceicostum* (d'Orbigny) (p. 182). Locality 147b. Middle part of Gatun formation, middle Miocene. USNM 562578.  
 12. Height 2.5 mm, diameter 1 mm.  
 15. Height (incomplete) 3.7 mm, diameter 2 mm.
- 15, 19, 20, 23. *Strombus gatunensis* Toulou (p. 189).  
 15, 19. Height (incomplete) 47.3 mm, diameter 32.3 mm. Locality 155. Middle part of Gatun formation, middle Miocene. USNM 562602.  
 20, 23. Height (not quite complete) 59.5 mm, diameter 37.5 mm. Locality 182a. Upper part of Gatun formation, western area, late Miocene. USNM 562632.
7. *Epitonium (Asperiscula) cf. E. gabbi* (de Boury) (p. 183).  
 Height 3.9 mm, diameter 2 mm. Locality 147g. Middle part of Gatun formation, middle Miocene. USNM 562579.
22. *Epitonium (Asperiscula) cf. E. rushii* (Dall) (p. 183).  
 Height (incomplete) 4.6 mm, diameter 2.3 mm. Locality 183. Upper part of Gatun formation, western area, late Miocene. USNM 562630.



MIDDLE AND LATE MIOCENE MOLLUSKS FROM GATUN FORMATION

