

## Quaternary and Recent land snails (Mollusca: Gastropoda) from Red Hills Road Cave, Jamaica

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### Abstract

The fossil record of terrestrial animals in the Antilles is dominated by vertebrates and gastropods from Quaternary cave fills. Red Hills Road Cave (RHRC), parish of St. Andrew, Jamaica, contains a fauna *circa* 30,000 years old, which is unusual both for the richness of its included tetrapods and gastropods, and the exceptional, three-dimensional preservation of millepedes and isopods. RHRC has yielded 62 species of Pleistocene gastropods; 50 extant species have been identified from near the cave and 12 more from elsewhere in the Red Hills, but only 30 are common to both fossil and Recent faunas. There is, thus, a marked divergence between the known Pleistocene and Recent snail faunas of this area, which results both from local extinction of Pleistocene species and immigration into the area by a significant proportion of the Recent fauna. This contrasts with previously reported molluscan cave faunas from Jamaica which have suggested that local endemic species have had much more static distributions over the same period. We interpret the changes at RHRC as indicating a reduction in precipitation from the Pleistocene to Recent. Gastropod species not previously reported from Jamaica include *Ptychopatala* spp. A and b, *Punctum* (*Toltecia*) *vitreum* Baker, *Punctum* (*Punctum*) sp. a, *Radiodiscus* sp. a and *Radiodiscus*? sp. b.

*Key words:* Pleistocene, Recent, cave faunas, gastropods, Jamaica

### Introduction

The fossil record of the Antillean islands is dominated by marine organisms. With the notable exception of the mid Tertiary amber deposits of the Dominican Republic (Baroni-Urbani and Saunders, 1982; Wu, 1996) and rare vertebrate bones (e.g., Domning *et al.*, 1997), non-marine (both terrestrial and freshwater) fossils from the region are mainly known from the Quaternary. The terrestrial animal taxa most commonly encountered are vertebrates (see, amongst many others, Pregill *et al.*, 1988; MacPhee *in* Fincham, 1997, pp. 47-56; McFarlane and Blake, 2005) and land snails (see, for example, Goodfriend, 1989), which generally form the dominant faunal elements of cave deposits. The taphonomic pathways leading to such concentrations of fossils are well known (Simms, 1994; Torres *et al.*, 2003).

The Red Hills Road Cave (RHRC) or, perhaps more correctly, fissure (McFarlane and Blake, 2005) in the parish of St. Andrew, Jamaica (Fincham, 1997, p. 304), has yielded an exceptionally diverse fauna of terrestrial tetrapods, land snails and, unusually, arthropods. The vertebrates (McFarlane and Blake, 2005) and arthropods (Donovan and Veltkamp, 1994) have already been partly described. The purpose of the present communication is to document the large and varied land snail fauna from this deposit and compare it with the Recent local

fauna. Very few Jamaican land snails occur throughout the island and most are endemic to quite small, local areas. Goodfriend (1989) concluded from comparison of the snail faunas from four late Pleistocene to Holocene caves with contemporary examples from the environs of the caves that very little change had occurred since the late Pleistocene. This implies that the boundaries of the distributions of local endemic snails have remained stable for considerable periods of time. The RHRC fauna is of particular interest because it differs significantly from the contemporary, local gastropod fauna. Not only does it contain species not now found in the immediate vicinity, but it also lacks some of the large and conspicuous extant species that occur commonly in the area. Thus, the boundaries of the ranges of both Pleistocene and Recent snails have changed in the area of the cave. Additionally, even where the same species is present in both fossil and living faunas, significant differences in size and shape may occur. Finally, the fossil fauna contains several species not previously reported from Jamaica, some of which may well be new to science. For all of these reasons, it is considered important to record the fossil fauna in detail (Pls. 1–39) and to compare it with available data on the contemporary fauna. All specimens illustrated in Plates 1–14, and Figures 3 and 5–10, are deposited in the Department of Palaeontology, Nationaal Natuurhistorisch Museum, Leiden (RGM). The SEM stubs on which Plates 15–39 and

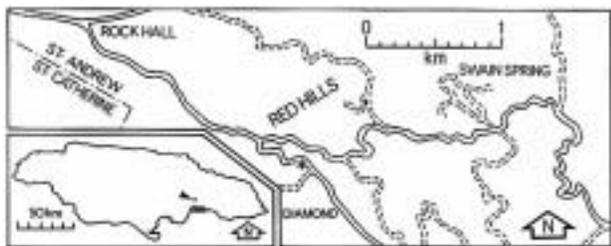


Fig. 1. Locality map to show the position of the late Quaternary RHRC (\*) on the south side of the Red Hills Road near Diamond, parish of St. Andrew, Jamaica (after Donovan and Veltkamp, 1994, fig. 1). Main and minor roads, and the boundary between the parishes of St. Andrew and St. Catherine, are shown. Inset map of Jamaica shows the approximate position of the main map (arrowed).

Figure 4 are based have been misplaced, hopefully only temporarily, but, assuming that they eventually re-emerge, these specimens are also destined for the RGM collections.

### Locality

The locality is on the south side of the Red Hills Road (Fig. 1; Jamaica 1:50,000 new series, grid reference 13/ 643 572), parish of St. Andrew, Jamaica, about 3.3 km west from the lookout between mileposts 9 and 10. The cave is flask-shaped and exposed in vertical section, with a narrow opening at the apex (Donovan and Gordon, 1989: fig. 2; Donovan *et al.*, 1995: fig. 7). It was presumably exhumed when the road was built. The cave was dissolved into well-lithified limestones of the mid Tertiary White Limestone Group, and is partially infilled with dripstones, fallen limestone boulders and siliciclastic sediment. The last is probably largely derived from the terra rossa soils that are prevalent in this area, hence the name Red Hills. Where lithified, the sediment is cemented by calcite. Much unconsolidated sediment is deduced to have been washed out of the cave following exposure (Donovan *et al.*, 1995). It is unknown how far the infilled cave extends below road level.

Fossils are abundant at this site, particularly vertebrates (Savage, 1990; McFarlane and Blake, 2005) and terrestrial gastropods, both common components of other Jamaican cave faunas. Arthropods are rare, but include millipedes (Donovan and Veltkamp, 1994), isopods, claws of nonmarine crabs, ostracodes and pupae of dipterans(?).

By comparison with the majority of vertebrate-rich cave faunas in Jamaica, the RHRC fauna is probably younger than 100,000 years old (MacPhee *et al.*, 1989). The precise age (or range of ages) of this deposit is unknown, but preliminary dating by amino acid racemization (Goodfriend, unpublished data) suggested a range in the order of 20,000–40,000 years. This agrees well with the radiocarbon date from a *Pleurodonte* shell of  $31,960 \pm 1220$  yr BP published by McFarlane and Blake (2005). Colour and colour banding preserved

on some lithified gastropods perhaps suggests a young age; however, last interglacial (Sangamonian; 125,000 years old) marine molluscs from well-lithified raised reefs in Jamaica show similar preservation of colour (Donovan and Littlewood, 1993).

The fossil snails documented herein represent a time-averaged sample. In the absence of abundant amino acid epimerization dates (see review in Goodfriend, 1992) from individual snails, this is nevertheless considered acceptable, as it provides a sample from what is presumed to have been a geologically brief time interval, enables the use of abundant material available from loose float and eliminates problems of stratigraphic mixing by burrowing of snails (Pflug, 1990). Nevertheless, it has been noted that there are some differences between faunas at different levels. For example, *Anoma fuscolabris* (Chitty) is more common in, and *Lucidella aureola* (Férussac) is apparently restricted to, the highest levels of the cave sediment.

Wherever possible, fossil and recent specimens have been compared with shell material preserved in The Natural History Museum, London (BMNH). In particular, the Chitty-Adams collection contains material selected and identified by C. B. Adams himself before he died and is as good a reference collection for Adams' species as could be desired. Additional comparisons have been made with the images displayed on Rosenberg & Drumm's website.

### Materials and Methods

A small number of snail and vertebrate fossils were picked in the field by hand, but most of the material came from large bulk samples. Samples were washed, sieved through 4.0, 2.0, 1.0 and 0.5 mm mesh sieves, and the residues picked using a Kyowa binocular microscope for the finer fractions. Recent material was collected immediately adjacent to the cave and from two other localities within 2–300 m of the cave, by searching for half an hour to an hour and by sieving litter through 2 mm and 0.5 mm mesh sieves in the field. Tree searches were not undertaken. Specimens were photographed with a Pentax P30 single lens reflex camera and using a Phillips scanning electron microscope (SEM). For

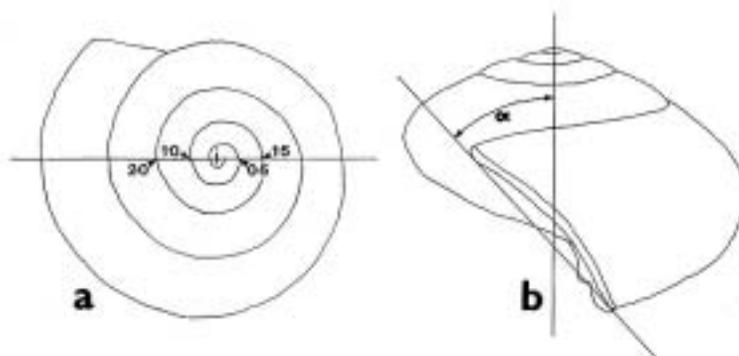


Fig. 2. (a), Diagram to illustrate whorl count. Key:  $i$  = initial width of the whorl; 0.5, 1.0, 1.5, 2.0, etc. = whorl counts. (b), Diagram to illustrate measurement of the angle ( $\alpha$ ) between the aperture plane and the axis of coiling.

SEM work specimens were mounted on aluminium stubs and coated with a 60 % gold/palladium mixture. A Wild camera lucida was used for measuring the angle between the aperture plane and the axis of coiling ( , Fig. 2b). Number of whorls was counted as shown in Figure 2a. All measurements were made by the senior author to ensure standardization of methodology.

### Land Snail Fauna

Nomenclature and systematic order follows Rosenberg and Muratov (2004), unless otherwise indicated.

Superorder Neritopsina

Family Helicinidae

Genus *Alcadia* Gray, 1840

Subgenus *Hjalmarsona* Baker, 1940

#### *Alcadia* (?*Hjalmarsona*) *solitaria* (C. B. Adams, 1845)

(Pl. 1, figs. 5–8; Pl. 15, fig. 1; Fig. 4)

**Description:** Shell small (about 10 mm maximum diameter), depressed in profile; with four whorls and a basal notch, not a distinct slit. Protoconch about half a whorl with characteristic ornament of radial ridges crossed at right angles by oblique striations. Early teleoconch with irregular growth lines and weak spiral bands of hair pits. Sutures shallow, whorls weakly tumid above and regularly rounded below. Aperture semi-circular with weakly thickened and slightly reflected margins, with a small V-shaped notch no deeper than wide basally, and parietal callus with a broad umbilical pad. The aperture plane that is not quite tangential to the penultimate whorl and the plane of the aperture is at  $41^\circ$  to the axis of coiling. As with all helicinid snails, the internal partitions between the whorls of the spire are resorbed during growth so that about a quarter to a third of a whorl back from the aperture the shell opens into a single large internal cavity which can be seen clearly in shells eaten by rats.

Operculum semi-circular in outline, with a ridge along the diameter accompanied by a shallow groove above and ending in a weak prong below. The weakly convex external surface shows poorly developed concentric growth lines (Pl. 15, fig. 1); the inner surface is concave with very distinctive, closely packed, fine tubercles on the lower half (Fig. 4). A strong rib runs down the parietal margin, which is distinctly denticulate (Pl. 15, fig. 1; Fig. 4) and ends in the second weak basal prong. At least four fossil shells have been found with the operculum in place. It fits inside the aperture and can be retracted well back from the margin.

**Occurrence:** A very common shell in the cave deposits. Not so far found living in the vicinity of the cave; however, it has been found dead within 2 km of the cave site (Rosenberg, written communication, September, 2005).

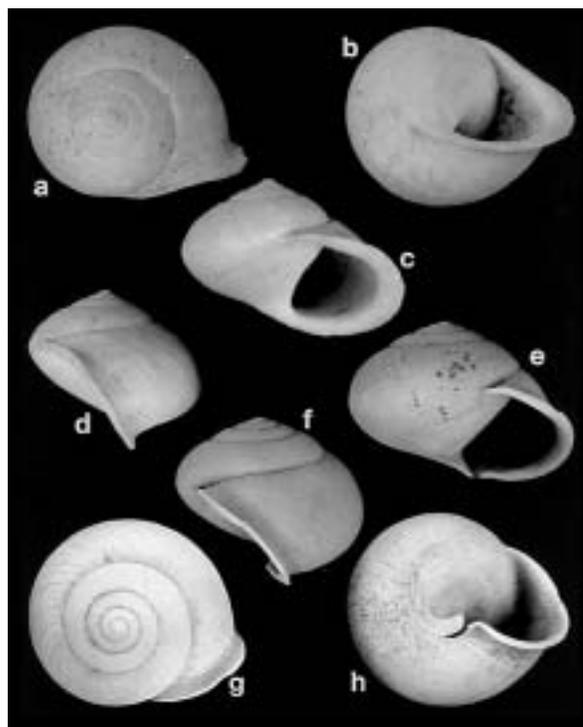


Fig. 3. Late Pleistocene gastropods from the RHRC, parish of St. Andrew, Jamaica. (a-d), *Helicina neritella* Lamarck, RGM 188 700, in apical (a), umbilical (b), apertural (c) and lateral (d) views. (e-h), *Alcadia brownii* (Gray), RGM 188 701, in apertural (e), lateral (f), apical (g) and umbilical (h) views. All specimens coated with ammonium chloride sublimate and approximately  $\times 2.20$ .

Subgenus *Palliatia* Wagner, 1907

#### *Alcadia* (*Palliatia*) *brownii* (Gray, 1824)

(Pl. 1, figs. 3, 4; Pl. 15, fig. 3; Pl. 29, figs. 4, 6, 7; Figs. 3e–h)

**Description:** Shell fairly small (up to 15.5 mm diameter), smooth, globular, imperforate, with four and three quarter slightly tumid whorls, and a semi-circular aperture with slightly thickened, weakly reflected margins and a distinct narrow slit basally that truncates the columella. Protoconch not easily distinguished from



Fig. 4. Internal surface of the operculum of *Alcadia* (?*Hjalmarsona*) *solitaria* (C. B. Adams),  $\times 16.50$ . Fossil, RHRC.

the teleoconch, but only half to three quarters of a whorl; with characteristic ornament of radial ridges crossed perpendicularly by weaker oblique striations. Earliest teleoconch smooth, then ornament of irregular growth striae begins together with spiral rows of hair pits poorly preserved in fossils. Sutures weak with the whorls slightly convex dorsally and regularly curved throughout cross section. Outline of spire gently convex, thus giving the whole shell a globular profile. Aperture semi-circular, tangential to preceding whorl, with slightly thickened, weakly reflected outer and basal margins. The aperture plane is almost tangential to the penultimate whorl ( $\alpha = 44-46^\circ$ ). Basal slit narrow, parallel-sided and twice as deep as wide; a distinct slit rather than a notch. Parietal callus notched above the slit and with a broad umbilical pad. The columellar margin is effectively truncated by the slit and protrudes rather like an extended thumb. The usual helicoid internal cavity is present.

The operculum is semi-elliptical in outline (Pl. 15, fig. 3), weakly calcified (and fossil examples often damaged) along the palatal margin, with a smooth parietal margin and two obvious basal 'teeth' separated by a distinct groove. The external surface is weakly convex with obvious concentric growth lines and a weak ridge running along the major diameter; internally the surface is weakly granular throughout (Pl. 29, figs. 4, 6, 7), but basally the granules become pointed (Pl. 29, fig. 6). The parietal margin is smooth with a weak ridge. Basally, the inner and outer ridges terminate in two distinct, rather flat prongs separated by a distinct notch. In life these prongs engaged in the basal slit of, and helped align the operculum in, the aperture. No fossil examples have so far been found with the operculum in place. However, opercula of *Alcadia* spp. are very distinctive. Those described here are large and so presumably originate from the larger fossil species, *A. brownii*.

*Occurrence:* Very common in the cave deposits and still living in the immediate vicinity of the cave. Fresh Recent shells have a thick, hairy periostracum and bright reddish brown shells. They occur uncommonly in the cave deposits, indicating clearly that contamination with Recent shells does occur and hence that accumulation of shell-rich cave fill continues to the present day, even if distinct layers cannot be recognized within the cave fill.

***Alcadia (sensu lato) jamaicensis* (G. B. Sowerby II, 1842)**

(Pl. 1, figs. 1, 2)

*Description:* Shell fairly small (up to 12 mm in diameter by 11 mm high), smooth, steeply conical, imperforate, with five and a quarter angular whorls and a tangential, semicircular aperture with weakly reflected lip. Protoconch bears very fine, spirally arranged pits and is of about one whorl. The early teleoconch bears a weak ornament of growth lines and extremely fine, irregular oblique striations. Suture shallow, separating scarcely tumid whorls, the last of which is initially very slightly angular at the periphery, but rounded at the aperture. Aperture semi-circular, with slightly flared, but distinctly thickened, double outer margin, solid parietal callus

spreading over the umbilical region and with a smoothly curved outline. The aperture plane is almost tangential to the penultimate whorl ( $\alpha = 45^\circ$ ). The large internal chamber characteristic of helicoid is present.

*Occurrence:* Not uncommon in the cave deposits. Recent shells are known from elsewhere within the Red Hills, but it is not confirmed alive in the vicinity of the cave. If locally extinct, this is probably a very recent occurrence.

Genus *Eutrochatella* Fischer, 1885

Subgenus *Eutrochatella* Fischer, 1885

***Eutrochatella (Eutrochatella) pulchella* (Gray, 1824)**

(Pl. 1, figs. 9-14; Pl. 21, figs. 2-4)

*Description:* Shell fairly small (13 mm diameter), smooth, conical, imperforate, with up to five whorls, steeply conical, with a keel on last whorl, an ornament of obvious raised spiral ridges and a strongly flared lip. Protoconch very small, less than half a whorl, angular with a very fine, malleated surface sculpture with a weakly spiral arrangement. Sutures of the early teleoconch just below the periphery giving the spire a pagodiform outline, with a rough surface and weak growth lines. Then, very weak spiral lines begin and become stronger with growth. Seven occur above the keel on the last two whorls and about 30 weaker ridges below the keel on the body whorl. On the spire the keel becomes crenulate with saw-tooth-like outgrowths that lie just above the suture. Growth lines occur throughout the shell, but are always weaker than the spiral ridges. Suture weakly impressed, just below keel in early whorls. Dorsally whorls are almost planar, the last distinctly angular although less so approaching the aperture, and with the periphery ornamented with discontinuous, elongate, white ridges that are the remains of the keel. Aperture more than a semi-circle, exactly tangential to penultimate whorl ( $\alpha = 41-45^\circ$ ), with broadly reflected outer and basal margins, and a parietal callus that extends over the umbilical region. Large internal cavity present. Shells with more strongly flared lips and taller, more pagodiform spires occur, but none approaches the named varieties of *E. pulchella*.

Operculum concentric, approximately semicircular in outline, with an inflection at about the diameter and a weak, sinuous flange along the parietal margin. The weakly convex external surface shows faint, concentric growth lines; the internal surface is very slightly granular. Parietal margin thickened with a distinct ridge internally, but this does not develop a groove or prongs basally as in *Alcadia* spp. At least four examples were found with the operculum still in place. It is retractable well inside the aperture.

*Occurrence:* Abundant in the cave deposits, one of the commonest species. Recent shells found in the immediate vicinity of the cave and known living elsewhere in the Red Hills. A widespread species that is extremely variable and has survived human disturbance quite well.

Genus *Helicina* Lamarck, 1799

***Helicina neritella* Lamarck, 1801**

(Pl. 15, figs 2, 4; Figs. 3a–d)

*Description:* Shell similar to that of *Eutrochatella pulchella*, but slightly larger (13–14 mm diameter), smooth, conical, imperforate, with four and three quarter angular whorls and a tangential, semi-circular aperture with a distinctly reflected lip. Protoconch with very fine pits arranged in spiral rows and of about one whorl. In Recent specimens and the best preserved fossils the rest of the shell is ornamented with irregular growth lines, very fine impressed spiral lines and irregular oblique striations. Sutures weakly impressed, not descending before the aperture. Whorls slightly tumid dorsally, angular in cross-section, becoming sub-rounded towards the aperture. Aperture with thickened and reflected lip, and a strong parietal callus extending over the umbilical area. Outer margins distinctly reflected forming an aperture plane that is exactly tangential to the penultimate whorl ( $\alpha = 45^\circ$ ). Usual large internal cavity present.

Operculum roughly semicircular in outline with fine concentric growth lines on the outer surface (Pl. 15, fig. 4) and weak granules on the inner surface (Pl. 15, fig. 2). With a thickened ridge close to the columellar margin.

*Occurrence:* Not uncommon in the cave deposits. Rare Recent shells have been seen in the immediate vicinity of the cave and elsewhere in the Red Hills, but no living examples have yet been confirmed. If it is now locally extinct, this is most likely due to very recent human disturbance.

Genus *Lucidella* Swainson, 1840

Subgenus *Lucidella* Swainson, 1840

***Lucidella (Lucidella) aureola* (Férussac, 1821)**

(Pl. 1, figs. 15–17)

*Description:* Shell small (up to 10 mm maximum diameter), globular, imperforate, with five and a half rounded whorls ornamented with spiral ridges, an angular aperture with thickened and reflected margins produced into two tooth-like processes, one above and one below. The protoconch is polished, smooth and just a half whorl. On the teleoconch the characteristic ornament of weak growth lines, and stronger spiral ridges and grooves, starts immediately and strengthens with growth. About a dozen ridges lie between the sutures on the penultimate whorl; ridges are half or less the width of the grooves between them. The sutures are moderately impressed, descending slightly just before the aperture. The whorls are rounded, but with an angular periphery. Upper whorls weakly corrugated on the spire, body whorl descending slightly just before the aperture, which is highly modified, but with a plane broadly tangential to the preceding whorl ( $\alpha = 43\text{--}45^\circ$ ). The outer and basal margins are reflected and thickened internally. A very narrow notch separates the penultimate whorl from the outer lip, which is then deflected down and inwards to form the upper tooth.

The basal margin is raised to form the lower tooth and there are embayments between the two teeth, and between the basal and the columella. The parietal callus is usually thin, but is thickened into a weak lamella just below the parietal-palatal junction, producing a short narrow sinus in some shells. The usual large internal cavity of heliciniids is present.

*Occurrence:* Rather a rare shell in the cave fauna, but living in the immediate vicinity of the cave. A common and island-wide species showing considerable variation. Recent shells from the vicinity of the cave are slightly smaller than the fossils (mean diameter 7.9 mm versus 9.2 mm) and the basal tooth is more obviously the stronger of the two palatal teeth, but otherwise they are very similar. Both are weakly corrugated on the spire and both have 12–13 spiral ribs between the sutures at the point where the body whorl begins to descend to form the aperture.

Subgenus *Perenna* Guppy, 1867

***Lucidella (Perenna) lineata* (C. B. Adams, 1845)**

(Pl. 20, figs. 1, 2)

*Description:* Shell like a smaller, flatter version of *L. aureola* (about 4.0 by 2.2 mm), with distinct spiral lines, an obvious lower tooth in the aperture and four to four and a quarter whorls. Protoconch of less than half a whorl; teleoconch with increasingly strongly developed spiral lines, which are most obvious on the underside of the body whorl, and seven of which lie between the sutures on the penultimate whorl. There is a broader area without a ridge immediately below the sutures. Sutures weakly impressed, descending distinctly just before the aperture. The whorls are almost planar above, last with rounded angular periphery. Aperture typical of *Lucidella* with an upper sinus, a thickened and reflected lip with very obvious basal tooth and columellar sinus beside it. Parietal callus thin, granular, filling the umbilicus and with a slight sinus before meeting the outer lip. No parietal-palatal lamella. Plane of the aperture at about  $60^\circ$  to the axis of coiling. Usual large internal cavity of heliciniids present.

*Occurrence:* A moderately rare shell in the cave deposits. As yet unknown living in the immediate vicinity of the cave.

Subgenus *Poenia* H. and A. Adams, 1856

***Lucidella (Poenia) depressa* (Gray, 1824)**

(Pl. 22, figs. 1, 5, 6)

*Description:* Shell like a larger and smoother version of *L. lineata*, with the apertural denticles reduced to broad swellings on the margin, the lower being very weak. Shell small (5.5 mm maximum diameter), depressed, of four smooth whorls, with subtriangular aperture with strongly reflected and thickened margins. Protoconch of half a whorl at most, initially smooth, but the ornament of the teleoconch starts just before the protoconch lip. Teleoconch with weak spiral ridges and weaker growth lines, but appears smooth to the naked eye. Sutures scarcely impressed, descending slightly

before the aperture. Whorls almost planar, but rounded below. Aperture with narrow sinus between penultimate whorl and outer lip, with very weak 'teeth', especially the basal, and hence a weakly defined columella sinus. Plane of the aperture at about 31° to the axis of coiling. Parietal callus thin, with slight embayment near the upper sinus and a very weak lamella close to the parietal-palatal junction on some shells. Usual helicimid internal cavity present.

*Occurrence:* A rather rare shell in the cave deposits, with less than ten seen in total. Rare Recent shells found in leaf litter near the cave. Rosenberg (written communication, September, 2005) has recorded live examples within 2 km of the cave.

Family Stoastomatidae

Genus *Fadyenia* Chitty, 1857

***Fadyenia blandiana* (C. B. Adams, 1849a)**

(Pl. 18, figs. 1–4; Pl. 19, figs. 1, 2; Figs. 5g, h)

*Description:* Shell minute, distinctly depressed with the diameter about one and a half times the height and with three whorls. The smallest of the species of *Fadyenia* from Red Hills Road Cave (1.5 mm maximum diameter). Protoconch smooth, about half a whorl; thereafter, characteristic ornament of fine spiral ridges starts, with one or two minor ribs between stronger major ribs. Sutures weakly impressed, descending very slightly just before the aperture, which is free, semi-circular in outline and separated from the penultimate whorl by a distinct notch dorsally. Outer lip reflected and flared very slightly, white, not extended where the spiral ribs join it, but bounded by a smooth rib. Plane of the aperture at about 15° to the axis of coiling. Umbilical keel obvious, without an extension as a tooth at the basal-columellar angle. Umbilicus filled with obvious callus, which is smooth to finely granular and sometimes bears meniscus-like ridges towards the centre of the umbilicus. A large internal cavity occurs as in helicimid species.

Operculum (Pl. 18, figs. 1, 2) semicircular, with a strongly concave external surface and more planar internal surface with concentric growth lines. A peripheral groove separates the two surfaces. The external surface is ornamented in the same manner as the umbilical callus, with or without fine granules in different specimens (Pl. 18, fig. 2).

*Occurrence:* Abundant in the cave deposits. The second most common of the four species of *Fadyenia*. Dead shells of this species have been found in the vicinity of the cave, but it is not yet established that it survives there still.

*Remarks:* We consider that four species of *Fadyenia* occur in the fossil and Recent fauna around Red Hills Road Cave (Fig. 5). *Fadyenia blandiana* (Figs. 5g, h) is distinct because it is smaller and has a lower spire than the other three species, which are all more conical. *Fadyenia leana* (Figs. 5e, f) is taller than *F. blandiana*, but has similar, rather weak, spiral ridges that are not produced at the aperture. The other two species, *F. jayana* (Figs. 5c, d) and *F. lindsleyana* (Figs. 5a, b), both have much more prominent spiral ridges that are produced as distinct spikes adjacent to

the aperture. *Fadyenia lindsleyana* is the largest of the four species and has a concave outline to the spire. *Fadyenia jayana* is about the same size as *F. leana* and has a straight or weakly convex outline to the spire. Baker (1934, p. 62) regarded *F. jayana* as a "paedogenetoid subspecies" of *F. lindsleyana* and Rosenberg and Muratov (2004) listed *F. jayana* as a subspecies of *F. lindsleyana*. However, we have large samples of both forms from the cave deposits and have found no difficulty in separating the two. Here they are regarded as distinct species.

***Fadyenia jayana* (C. B. Adams, 1849a)**

(Pl. 16, figs. 2, 4; Pl. 17, figs. 1, 2; Pl. 20, figs. 3, 4; Figs. 5c, d)

*Description:* Shell minute (2.0–2.1 mm maximum diameter), conical with a straight or slightly convex outline to the spire, with four whorls, which bear two types of delicate, sharp, spiral ridges produced into spikes at the aperture. Major ridges are higher than minor ridges, which are very weak and one or two of which lie between each pair of major ridges. Protoconch of about half a whorl, smooth, separated from the teleoconch by a distinct break. Teleoconch with characteristic ornament of spiral ridges present immediately the teleoconch starts. Four major ridges between sutures on the penultimate whorl. Sutures weakly impressed, descending slightly just before the aperture and revealing a fifth major ridge in doing so. Whorls slightly convex above, strongly convex below. Aperture protruding slightly, free of the last whorl, semicircular in outline and with a slightly thickened, weakly reflected outer lip, which extends into spikes where the spiral ridges meet it. Usually ten or eleven such spikes around the outer lip, including the one at the parietal-palatal angle. The basal few ribs do not form spikes. Basal-columellar junction angular, with a keel spiralling out from the umbilicus to the angle, where it extends into a weak tooth. Inner margin of the aperture slightly concave. Plane of the aperture at about 10° to the axis of coiling. Umbilical area filled with callus that extends as the inner margin of the free aperture and is ornamented with granules of two sizes similar to those on the external surface of the operculum. Large internal cavity present.

Operculum (Pl. 16, figs. 2, 4; Pl. 17, figs. 1, 2) semicircular, strongly concave on the external surface, which is ornamented with fine granules throughout, accompanied by a variable number of large, irregular, linear tubercles aligned perpendicular to the straight margin. Internal surface smaller than external, planar and with concentric growth lines, bearing a distinct prong on the lower left margin. A peripheral groove runs around the entire operculum between the inner and outer surfaces.

*Occurrence:* Abundant in the cave deposits. The commonest of the four species of *Fadyenia*. Unknown living in the vicinity of the cave. Specimens in the Chitty-Adams collection in The Natural History Museum, London (BMNH), are rather more strongly ornamented, but otherwise similar to those from the cave deposits.

*Remarks:* Regarded as a subspecies of *F. lindsleyana* by Rosenberg and Muratov (2004).

***Fadyenia leana* (C. B. Adams, 1849a)**

(Pl. 16, figs. 1, 3; Pl. 19, figs. 3, 4; Pl. 32, fig. 6; Figs. 5e, f)

*Description:* Shell similar to that of *F. jayana*, minute, conical, but with a slightly higher spire, three and three quarters to four whorls, and with very much less obvious spiral ridges not produced into spikes at the aperture. The ribbing is the most obvious difference. At a glance *F. leana* appears smooth, whereas *F. jayana* is obviously ribbed. The difference between major and minor ridges is also much less obvious in *F. leana*. Protoconch smooth, of about half a whorl, more bulbous than in either of the strongly ribbed species. Suture weakly impressed, descending slightly before the aperture. Whorls equally convex above and below, with a regularly rounded cross-section. Aperture as in *F. blandiana* in that it lacks spikes and there is a smooth, sometimes double-edged, band around the outer margin externally, but adjacent to the penultimate whorl rather than free. Umbilical ridge weakly developed, often absent. Umbilical region filled with finely granular to smooth callus and the usual large internal cavity is present.

Operculum (Pl. 16, figs. 1, 3) very much like that of *F. blandiana*, but larger. Very rarely, ornamented with larger granules externally. Internal surface smaller than external, planar and with concentric growth line, but lacking the distinct prong at the lower left margin seen in *F. jayana*. A peripheral groove runs around the entire operculum between the inner and outer surfaces.

*Occurrence:* Abundant in the cave deposits, but not quite as common as the preceding two species. Unknown living in the vicinity of the cave.

***Fadyenia lindsleyana* (C. B. Adams, 1849a)**

(Pl. 17, figs. 3, 4; Figs. 5a, b)

*Description:* Shell minute (2.3–2.4 mm maximum diameter), but the largest of the *Fadyenia* species at Red Hills Road Cave, conical with a concave outline to the spire and four whorls. Very much like a slightly larger version of *F. jayana*. Protoconch smooth, about half a whorl and separated from the teleoconch by a distinct break. Ornament of distinct major and minor ribs starts immediately with the early teleoconch. Four or five major ribs between the sutures of the penultimate whorl. Major ribs produced into distinct spikes at the aperture, eleven or twelve of which occur, including the rib at the parietal-palatal angle. Basal ribs weaker and less produced or not expanded at all. Half a whorl back from the aperture the profile of the last whorl is flat above, slightly angular at the periphery and rounded below, but becomes more regularly rounded at the aperture. Keel at the basal-palatal angle very obvious, forming a distinct flange at the aperture, which is semicircular in outline with a slightly concave columellar margin. Aperture free of the penultimate whorl, but viewed from above the profile is angular rather than notched. Umbilicus excentric, filled with callus, which bears the same ornament of fine and coarse granules as that of the external surface of the operculum.

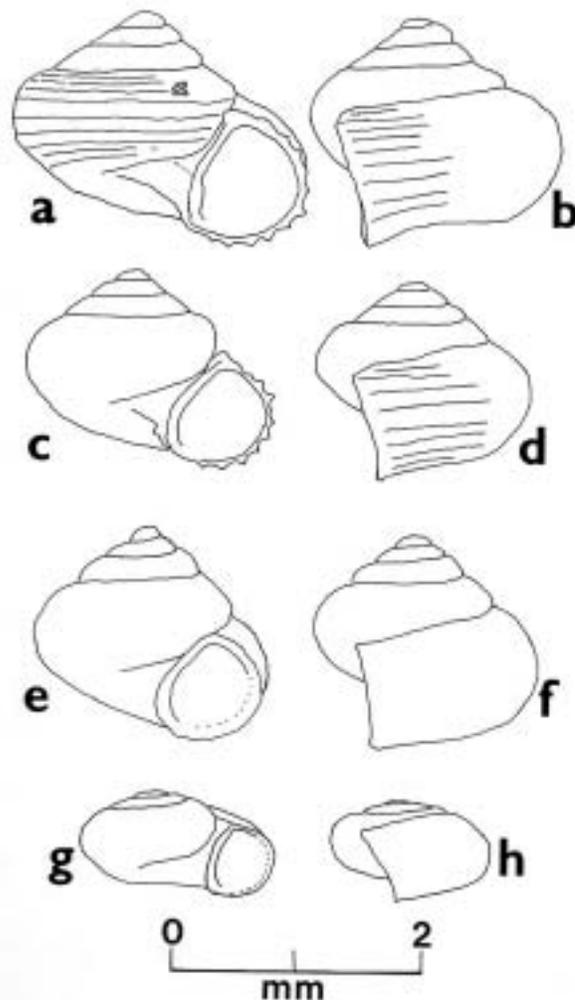


Fig. 5. Camera lucida drawings of species of *Fadyenia*. (a, b) *F. lindsleyana* (C. B. Adams) (RGM 456 297), (a) Apertural view, (b) Lateral view. (c, d) *F. jayana* (C. B. Adams) (RGM 456 298), (c) Apertural view, (d) Lateral view. (e, f) *F. leana* (C. B. Adams) (RGM 456 299), (e) Apertural view, (f) Lateral view. (g, h) *F. blandiana* (C. B. Adams) (RGM 456 300), (g) Apertural view, (h) Lateral view. Scale bar = 2 mm. Fossil, RHRC.

Operculum semicircular, deeply concave externally with a finely granular surface bearing four to six large tubercles, often elongated in a direction perpendicular to the straight margin. One specimen with the operculum in place (Pl. 17, figs. 3, 4) also has fine, radiating ridges around the periphery and on the parietal margin. All opercula with a very obvious flange at the basal-palatal angle. Internal surface with obvious concentric growth lines, separated from the outer surface by the usual peripheral groove.

*Occurrence:* The rarest of the *Fadyenia* species in the cave deposits, with between 50 and 100 specimens seen, compared with hundreds to thousands of the other three species. Two or three shells are sufficiently fresh to suggest that they are Recent contaminants of the cave fauna. Observed by Rosenberg (written communication, September, 2005) from within 2 km of the cave.

Order Architaenioglossa

Family Neocylcotidae

Genus *Poteria* Gray, 1840

Subgenus *Bartschivindex* Baker, 1943

***Poteria (Bartschivindex) varians* (C. B. Adams, 1851c)**

(Pl. 2, figs. 1–6)

*Description:* Shell moderately large, depressed conical (up to 25 mm by 15 mm), perforate, with four to four and a half rapidly expanding, rounded whorls and an unmodified, slightly angular, pyriform aperture. The protoconch is smooth, just distinguishable from the striate teleoconch and almost one whorl in extent. The early teleoconch is ornamented with closely spaced growth lines, which become increasingly irregular. Oblique, chevron-like corrugations occur on later whorls plus some vague spiral grooves on the body whorl. The suture is distinctly impressed, descending slightly at the aperture, and the whorls are distinctly tumid with an almost perfectly circular cross-section. The umbilicus is open and deep, about a fifth of the total diameter, with a distinct rounded rib which terminates at the basal-columellar angle of the aperture. The rib is only developed on the last whorl and does not correspond to a notch in the edge of the aperture. The aperture is just attached to the preceding whorl at the parietal margin, angular at the suture and at the basal-columellar margin, scarcely advanced above, with neither reflected nor thickened margins. The aperture plane is not at all tangential to the preceding whorl ( $\alpha = 38^\circ$ ). Traces of very narrow, now white, spiral bands are preserved rarely, indicating that shells from the cave deposits had colour bands in life. Some had a broad subperipheral band, presumably darker brown in life.

The operculum is multispiral and bilamellate, with internal lamellae that curve up (that is, outwards when in the aperture) at their periphery and external lamellae that curve outwards to meet the lamella of the succeeding whorl. On both surfaces the lamellae meet and overlap, giving the impression of a solid disc. Up to five whorls are preserved, but the centre is weakly calcified and usually becomes a hole in fossil opercula, so the total number is unknown. One shell has been found with the operculum in place.

*Occurrence:* Not very common in the cave deposits, about 50 shells having been recovered. So far no poteriid has been located alive in the vicinity of the cave, but Rosenberg (written communication, September, 2005) has recorded *Poteria subglobosa* (Torre *et al.*, 1942) living within 2 km of the cave. Specimens of the living species from the Red Hills are illustrated by Rosenberg and Drumm (2004). They have a taller, more globular shell than the fossils and seem to lack the characteristic chevron ridges. We do not think they are identical to either of the fossil species.

***Poteria (sensu lato) sp.***

(Pl. 2, figs. 7–10)

*Description:* Shells very similar to the above, but slightly smaller and, although malleated, without the chevron corrugations that are so obvious in *P. varians*. Internally the margin of the aperture

is almost perfectly circular, although the sutural angle is obvious externally and the basal ridge around the umbilicus is equally well developed. Plane of the aperture at about  $42^\circ$  to the axis of coiling.

*Occurrence:* Rather rare in the cave deposits, with only about 20 shells seen. All examples of this species are fresher than those of *P. varians*, but we do not think they are part of the Recent fauna. No recent shells of any poteriid have been found in the immediate vicinity of the cave, but see comments under *P. varians*, above.

Superorder Coenogastropoda

Family Annulariidae

Genus *Adamsiella* Pfeiffer, 1851

Subgenus *Adamsiella* Pfeiffer, 1851

***Adamsiella (Adamsiella) grayana* (Pfeiffer, 1846a)**

= *Cyclostoma obscurum* G. B. Sowerby II, 1843

(non *C. obscurum* Draparnaud, 1801) =

*Adamsiella variabile* (C. B. Adams, 1849b)

(Pl. 3, figs. 8–11)

*Description:* Shell fairly small (up to 15 mm high), high spired, perforate, decollate, with about four rounded whorls remaining in the adult stage, with circular aperture with strongly reflected and thickened margin. Protoconch smooth, just over one and a half whorls. Teleoconch initially with characteristic ornament of widely spaced vertical (that is, radial) ribs, sometimes alternately weak and strong, but becoming more closely spaced (both absolutely and relatively). By the second whorl of the teleoconch, ribs develop small, aligned thickenings which continue in the grooves between the radial ribs and eventually form spiral ribs that give the lower two or three whorls a distinctly cancellate ornament. About 30 spiral ribs between the sutures on the penultimate whorl, the strongest of which lies just below the suture. Sutures deep, not descending towards the aperture. Whorls well rounded, of almost perfectly circular cross-section. Aperture almost perfectly circular, with inner and outer margins present, but not clearly demarcated. The outer forms a narrow, thick flange composed of numerous lamellae, broader adjacent to the umbilicus and extending a little way up the preceding whorl at the suture. Plane of the aperture almost parallel to the axis of coiling, with about  $5^\circ$ . Shell perforate with a very narrow umbilicus that penetrates the entire spire, about 10% of the diameter.

Operculum multispiral, bilamellate, with raised and reflected outer lamellae that do not maintain contact.

*Occurrence:* Moderately common as a fossil in the cave deposits and living examples can be collected adjacent to the cave. Fresh shells, with the characteristic deep purple colour, occur not uncommonly in the cave deposits, again demonstrating that contamination with Recent shells occurs and that the cave fauna is still accumulating. The only difference between Recent and fossil shells noted is that tends to be higher in Recent shells, reaching around  $12^\circ$ .

Genus *Colobostylus* Crosse and Fischer, 1888  
 Subgenus *Colobostylus* Crosse and Fischer, 1888

***Colobostylus (Colobostylus) thysanoraphe***  
**(G. B. Sowerby II, 1843)**

= *Cyclostoma jayanum* C. B. Adams, 1849b  
 (Pl. 3, figs. 4–7; Pl. 29, fig. 3)

*Description:* Shell moderately large, high-spired (up to 21 mm high), perforate, decollate with three and a half to four rounded whorls remaining, and with a circular aperture with an extensive frill around it. Protoconch smooth and shiny, with a dark spot at the apex, and of just over one and a half whorls. Teleoconch with characteristic ornament of sharply raised radial ribs starts at one and a half whorls and ornament grows stronger. At about three and a half whorls the ribs start to bunch together at the suture in groups of five or six, producing little tubercles. About two whorls are lost on decollation. Suture distinctly impressed, ascending slightly towards the aperture. Whorls convex, last almost perfectly circular in cross-section. Aperture almost perfectly circular inside, with a slightly protruding and weakly reflected inner margin. The outer margin is a distinct flange extending in an ear-like lobe up the penultimate whorl and across the base of this whorl in a broader umbilical flange, but not sealing the deep, narrow umbilicus. The plane of the aperture is tilted slightly backwards so that it approaches the axis of coiling up the spire (that is, is negative and about  $-5^\circ$ ). The aperture plane is not quite parallel to the surface when the spire rests on the substrate and not at all tangential to the preceding whorl. Seen from above the aperture plane is almost perfectly radial. The umbilicus is narrow, about 5 % of the shell diameter. It may not penetrate the body whorl, but is present throughout the rest of the spire and can be seen at the point of decollation. Several shells preserve traces of colour markings in a shade of pale brown colour. Generally two broad spiral bands occur, one at the periphery and the other below it. These bands may be more obvious behind the outer lip and both may be broken up into patches of colour. Other shells show a series of discontinuous speckled spiral lines and commonly there is a pale subperipheral band.

Operculum unknown attached to shells, but abundant in the cave deposits (Pl. 29, fig. 3). It is pyriform, multispiral and bilamellate, with a deep groove between the internal and external lamellae. Both lamellae are spiral, the external preserving three to three and a half whorls, the precise number depending on the size of the hole that develops centrally where the operculum was very weakly calcified. External lamella planar with retrorsal growth lines, but slightly reflexed peripherally to fit over the inner lip of the aperture. Internal lamella much smaller, slightly concave, composed of a spiral ridge which turns outwards (that is, peripherally) to meet the succeeding whorl. In fossils the weakly calcified outer edge of the spiral ridge is commonly damaged so that a spiral groove appears between the whorls of the inner lamella.

*Occurrence:* One of the more common fossil shells, but so far no

trace of living snails has been found in the vicinity of the cave.

*Remarks:* We follow the late Glenn Goodfriend in regarding *Cyclostoma thysanoraphe* Sowerby as a senior synonym of *C. jayana* Adams. Both species were accepted in Rosenberg and Muratov (2004).

Subgenus *Tudorops* Henderson and Bartsch, 1920

***Colobostylus (Tudorops) yallahensis* (C. B. Adams, 1851a)**  
 (Pl. 3, figs. 1–3; Pl. 21, fig. 1)

*Description:* Shell fairly small, high-spired (up to 14 mm high), decollate, with three to three and a half rounded whorls remaining, and a circular aperture with a narrow frill round it and an inner margin that protrudes distinctly from within the frill. Protoconch initially smooth, but with faint growth lines forming towards the junction with the teleoconch and about one and a half whorls. Early teleoconch with characteristic ornament of raised radial ribs which start evenly developed, then become alternately one strong and one weak, then two strong and one weak on the upper whorls, and finally become more irregular. For the last two whorls or so these vertical ribs are modified by more or less coincidental white swellings which are both raised and thickened, and give the impression of seven or eight spiral ribs between the sutures and twelve or so on the base of the body whorl. Similar, but less regular, swellings occur adjacent to the suture, yet they do not coalesce to form nodes. About two whorls lost on decollation. The suture is deep and does not descend towards the aperture. Whorls are rounded and almost perfectly circular in cross-section. The aperture has a distinctly protruding, almost perfectly circular inner lip with about three pairs of radial ribs between its edge and the outer lip. The inner lip appears to be a tertiary sexual character, with smaller (presumed male) shells having a more strongly protruding inner lip. The outer lip forms a narrow flange all round the aperture, slightly frilled adjacent to the umbilicus and, at the suture, raised into an ear-like lobe composed of four or more lamellae reflected at different levels within the ear. The plane of the aperture is almost parallel to the axis of coiling, but with about  $8-9^\circ$ , perfectly radial when viewed from above. Umbilicus deep and narrow, less than 10 % of the diameter, not covered, but partially obscured, by the umbilical flange of the outer lip.

Operculum (Pl. 21, fig. 1) multispiral and bilamellate, with up to three and three quarter whorls on the outer surface (plus a small un- or weakly calcified central hole in fossils), with retrorsal grooves, but basically planar externally. Outer lamella greatly exceeds the inner lamella in diameter and is curved back (that is, towards the aperture) at the outer edge. When in place it overlaps the inner lip of the aperture and fits like a pot lid. A deep groove separates the inner and outer lamellae. The inner lamella is smoother than the outer with very weak retrorsal grooves. Both spiral lamellae curve outwards and are completely in contact with the succeeding whorl, so that both surfaces are more or less planar.

At least six fossil shells have been found with the operculum in place.

*Occurrence:* One of the commonest shells in the cave deposit, but no examples have been found living in the vicinity of the cave and the nearest known sites are at a considerable distance (see below).

*Remarks:* Adams (1849b) described a closely similar species, *C. hyacinthinum*, from the parish of St. Elizabeth. Subsequently, he accepted *C. yallahense* from Yallahs, parish of St. Thomas, south-east Jamaica, as a distinct species because the two areas of distribution were so widely separated (Adams, 1851c). *Colobostylus hyacinthinum* has a slightly fatter body whorl and a thinner peritreme than *C. yallahense*, so there are some minor morphological differences between the shells of the two species. In the Sykes collection (BMNH) is a single specimen of *C. yallahense* from Mount Diablo, near the border of the parishes of St. Catherine and St. Ann, east central Jamaica. This specimen is both the closest morphologically to the fossils from RHRC and the locality is the closest geographically, being about 30 km further northnorthwest.

Genus *Parachondria* Dall, 1905

Subgenus *Parachondrella* Henderson and Bartsch, 1920

***Parachondria (Parachondrella) mutica***

**(C. B. Adams, 1849b)**

*Description:* Shell small (up to 17 mm high), high spired, conical, decollate with four and a half to five weakly rounded whorls remaining, and a distinctly pyriform aperture with a simple weakly reflected lip. Protoconch smooth, of about one and a quarter whorls. Teleoconch with characteristic ornament of simple vertical ribs, which increase in strength with growth. Ribs are slightly produced adjacent to the suture, but do not develop into nodes. About three whorls are lost on decollation. Sutures only weakly impressed and not descending towards the aperture. Whorls only gently convex above the periphery, well rounded below, last rounded oval in cross-section. Aperture distinctly pyriform with the long axis at about 10° to the axis of coiling, simple with a weakly reflected lip. The lip extends very slightly at the suture and attachment to the penultimate along the parietal margin is very short. Plane of the aperture almost parallel to the axis of coiling ( $\alpha = 15^\circ$ ), almost perfectly radial when viewed from above. Shell perforate with a narrow umbilicus about 5 % of the diameter. Shell with flecks of brown colour arranged in both vertical lines and spiral bands, with a continuous subperipheral spiral band on some shells.

Operculum paucispiral, of about one and a half whorls, with discrete, raised, retrorsal flanges on the outer surface, separated by a deep groove from a larger inner lamella.

*Occurrence:* Common in the Recent fauna surrounding the cave, but unknown as a fossil in the cave deposits.

Subgenus *Parachondria* Dall, 1905

***Parachondria (Parachondria) fascia (Wood, 1828)***

*Description:* Shell moderately large (up to 25 mm high), high spired, decollate with four to four and three quarters weakly rounded whorls remaining, and a slightly oval aperture with a slightly protruding inner lip and a moderate frill around it. Protoconch unknown as a fossil. Teleoconch with characteristic development of ornament. Initially only vertical ribs present, but traces of spiral ribs increase in strength with growth. Distinctly decussate ornament occurs on the lowest two whorls. Vertical (that is, radial) ribs are very slightly more strongly developed than the spiral ribs; on every third to fifth vertical rib a white node occurs at the suture. Nodes involve one or two ribs at most. Eleven spiral ribs are visible between the sutures on the upper whorls. This number remains constant throughout the preserved portion of shells and the relative strength and spacing of the ribs does not change. An estimated two whorls are lost on decollation. Sutures only weakly impressed and not descending towards the aperture. Whorls only gently convex above the periphery, well rounded below, last slightly pyriform in cross-section. Aperture very slightly oval with the long axis at about 30° to the axis of coiling. Inner margin protrudes slightly and is weakly reflected; outer margin is a narrow flange extending a little up the penultimate whorl in a small ear-like lobe, and strongly reflected and curled in on itself adjacent to the umbilicus. Plane of the aperture parallels the axis of coiling or is tilted back very slightly (that is,  $\alpha = 0$  to  $-5^\circ$ ), almost perfectly radial when viewed from above, and at a distinct angle to the surface when the spire rests on the substrate. Shell perforate with a narrow umbilicus about 5 % of the diameter. Narrow, vertical, brown colour bands remain, continuous on one example, interrupted on another.

Operculum unknown from the cave deposits.

*Occurrence:* Extremely rare in the cave deposits. Only four shells found so far, although all are well preserved and three are adult. Rare Recent shells found within a few hundred metres of the cave.

Family Truncatellidae

Genus *Geomelania* Pfeiffer, 1845b

Subgenus *Merrilliana* Clench and Turner, 1948

***Geomelania (Merrilliana)***

***parvula* Pilsbry and Brown, 1910**

= *Geomelania parva* Chitty, 1853, non *Geomelania gracilis* var.

*parva* C. B. Adams, 1850a

= *Geomelania parvulina* Clench and Turner, 1948 (new name for *G. parva* Chitty, 1853)

(Pl. 23, figs. 4–6; Pl. 27, fig. 1; Figs. 6a–c)

*Description:* Shell small and high spired (4.5–6.35 mm high by 1.5–1.8 mm diameter), imperforate, decollate with five to six whorls remaining after loss of about five whorls, with a pyriform aperture with simple, weakly reflected outer lip. Protoconch flat-

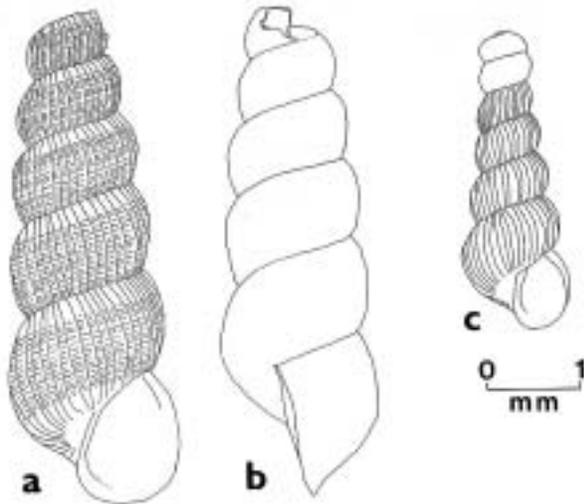


Fig. 6. Camera lucida drawings of an adult (RGM 456 301) and juvenile shell (RGM 456 302) of *Geomelania (Merrilliana) parvula* Pilsbry and Brown (a) Apertural view of adult to show surface ornament. (b) Lateral view of adult to show aperture plane. (c) Apertural view of juvenile shell. Scale bar = 1 mm. Fossil, RHRC.

topped, smooth, transparent (glass-clear even in fossils) and about two and a quarter whorls. Teleoconch not sharply demarcated from the protoconch, but starts with characteristic ornament of vertical ribs, initially rounded and about half the width of the grooves between, accompanied by much more delicate spiral lines between the vertical ribs. About 20 spiral ribs between sutures, with a narrow, but distinct, band free of, or with very faint, spiral ribs just below the suture and spiral ribs less strongly developed on the base of the body whorl. The ornament increases in strength as the shell grows. Sutures are distinctly impressed with well-rounded whorls. Aperture pear-shaped with a tendency to a squarish outline basally due to a slight inflexion of the outer lip at the palatal-basal margin. Outer lip simple, reflected and weakly flared especially at the palatal-basal junction, but not thickened. In profile the lip is slightly sinuous, extending forward at the palatal-basal junction and cut back a little at the basal-columellar junction. Plane of the aperture virtually parallel to the axis of coiling ( $\approx 0^\circ$ ). Parietal margin thickened, attached to the penultimate whorl, with a weak notch at the angular parietal-palatal junction.

Operculum unknown.

**Occurrence:** One of the commoner shells in the cave deposit. Not found living in the vicinity of the cave, but recorded elsewhere in the Red Hills.

**Remarks:** The single type specimen of *Geomelania parva* Chitty is at the lower end of the size range for this species (4.5 by 1.5 mm) with barely 5 whorls, but is fully mature with a thickened outer lip. Fossil specimens range from the same size as the type, when they look slightly immature, up to at least 6.35 by 1.7 mm. The type possesses the slightly flattened area just below the sutures that is virtually free of spiral lin-

ations, which is unique among species of *Geomelania* as far as we are aware. Clench and Turner suggested the new name *G. parvulina* for this species, unaware that Pilsbry and Brown (1912, p. 587) had already proposed the new name *G. parvula*.

Subclass Pulmonata

Family Carychiidae

Genus *Carychium* Müller, 1774

***Carychium jardineanum* (Chitty, 1853)**

= *Carychium exile* (C. B. Adams, 1849c) non *Carychium exile* Lea, 1842, *Carychium jamaicensis* Pilsbry, 1891

(Pl. 33, figs. 2, 3)

**Description:** Shell minute, high spired (about 2.0 by 0.75 mm), imperforate, with four and three quarter slightly tumid whorls, and an aperture with three denticles. Protoconch smooth, shiny, not clearly distinct from teleoconch, which has an ornament of very weak, irregular growth striae. Sutures moderately impressed, not descending towards the aperture. Whorl profile quite strongly convex, especially on middle whorls, less so on body whorl. Aperture oval, modified by a strong parietal lamella, weaker columellar lamella and by a concavity of the thickened palatal lip which does not form a real tooth. Outer, basal and columellar margins strongly reflected and thickened, parietal callus thin. Plane of the aperture at about  $33\text{--}34^\circ$  to the axis of coiling. Internally, two lamellae spiral down the columella for at least the last whorl and a half, terminating in the parietal and columellar lamellae of the aperture. The upper lamella is strongly flexed down immediately above the aperture and this can be seen through transparent shells. The form of this flexure is often a specific character in *Carychium*.

**Occurrence:** A very common shell in the cave deposits. Living snails have not been found in the vicinity of the cave, nor elsewhere in the Red Hills, as far as we are aware. *Carychium jardineanum* is characteristic of very wet climates and still occurs in the Cockpit Country.

Family Pupillidae

Genus *Ptychopatala* Pilsbry, 1889b

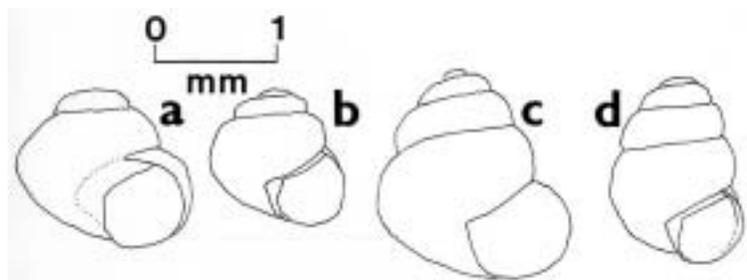


Fig. 7. Camera lucida drawings of apertural views of species of *Ptychopatala*. (a) *Ptychopatala dioscoricola* (C. B. Adams) (RGM 456 303). (b) *Ptychopatala macneilli* (Clapp) (RGM 456 304). (c) *P. sp. a* (RGM 456 305). (d) *P. sp. b* (RGM 456 306). Scale bar = 1 mm. (a) Recent, (b–d) Fossil, RHRC.

***Ptychopatala dioscoricola* (C. B. Adams, 1845)**

(Pl. 25, figs. 1, 3, 4; Fig. 7a)

*Description:* Shell minute, conical (about 1.5 mm high), equant or very slightly wider than high, with three to three and a quarter, tumid whorls, a narrow umbilicus and virtually unmodified aperture. Protoconch distinctly pitted and about one whorl. Separated from the teleoconch by an impressed line. Teleoconch with growth lines and the fine spiral lineations characteristic of this species. Sutures strongly impressed, not descending towards the aperture. Whorls rounded, almost perfectly circular in cross-section. Aperture rounded with a very slightly flattened palatal margin. Lips thin, sharp, columellar a little reflected; parietal callus thin, otherwise aperture unmodified. Aperture plane almost exactly tangential to the penultimate whorl ( $\alpha = 34^\circ$ ). Umbilicus narrow and very deep, penetrating entire shell, about one tenth the diameter or less.

*Occurrence:* Not uncommon living among leaf litter in the vicinity of the cave, but unknown as a fossil.

*Remarks:* We think four fossil and Recent species of *Ptychopatala* occur altogether in Jamaica (Fig. 7). *Ptychopatala dioscoricola* is the only species with spiral striae and has the lowest spire. It is only known from the Recent. The other three species have minutely granular surface ornament with growth striae only. Here we follow Hubricht (1985) and Rosenberg and Muratov (2004) in regarding *Ptychopatala minor* (Pilsbry, 1920) and *Ptychopatala macneilli* (Clapp, 1918) as synonyms. *Ptychopatala macneilli* (Fig. 7b) is very similar to *P. dioscoricola*, but usually a little smaller and slightly higher than wide. *Ptychopatala* sp. a (Fig. 7c) is larger than *P. macneilli*, more high-spined and has a proportionately larger umbilicus. Finally, *P. sp. b* (Fig. 7d) has the highest spire, being about one and a half times as high as wide, with a very narrow shell, but is not quite as large as *P. sp. a*. Both fossil and Recent examples of *P. macneilli* and *P. sp. a* occur, whereas *P. sp. b* is only known as a fossil. Neither of the latter has previously been recorded from Jamaica.

***Ptychopatala macneilli* (Clapp, 1918)**

(Pl. 24, figs. 3, 4; Pl. 27, fig. 5; Fig. 7b)

*Description:* Shell minute, conical (about 1.5 mm high), with three to three and a quarter malleated, tumid whorls, a narrow umbilicus and virtually unmodified aperture. Protoconch distinctly pitted and about one whorl. Separated from the teleoconch by an impressed line. Teleoconch with growth lines and irregular pitted ornament, but no trace of the spiral lineations characteristic of *P. dioscoricola* (Adams). Sutures strongly impressed, not descending towards the aperture. Whorls rounded, almost perfectly circular in cross-section. Aperture rounded with a very slightly flattened palatal margin. Lips thin, sharp, columellar a little reflected especially adjacent to the umbilicus; parietal callus thin, otherwise aperture unmodified. Aperture plane much less tangential to the penultimate whorl, despite similar value of  $\alpha$  ( $\alpha = 28-33^\circ$ ). Umbilicus

narrow and very deep, penetrating entire shell, about one tenth the diameter or less.

*Occurrence:* A rare shell in the cave deposit with only about 20 specimens seen so far, despite their small size. Recent *P. macneilli* is rarer than *P. dioscoricola*. The rarity of the fossil shells suggests that they could be contaminants, but they are often stained with the red colour of the cave fill and resemble other small fossil shells. However, their status as fossils remains suspect while they are unknown cemented into the cave fill.

***Ptychopatala* sp. a**

(Pl. 23, figs. 1, 2; Fig. 7c)

*Description:* Shell minute, conical, up to 1.7 by 1.4 mm, distinctly higher than wide, with about three and three quarter whorls, a relatively wide umbilicus and virtually unmodified aperture. The protoconch is pitted, about one whorl, separated from the teleoconch by an impressed line, then the characteristic colabral growth striations begin. Sutures strongly impressed, not descending towards the aperture. Whorls rounded, almost perfectly circular in cross-section. Aperture rounded, lip thin, scarcely reflected near the umbilicus and not at all elsewhere. Aperture plane almost exactly tangential to the penultimate whorl ( $\alpha = 27-29^\circ$ ). As with the preceding species,  $\alpha$  is lower in fossil than Recent shells. Umbilicus relatively wide, about one seventh the diameter.

*Occurrence:* Very rare in the cave deposits (eight specimens seen) and seemingly even rarer in the leaf litter surrounding the cave (one adult and two juveniles collected). The umbilicus is not quite as wide in the fossil as in the Recent shells, but the other features are distinctive.

***Ptychopatala* sp. b**

(Pl. 25, fig. 2; Pl. 26, fig. 2; Fig. 7d)

*Description:* Shell minute, high-spined, up to 1.55 by 1.05 mm. Proportionately the tallest of the *Ptychopatala* species, with three and a half to three and three quarter tumid whorls, a minute umbilicus and virtually unmodified aperture. Protoconch pitted, one and a quarter whorls, distinguished from the teleoconch by the onset of growth striae. Sutures impressed, not descending towards the aperture. Whorls rounded, circular in cross-section. Aperture almost perfectly circular, lips thin, scarcely reflected over the umbilicus which is very narrow. Aperture plane much less tangential to the penultimate whorl than in *P. dioscoricola* or *P. macneilli*, despite a relatively high  $\alpha$  ( $\alpha = 30^\circ$ ).

*Occurrence:* Very rare in the cave deposits, only three shells seen. Unknown living in Jamaica. The tallest and thinnest of the species of *Ptychopatala*. Shell outline is more like a species of *Vertigo* than *Ptychopatala*, but shells lack apertural denticles and have all the other characteristics of *Ptychopatala*.

Family Vertiginidae

Genus *Bothriopupa* Pilsbry, 1898

***Bothriopupa tenuidens* (C. B. Adams, 1845)**

*Description:* Shell minute, high-spined, up to 1.7 by 1.1 mm, with four to four and a half tumid whorls, with striate-granular surface ornament, and an aperture furnished with four teeth. The parietal lamella is large and prominent, the other three are smaller, two on the palatal margin and one columellar denticle. Surfaces of the protoconch and teleoconch are minutely granular, with very weak, irregular, colabral striae on the later growth stages. Whorls very tumid, the last with a short groove just before the aperture corresponding to the lower palatal denticle. Sutures impressed, not descending towards the aperture. Aperture subquadrate, with an upper palatal angle and planar to slightly concave main palatal lip, which is thickened, white and reflected in fully mature shells. Parietal denticle lamellate, extending twice as far into the aperture and twice as far back into the body whorl as the other three denticles. No parietal callus, but in one shell a short, weak denticle parallel to the aperture plane to the left of the parietal lamella, and another weak denticle to the right. Upper palatal denticle opposite the parietal; lower almost at the basal angle. Columellar lamella directed slightly downwards in conventional orientation (i.e., anteriorly). Plane of the aperture at about 23° to the axis. Narrow umbilicus appears to penetrate the entire spire.

*Occurrence:* Not uncommon living in litter around the cave. Unknown in the cave deposits.

Genus *Vertigo* Müller, 1774

***Vertigo gouldii* (Binney, 1843)**

*Description:* Shell minute, high spired (about 1.3 by 0.75 mm), cylindrical, with four shiny, weakly striate whorls, and an aperture furnished with four teeth; one parietal, one palatal, one basal and one columellar. Protoconch shiny, smooth, grading into teleoconch, which has more obvious growth striations. Sutures moderately impressed, not descending towards the aperture. A weak pit on the last whorl corresponds to the palatal denticle. The margins of the aperture are scarcely flared at all and there is only one denticle on the parietal, palatal, basal and columellar margins. The palatal tooth is about midway along the palatal margin and the basal tooth is set further into aperture than the other denticles. The columellar tooth does not turn down internally. Plane of the aperture at about 20° to the axis of coiling, but difficult to determine because of the flexure of the outer lip.

*Occurrence:* Another very rare shell in the cave fauna, but so far unknown living in the immediate vicinity of the cave. About five adult shells and several immature examples of less certain affinities have been collected from the cave deposits.

*Remarks:* According to Pilsbry (1919, p. 75) and Rosenberg and Muratov (2004), three species of *Vertigo* are known from Jamaica, of which one, *V. gouldii*, typically has only one parietal tooth. *Vertigo hexodon* (Adams, 1849c) is much larger than all the fossil shells and, according to Pilsbry, it is probably a junior synonym of

*V. ovata* (Say, 1822). Both fossil and Recent specimens of *V. milium* are smaller than typical examples from North America, but Pilsbry (1919, p. 149) recorded an example from Browns Town only 1.2 mm long. Other Caribbean Pupillacea are known to be smaller than those from North America, so we do not think that size is a significant specific character in the Vertiginidae.

***Vertigo milium* (Gould, 1840)**

(Pl. 24, figs. 1, 2)

*Description:* Shell minute, high spired, slightly smaller than that of *V. gouldii* (about 1.2 by 0.75 mm), more oval in outline, with four shiny, more obviously striate whorls, and an aperture furnished with six teeth; two parietal, two palatal, one basal and one columellar. Protoconch shiny, smooth, grading into teleoconch, which has more obvious growth striations. Sutures more deeply impressed than those of *V. gouldii* and descending very slightly towards the aperture. Whorls tumid, last with a basal groove that corresponds to the lower palatal lamella. Aperture semi-oval, with slightly flared and thickened margins, with straight parietal margin, concave palatal margin which helps to define a distinct sinus to the upper right, and rounded basal and columellar margins. Two parietal and two palatal lamellae. The right parietal and upper palatal almost meet separating a sinus from the main aperture where the pneumostome opened in life. The concavity of the palatal margin corresponds to the upper palatal lamella. The lower is larger and ends deeper into the aperture, where it turns down slightly and corresponds to the external groove on the last half whorl. The basal lamella is short, inconspicuous and set even deeper into the aperture than the lower palatal. The columellar lamella is relatively high up on the columella and turns down slightly internally. Plane of the aperture at about 21–22° to the axis of coiling. The shell has a minute umbilical pit, but only in the last whorl; it does not penetrate the spire.

*Occurrence:* A very rare snail in the cave fauna. Only one fully grown specimen seen so far, but some of the juvenile *Vertigo* shells may belong to this species. Recent *V. milium* occurs equally rarely in the immediate vicinity of the cave, and CRCP has recorded it from near Cavaliers and Stony Hill, 5–6 km further east.

Family Punctidae

Genus *Punctum* Morse, 1864

Subgenus *Punctum* Morse, 1864

***Punctum (Punctum) sp. a***

(Pl. 32, figs. 3–5; Figs. 8i–l)

*Description:* Shell minute (about 1.1 mm diameter), planispiral, but with moderately elevated spire (height about 55 % of maximum diameter), striate, three to three and a quarter rounded whorls, a wide umbilicus and an unmodified aperture. The whorls are distinctly ribbed with fine, regular, radial ridges. The protoconch is one and a quarter whorls, ornamented with pits in a spiral pattern and is very finely reticulate for the last quarter whorl. The

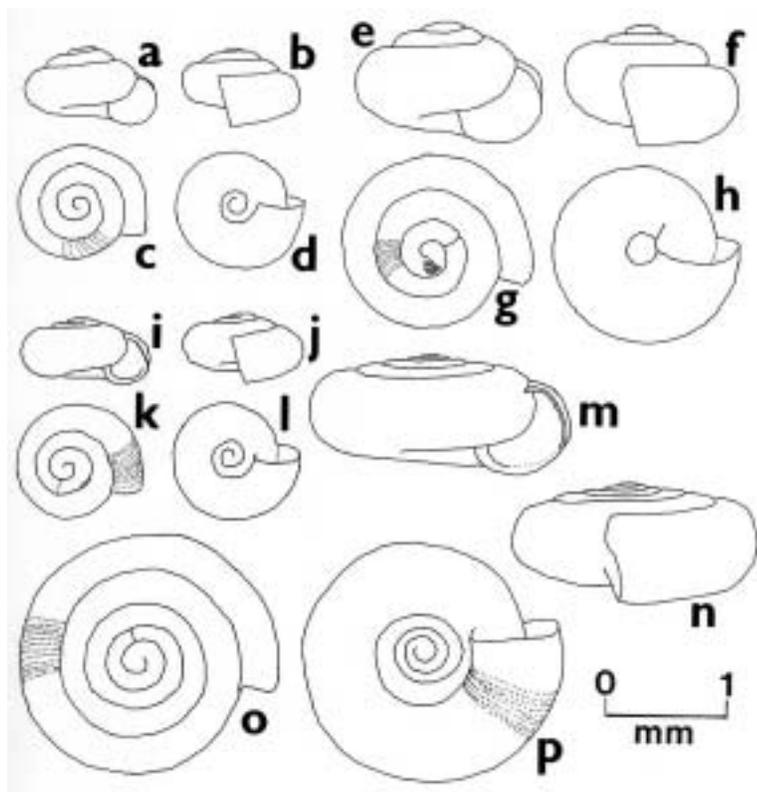


Fig. 8. Camera lucida drawings of species of *Punctum* and *Radiodiscus*. (a–d) *Punctum* (*Toltecia*) *vitreum* H. B. Baker (RGM 456 307), (a) apertural view, (b) lateral view, (c) dorsal view, (d) ventral view. (e–h) *Radiodiscus* sp. a (RGM 456 308), (e) apertural view, (f) lateral view, (g) dorsal view, (h) ventral view. (i–l) *Punctum* (*Punctum*) sp. a (RGM 456 309), (i) apertural view, (j) lateral view, (k) dorsal view, (l) ventral view. (m–p) *Radiodiscus?* sp. b (RGM 456 310), (m) apertural view, (n) lateral view, (o) dorsal view, (p) ventral view. Scale bar = 1 mm. Fossil, RHRC.

characteristic simple radial ridges appear at about one and a quarter whorls, with the teleoconch, and increase in strength with growth. There are no finer riblets between the radial ribs as in the subgenus *Toltecia* (see below). Very fine spiral lineations occur between the radial ribs especially in the umbilical region. The suture is deep and does not descend to the aperture; the whorls are more tumid above and flatter laterally, so that the whorl cross-section is not regularly rounded, but more angular above, less curved laterally and below, so appearing squarish. Aperture simple, without reflected margins, plane at about 14–15° to the axis. The umbilicus is about 30 % the diameter.

**Occurrence:** Not uncommon in the cave deposits. So far unknown living in the vicinity of the cave. All live specimens of *Punctum* we have seen from the Red Hills belong to the next species.

**Remarks:** This species is similar to *Punctum minutissimum* (Lea, 1841), but has fewer, stronger radial ribs and apparently weaker spiral ornament, although the latter may be partly due to poor preservation.

Four species of Punctidae and/or Helicodiscidae occur in the cave deposits (Fig. 8), none of which has been reported from

Jamaica previously as far as we are aware, although Rosenberg (written communication, September, 2005) informs us that he has collected specimens that are probably the same as the two species of *Radiodiscus* mentioned below from John Crow Peak about 20 km east of the cave, and a species of *Punctum*, tentatively identified as *P. minutissimum*, generally from disturbed ground. *Punctum vitreum* (Figs. 8a–d) is the smallest and least strongly ornamented, and has a glassy, translucent shell. *Punctum* sp. a (Figs. 8i–l) is about the same size as *P. vitreum*, but with the height about 55 % of the diameter and stronger, more closely spaced, simple radial ribbing. These are accompanied by a larger species (up to 1.55 mm diameter) with the same shape as *Punctum vitreum* (height about 65 % of diameter), but which has obvious spiral striations on the protoconch followed by very obvious radial ridges on the teleoconch (Figs. 8e–h). This agrees well with the genus *Radiodiscus* Pilsbry and Ferriss, 1906. It is described here as *Radiodiscus* sp. a and is similar *R. proameri* Baker, 1930, but has a significantly narrower umbilicus. The largest species, *Radiodiscus?* sp. b (Figs. 8m–p) reaches 2.2 mm diameter, has the lowest spire (height about 50 % of diameter) and largest umbilicus (38 % of diameter). It is ornamented with regular radial ribs, with 7–8 finer, beaded radial riblets in between (Pl. 34, fig. 2). It is similar to *Radiodiscus millecostatus* Pilsbry and Ferriss, 1906, except that the protoconch is virtually smooth and completely lacks the spiral ornament characteristic of the genus *Radiodiscus*.

Subgenus *Toltecia* Pilsbry, 1926

### *Punctum* (*Toltecia*) *vitreum* Baker, 1930

(Pl. 35, figs. 1, 3; Figs. 8a–d)

**Description:** Shell minute (about 1.1 mm diameter), planispiral, but with moderately elevated spire (height about 65 % of maximum diameter), shiny, three to three and a half rounded whorls, a wide umbilicus and an unmodified aperture. The protoconch is shiny, apparently smooth, grading imperceptibly into the teleoconch, which has exceedingly fine and irregular growth lines. Whorls of the teleoconch ornamented with fine raised ribs, between which are two or three exceedingly fine radial riblets and similarly fine spiral riblets. Suture moderately deep, not descending towards the aperture; whorls moderately convex above, with regularly rounded cross-section. Aperture completely unmodified, nearly circular in outline, with thin, unreflected margins, planar in profile with about 16°. Umbilicus about 30 % of the shell diameter.

**Occurrence:** Fairly common in the cave deposits, and the commonest of the punctids and helicodiscids. A single fresh shell with

periostracum intact was recovered from the cave deposits, and a few live specimens have been collected from leaf litter in the vicinity of the cave and elsewhere in the Red Hills.

Family Helicodiscidae

Genus *Radiodiscus* Pilsbry and Ferriss, 1906

***Radiodiscus* sp. a**

(Pl. 31, figs. 3, 4; Pl. 32, figs. 1, 2; Pl. 33, fig. 5; Pl. 34, figs. 3, 4; Figs. 8e–h)

*Description:* Shell a little larger than the preceding two species (up to 1.55 mm diameter) and proportionately deeper, with a slightly elevated spire (height 65 % of diameter), with three to three and a quarter rounded whorls, ornamented with distinct radial ribs, with an unmodified aperture and a narrow umbilicus 15 % of the shell diameter. The protoconch protrudes a little, is ornamented with spiral ridges and grooves (a characteristic of *Radiodiscus*), and is of one and a quarter whorls, the last quarter whorl having a finely reticulate ornament. The teleoconch starts with characteristic radial ribbing and obvious weaker spiral lines between the radial ribs. The suture is deep and does not descend towards the aperture; the whorls are regularly rounded, but their profile is deeper than those of *Punctum vitreum* and continues much further beneath the preceding whorl. As a result, the umbilicus is narrow and deep. In profile the palatal margin of the aperture is distinctly sinuous and the aperture plane lies at about 10° to the axis.

*Occurrence:* A very rare shell in the cave deposits, with only about ten specimens located so far. Unknown living in the vicinity of the cave, but possibly this and the next species may have been found on John Crow Peak, 20 km east of the cave (Rosenberg, written communication, September, 2005).

***Radiodiscus?* sp. b**

(Pl. 31, fig. 5; Pl. 33, figs. 1, 4; Pl. 34, figs. 1, 2; Figs. 8m–p)

*Description:* Very like a larger version of *Radiodiscus?* sp. a, but with a flat-topped spire, with four and three quarters obviously ribbed, rounded whorls, a wide umbilicus over a third the shell diameter and up to 2.2 mm diameter. The protoconch is shiny, apparently smooth, and of one and a third whorls. The teleoconch has obvious radial ribs, between which are seven or eight finer radial riblets with a beaded ornament, the beads of which are aligned in a spiral direction and produce the appearance of spiral ornament near the sutures. The sutures are deep and do not descend towards the aperture; the whorls are regularly rounded with a lunate cross-section and strongly overlap the preceding whorl. Aperture unmodified, but with a weak sinus adjacent to the penultimate whorl when viewed from above, sinuous in profile and with the aperture plane at about 10° to the axis. Umbilicus wide, expanding regularly to reveal earlier whorls, 38 % of the diameter.

*Occurrence:* A rare species in the cave deposits with only about 20 specimens found. Unknown living in the vicinity of the cave.

Family Ferussaciidae

Genus *Karolus* de Folin, 1870 (*in de Folin and Perier*, 1867–1886)

***Karolus iota* (C. B. Adams, 1845)**

*Description:* Shell minute, up to 2.25 mm high by 0.5 mm in diameter, high-spired, imperforate, with four smooth, shiny whorls and an elongate pyriform aperture with a truncated columella. Protoconch not distinguishable from the teleoconch. Shell transparent, shiny, with the faintest colabral growth striae. Whorls scarcely tumid, sutures very weakly impressed, appearing to be double because the attachment can be seen through the transparent shell. Body whorl up to 60 % of total height. Aperture narrow, elongate pyriform, with a sharp angle above and a truncated columella. Parietal callus relatively strong, with a weak spiral ridge descending from within the shell. Outer lip neither expanded nor thickened, but with a symmetrically sinuous profile. Lower part of the aperture profile exactly tangential to the preceding whorl, giving an angle of 29°, upper part leans back at an almost identical angle ( = -28°).

*Occurrence:* Unknown in the cave deposits, but a few shells have been found in litter samples from near the cave. *Karolus* is subterranean.

Family Subulinidae

Genus *Allopeas* H. B. Baker, 1935a

***Allopeas micra* (d'Orbigny, 1835)**

(Pl. 23, fig. 3)

*Description:* Shell small, up to 4.35 mm high by 1.75 mm in diameter, high-spired, with five to five and a quarter shiny, rather shouldered whorls and an oval aperture with a straight columella. Protoconch smooth, shiny, about one and a half whorls, separated from the teleoconch by an impressed line cut away below. Juvenile and adult shell transparent, shiny, with colabral growth striae and stronger ribs on the shoulders of the whorls. Whorls tumid, sutures distinctly impressed, not descending towards the aperture. Body whorl up to 60 % of total height. Aperture oval, with a straight columella, reflected over a very narrow umbilicus. Parietal callus very thin. Outer lip neither expanded nor thickened, but with a slightly sinuous profile at 12.5° to the preceding whorl.

*Occurrence:* Unknown in the cave deposits, but shells are common in litter samples from around the cave. Probably a recent introduction to Jamaica that is widespread over the island. The species is now pantropical.

Genus *Opeas* Albers, 1850

***Opeas hannense* (Rang, 1831)**

= *Opeas pumilum* (Pfeiffer, 1840)

*Description:* Shell small, up to 5.60 mm high by 2.25 mm in diameter, high-spired, with about six striate, convex whorls and an oval aperture with a straight columella. Protoconch smooth, shiny,

about two whorls, separated from the teleoconch by a faint impressed line. Juvenile and adult shell translucent, with obvious colabral growth striae and stronger ribs which extend more than half way down the whorls. Whorls tumid, sutures distinctly impressed, not descending towards the aperture. Body whorl up to 60 % of total height. Aperture oval, with a straight columella, reflected over a very narrow umbilicus. Parietal callus very thin. Outer lip neither expanded nor thickened, but with a slightly sinuous profile at 13° to the preceding whorl.

*Occurrence:* Unknown in the cave deposits, but shells are common in litter samples from around the cave. Also probably a recent introduction to Jamaica and equally widespread over the island. Like *L. micra*, *O. hannense* has become pantropical.

*Remarks:* This and the preceding species are very similar. Shells of *Opeas hannense* tend to be larger, more obviously striate and less translucent than those of *Allopeas micra*.

#### Family Spiraxidae

Genus *Micromena* H. B. Baker, 1939

#### *Micromena problematica* (Pilsbry, 1907)

= *Bulimus minimus* C. B. Adams, 1849c, non *B. minimus*  
Bruguère, 1789

*Description:* Four or five minute shells resembling the apical whorls of a very small *Geomelania* have been found in sievings among leaf litter in the immediate vicinity of the cave. They differ from *Geomelania* in having a rounded rather than a flat-topped apex, approximately half the diameter of that in *G. parvula*, and on which delicate vertical ribbing starts in the first whorl. The whorls are proportionately taller and less tumid, and the vertical ribs are proportionately stronger, but the spiral striae are not as well developed. The largest shell has six whorls and is 2.25 mm long. The shells agree very well with the illustration of the type of *Bulimus minimus* C. B. Adams, 1849c (Jacobson and Boss, 1973, pl. 89, fig. 16), which has about 6 whorls at 2.2 mm long and is now regarded as a species of *Micromena*.

*Occurrence:* Very rare in leaf litter around the cave, but unknown as fossils.

Genus *Spiraxis* C. B. Adams, 1850b

Genus *Repressaxis* H. B. Baker, 1939

#### *Spiraxis (Repressaxis) terebella* (C. B. Adams, 1849c)

(Pl. 30, figs. 2, 3)

*Description:* Shell minute, none complete, but not more than 7.0 by 1.6 mm, high-spined, with an estimated seven, distinctly striate whorls, which are initially tumid, but become flattened on the body whorl. Protoconch smooth, shiny, distinctly pointed, passing imperceptibly into the teleoconch, which is distinctly longitudinally striate. Striae continue throughout growth and are accompanied by occasional varices. In earlier growth stages the aperture is rounded, and the columella distinctly thickened and quite strongly

twisted, but the mature aperture is rather quadrate, with a less strongly thickened and less twisted, but not truncated, columella and a flattened outer lip. Since none is complete, it is not possible to measure the angle of the aperture plane.

*Occurrence:* Rather rare in the cave deposits and one or two fresh shells, which could well be Recent, recovered from the first sample.

*Remarks:* Both spiraxids and oleacines are carnivorous snails, but little else is known about the life habits of Jamaican species.

#### Family Oleacinidae

Genus *Costavarix* H. B. Baker, 1935c

#### *Costavarix costulatus* (C. B. Adams, 1845)

(Pl. 30, figs. 1, 5; Pl. 31, fig. 2)

*Description:* Shell small (up to at least 7 mm high by 2 mm diameter), high-spined, imperforate, ornamented with sharp, prominent vertical costae, about 22 per whorl, with a narrow aperture, weak anterior sinus and truncated columella. Protoconch tall and thin, with sharply pointed apex of two and a half whorls, initially smooth for half a whorl, then with distinct striations developing into ribbing. Early teleoconch with characteristic ornament of vertical costae usually with four or five extremely fine vertical striations between, but up to 16 may occur in later growth. Both costae and striations are less marked below, and distinctly angled at the periphery of the body whorl. The major costae tend to be reflected backwards so that they are convex towards the aperture, concave behind and apparently represent the varices on this species. Suture distinctly impressed, not descending towards the aperture. Whorls rather shouldered and flattened laterally, giving the spire a stepped profile. Body whorl 50–55% of total height. Aperture narrow, elongate diamond shaped, with straight reflected outer lip and weak anterior sinus, distinctly twisted and truncated columella, parietal callus thin and narrow. In profile, outer lip is sharply bent at level of the suture to form an anterior sinus; the aperture plane is almost tangential to the penultimate whorl and lies at about 15° to the axis.

*Occurrence:* Rare in the cave deposits, distinctly less common than the next species. So far not found alive in the vicinity of the cave. Rosenberg (written communication, September, 2005) has recorded this species elsewhere in the Red Hills.

*Remarks:* Herein we distinguish ten oleacine species. Two of them, *Costavarix costulatus* and *C. gossei*, have strongly ribbed shells which do not exceed 8 mm high in the fossil fauna, but are usually incomplete and may have grown larger. Two others, *Euvaricella venusta* and *Varicella (Varicellaria) griffithii*, are large (up to 26 or 28 mm high) and have strongly modified apertures. *Euvaricella nemorensis* has a high-spined, strongly striate shell (reaching 20 by 5.5 mm), with an abruptly truncated columella and obvious brown bands behind each growth varix, usually preserved in fossils.

There are five smaller species (Fig. 9), which are of very similar

overall shape, differing principally in size, nature of the columella and details of striation. *Euvaricella* sp. a (Figs. 9i, j) reaches 7 by 2.25 mm and differs from all the others in having a truncated columella. The remaining four are all species of *Sigmataxis*. *Sigmataxis procerus* (Figs. 9a, b) is the largest, reaches 16.5 by 4 mm and has widely and irregularly spaced incised striae. *Sigmataxis* sp. a (Figs. 9c, d) reaches 8.5 by 2.4 mm, with similar striae to, but a more pointed apex than, *S. procerus*. *Sigmataxis* cf. *S. pauperculus* (Figs. 9e, f) reaches 6 by 1.75 mm and has more closely spaced striae than the other four species. Finally, the Recent species, *Sigmataxis* sp. b (Figs. 9g, h), is the smallest, reaches only 5 by 1.3 mm, and has regularly and widely spaced striae. None of these last five species appears to have had brown colour bands behind growth varices as is common in other oleacine genera.

***Costavarix gossei* (Pfeiffer, 1846c)**

?= *Achatina gracilior* C. B. Adams, 1850a

(Pl. 29, fig. 1; Pl. 31, fig. 1)

**Description:** Shell like a more delicate and less obviously ornamented version of the preceding species. About the same size (up to 8 mm high) with more sparse costae and more obvious striae between them. About 16 costae per whorl, reaching to just below the periphery on the body whorl, but continuous between sutures on the spire. Much less obvious than those of the preceding species and more like simple ribs, not reflected nor concave behind and with as many as 20 finer riblets in between. Protoconch silky, less strongly striate. Body whorl about 55% of total height. Suture deep, whorls narrowly shouldered, gently convex. Aperture more oval, with sharp, straight outer lip, curved basal lip, straight, truncate columella and narrower than in *C. costulatus*. In profile, outer lip more strongly sinuous than in *C. costulatus*, the aperture plane is almost tangential to the penultimate whorl and at about 20° to the axis.

**Occurrence:** More common than the *C. costulata*, but rarer than most other oleacine species in the cave deposits. Both species occur in most samples without intermediates. Unknown living in the vicinity of the cave or elsewhere in the Red Hills. There is no example of *C. gracilior* in the Chitty-Adams collection in the BMNH, so we have been unable to compare specimens. However, the shells agree well with Adams' description (Adams, 1850a, p. 104).

**Remarks:** Rosenberg and Muratov (2004) regarded '*Achatina gracilior* C. B. Adams, 1850a' as a possible junior synonym of '*Achatina gossei* Pfeiffer, 1846c'.

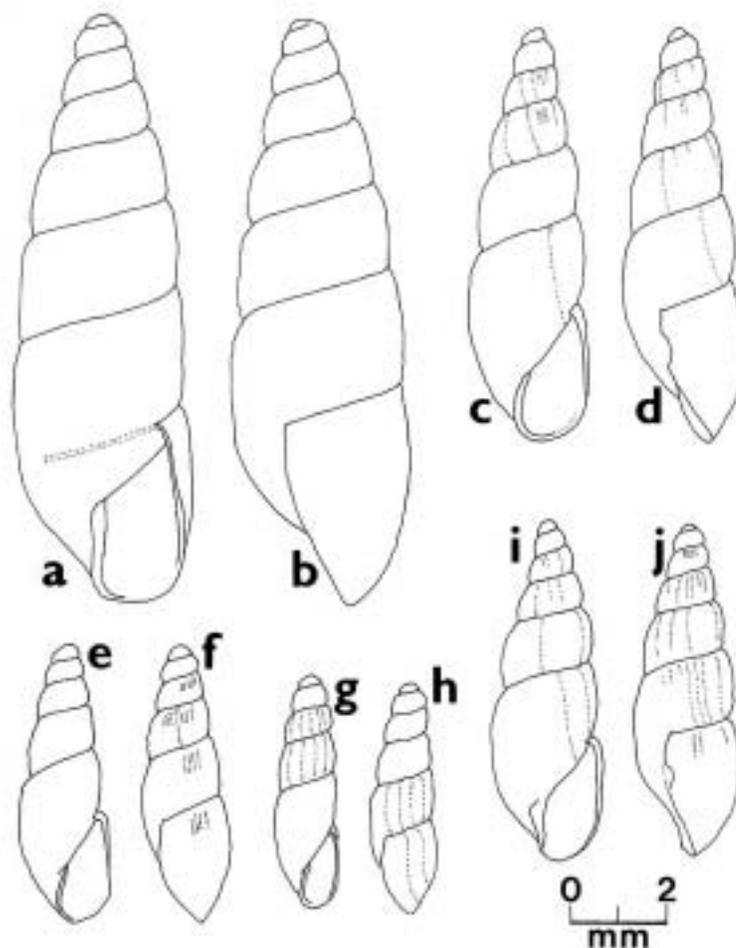


Fig. 9. Camera lucida drawings of species of *Sigmataxis* and *Euvaricella*. (a, b) *Sigmataxis procerus* (C. B. Adams) (RGM 456 311), (a) Apertural view, (b) Lateral view. (c, d) *Sigmataxis* sp. a (RGM 456 312), (c) Apertural view, (d) Lateral view. (e, f) *Sigmataxis* cf. *S. pauperculus* (C. B. Adams, 1849) (RGM 456 313), (e) Apertural view, (f) Lateral view. (g, h) *Sigmataxis* sp. b (RGM 456 314), (g) Apertural view, (h) Lateral view. (i, j) *Euvaricella* sp. a (RGM 456 315), (i) Apertural view, (j) Lateral view. Scale bar = 2 mm. Fossil, RHRC.

Genus *Euvaricella* H. B. Baker, 1935c

***Euvaricella nemorensis* (C. B. Adams, 1849c)**

(Pl. 4, figs. 11–13)

**Description:** Shell moderately large (up to 20 mm high by 5.5 mm diameter) and high-spined, with up to six obviously striate, smooth, shiny whorls, with varices accompanied by brown colour bands, with the obviously truncated columella typical of *Varicella*. Protoconch of two to two and a quarter smooth whorls, separated from teleoconch by the incised line of the first varix. Teleoconch with impressed striae separating broad ribs, weaker below the periphery on the body whorl, with gently convex whorls. Suture moderately impressed, not descending towards the aperture, emphasized by the sharp curvature at the top of each whorl. Whorls gently convex. Aperture pyriform in cross-section, with very narrow upper margin, outer and basal lips sharp, not thickened at all. Outer lip planar above, then gently curved round very

weak anterior sinus. Columella straight, truncate below; parietal callus thin and narrow. In profile, outer lip gently curved, without a trace of an inflection, aperture plane not quite tangential to the penultimate whorl, at 8–9° to the axis. Complete shells of up to six and a quarter whorls with about 15–19 varices accompanied by brown lines.

*Occurrence:* Fairly uncommon in the cave deposits. So far not found living in the vicinity of the cave.

***Euvaricella* sp. a**

(Figs. 9i, j)

*Description:* Shell small (up to 7.0 by 2.25 mm), with up to six and a half whorls, and an elongate aperture with a truncated columella. Protoconch pointed, shiny, of two whorls, the first smooth and the second striate, separated from the teleoconch by the first varix. Axis of the protoconch sometimes at a slight angle to that of the teleoconch, giving the shell a bent appearance. Teleoconch striate and shiny, and with periodic varices which are scarcely more strongly developed than the striations, making the number difficult to determine. Sutures distinctly impressed, not descending towards the aperture, which is elongate, has a sharp outer lip and a truncated columella. In profile the outer lip is regularly curved and lies at about 15° to the axis of coiling.

*Occurrence:* A very rare shell in the cave deposits. Unknown living in the area.

***Euvaricella venusta* (Pfeiffer, 1841)**

(Pl. 4, figs. 8–10)

*Description:* Shell moderately large (reaching about 28.0 by 10.5 mm diameter), high-spined, imperforate, varicated, with seven moderately tumid, ribbed whorls, a narrow aperture with a toothed outer lip and a straight, truncated columella. Protoconch large, smooth and shiny, two and a half to two and three quarter whorls, with weak striations starting at about two whorls, separated from the teleoconch by the first weak varix. Teleoconch with narrow impressed striations defining broad, shiny, smooth ribs. Up to 19 varices, the first few not accompanied by brown stripes, but colour bands occur behind later varices. Sutures not incised and not descending towards the aperture. Whorls slightly shouldered, gently convex laterally. Body whorl about 63 % of total height. Aperture relatively broad, with only the slightest concavity to outer lip in mature adults, not widening below. Outer lip sharp, not reflected or thickened, in profile gently curving down from the suture with only the slightest angularity to produce a weak anterior sulcus. At the angle a small denticle is sometimes developed on the outer lip (Pl. 4, fig. 9). Plane of the aperture at about 18° to the axis. Columella only slightly sinuous, straight in profile, and distinctly truncate below.

*Occurrence:* Common in the cave deposits. One Recent shell found in the vicinity of the cave.

Genus *Sigmataxis* Pilsbry, 1907

***Sigmataxis* cf. *S. pauperculus* (C. B. Adams, 1849c)**

(Pl. 30, figs. 4; Figs. 9e, f)

*Description:* Shell similar to that of *Euvaricella* sp. a, but smaller (6.0 by 1.75 mm) and with a twisted, not a truncated columella, with just over five shiny, striate whorls, the last about 65 % of the total height. Protoconch smooth, shiny, of just under two whorls, striate towards the end, separated from the teleoconch by the weak lip of the first varix. Teleoconch shiny, with widely spaced, irregular striations, weaker on the base of the body whorl. Sutures weakly impressed, whorls very slightly shouldered in narrow band by suture, which does not descend towards the aperture. Whorls gently convex. Aperture elongate pyriform, with thin, slightly flattened outer lip, curved basal lip that runs uninterruptedly into base of gently twisted columella, with thin and narrow parietal callus. In profile, the outer lip is regularly curved, aperture plane at about 18–19° to the axis, almost tangential to the penultimate whorl.

*Occurrence:* Not uncommon in the cave deposits. Unknown living in the vicinity of the cave.

***Sigmataxis procerus* (C. B. Adams, 1845)**

(Pl. 4, figs. 1–3; Pl. 27, figs. 2, 6; Figs. 9a, b)

*Description:* Shell moderately large (up to 16.5 by 4.0 mm) and high-spined, becoming cylindrical in the lower portion, with up to eight colourless, smooth, shiny whorls. The protoconch is shiny, of two whorls, separated from the teleoconch by the first varix. The teleoconch is also shiny, with very widely separated and irregularly spaced, impressed lines, difficult to distinguish from the weak varices which totally lack colour bands. Striae weaker below the periphery on the body whorl, which is about one third the total height. Whorls slightly tumid, more so in the early shell and lacking any trace of colour. Sutures weakly impressed, not descending towards the aperture. Aperture elongate-pyriform, outer lip sharp, not thickened. Columella thickened, slightly twisted internally, but appearing straight in the aperture, not truncated below, but running smoothly into the basal lip. Parietal callus very thin and narrow. In profile, outer lip gently curved to form a very weak anterior sinus. Plane of the aperture not quite tangential to the preceding whorl, at about 14° to axis.

*Occurrence:* Common in the cave deposits. Very fresh shells of this species have been found in the vicinity of the cave, but we have yet to confirm that it still lives there. Recent shells are transparent, colourless to milky white, and without any trace of darker bands, but with a thin and very distinct parietal callus. They reach 15.00 by 3.25 mm.

***Sigmataxis* sp. a**

(Pl. 29, fig. 2, 5; Pl. 30, fig. 6; Figs. 9c, d)

*Description:* Shell small (up to 8.5 by 2.4 mm) and high-spined, slender, with up to six colourless, smooth, shiny whorls. The proto-

conch is shiny, of two whorls, separated from the teleoconch by the first varix. Other details of the shell identical to that of *S. procerus*, differing only in the smaller size. In profile, the outer lip is gently curved to form a very weak anterior sinus. Plane of the aperture not quite tangential to the preceding whorl, at about 14° to axis.

*Occurrence:* Very rare in the cave deposits, two adult and one juvenile shell found in the first sample. Unknown living in the vicinity of the cave.

### ***Sigmataxis* sp. b**

(Figs. 9g, h)

*Description:* Shell minute, the smallest of the *Sigmataxis* species from Red Hills Road Cave, 5.0 by 1.3 mm, high-spired, with about five shiny, striate whorls and an elongate aperture. Protoconch of about one and a half whorls, separated from the teleoconch by the first varix. Teleoconch smooth, but with distinct striae and occasional varices. Whorls scarcely tumid. Sutures weakly impressed, not descending towards the aperture, which is elongate quadrate with a distinctly flattened outer lip, typically twisted *Sigmataxis* columella and very weak parietal callus. In profile the outer lip is symmetrically curved with the lower part tangential to the preceding whorl and the aperture plane at about 20° to the axis of coiling.

*Occurrence:* Unknown in the cave deposits, but rare Recent shells found in leaf litter from around the cave.

Genus *Varicella* Pfeiffer, 1856

Subgenus *Varicellaria* Pilsbry, 1907

### ***Varicella* (*Varicellaria*) *griffithii* (C. B. Adams, 1845)**

(Pl. 4, figs. 4–7)

*Description:* Shell very like that of *E. venusta*, but smaller (up to 26 mm high by 9 mm diameter) and proportionately more slender, with a smaller apex, more whorls that are more obviously ribbed, and a very obvious anterior sulcus to the aperture. The shell is high-spired, imperforate, varicated, with seven and a half moderately tumid, ribbed whorls and a narrow aperture with a toothless, distinctly sinuous outer lip, truncated columella and prominent anterior sulcus. The protoconch is initially smooth and shiny, with distinct radial ribs commencing at about three quarters of a whorl and increasing in strength rapidly; strongest on the second whorl, thereafter becoming finer again. The first varix occurs at just over three whorls with a vertical brown stripe just behind it. On one example the axis of coiling changes orientation slightly after the first varix, so we assume that the protoconch is about 3.2 whorls. Fourteen to twenty varices with associated brown stripes occur up to and including the final aperture, occasionally with a double colour band on earlier whorls. Ribbing on the juvenile and adult shell is distinct and regular, and often changes orientation slightly at varices. Body whorl occupies half the total height of the shell and varices become more strongly sinuous on it. The suture is distinctly impressed despite the relatively smooth profile of the spire,

not descending towards the aperture. Whorls gently tumid, but with narrow, flat-topped ledge at the top that slopes in towards sutures and which is very sharply angled, so the suture is accompanied by a narrow channel at the top of each whorl. Cross-section of whorls oval, but with slight concavity towards final aperture. The aperture is crudely S-shaped in outline, narrower above, swelling out below into a distinct basal (anterior) sinus and with a distinct concavity in the middle of the outer lip. The outer lip is thin and relatively sharp above the concavity, distinctly thickened and more reflected below, but most strongly thickened at the inflection marked by the concavity. The columella is twisted, sharply truncated and defines a narrow anterior canal that is turned sharply left at the base. The parietal callus is very thin and narrow. In profile the outer lip slopes forward down to the inflection, then sharply back into the anterior sinus. The profile of the columella is decidedly concave. Altogether the aperture is highly modified and appears distorted. The concept of an aperture plane is inappropriate, but the aperture is approximately tangential to the penultimate whorl.

*Occurrence:* Not uncommon in the cave deposits, but much less so than the succeeding species. Fresh shells found in the vicinity of the cave, but not so far confirmed living in the area.

Family Bulimulidae

Genus *Drymaeus* Albers, 1850

Subgenus *Mesembrinus* Albers, 1850

### ***Drymaeus* (*Mesembrinus*) *immaculatus* (Reeve, 1850)**

*Description:* Shell moderately large (up to 30 mm high), high-spired, bulimoid, with a narrow umbilicus, six and a half convex whorls and an oval aperture. Protoconch with characteristic pitted ornament, in a decussate pattern, of one and a half whorls. Teleoconch shiny, lacks pits, but has weak growth striae and impressed spiral lines. Sutures scarcely impressed, not descending towards the aperture. Whorls only gently convex. Aperture oval, with thin, unmodified lips, but columellar margin slightly reflected over the umbilicus which is narrow and does not penetrate the body whorl. Aperture plane at 15° to the axis of coiling.

*Occurrence:* A few shells, some fairly fresh, among the Recent fauna from around the cave, but it is uncertain that *D. immaculatus* still lives in the area. Unknown in the cave deposits.

Family Urocoptidae

Genus *Anoma* Albers, 1850

### ***Anoma* *fuscolabris* (Chitty, 1853)**

(Pl. 3, figs. 12–14; Pl. 27, fig. 4)

*Description:* Very shiny, white shell of moderate size (up to 20 mm high), high-spired and distinctly fusiform in outline, decollate with six and a half to seven and three quarter whorls remaining in adults, with oval, adpressed aperture with somewhat sinuous, reflected and thickened outer lip, and aperture plane exactly tangential to the penultimate whorl. Protoconch shiny and smooth,

cylindrical, of three moderately tumid whorls, sometimes set at a slight angle to the juvenile whorls, from which it is separated by a fine impressed line at 25° to the axis. The teleoconch is also shiny, initially with tumid whorls, but these become flatter with less impressed sutures and ornamented with very weak growth lines as growth proceeds. Adult shell distinctly fusiform in outline, widest at second or third whorl back from the aperture, smooth and shiny with weak growth lines, nine to ten whorls lost on decollation. Definite ribs start on the body whorl and increase in strength up to the aperture so that the last half whorl is distinctly ribbed. The body whorl is about 37.5 % the total height after decollation, narrows below and has a weak rounded basal keel running to the base of the aperture. The aperture is adnate, ovate with the long axis slightly oblique to the axis of coiling. Outer lip reflected and thickened, distinctly sinuous and sometimes weakly angular at the base, corresponding to the basal keel of the body whorl. On the umbilical side it is slightly twisted, while inside the aperture the columella appears to be truncated due to a distinct thickening clearly visible only when the aperture is damaged. The parietal callus is moderately thick and, together with the other margins, forms an aperture plane that is exactly tangential to the penultimate whorl and at about 23–24° to the axis.

*Occurrence:* A common shell in the cave deposits. A single very old, dead shell has been found the vicinity of the cave with no trace of cave deposits attached. Otherwise unknown living near the cave or elsewhere in the Red Hills area. *Anoma* lives up trees, suggesting the area was well wooded when the cave deposits were forming.

Genus *Apoma* Beck, 1837

***Apoma chemnitzianum* (Férussac, 1821)**

= *Apoma elongata* Beck, 1837 (ex Chemnitz, 1786 non binomial)

*Description:* Shell white, moderately large (up to 28.0 mm high by 4.75 mm wide), high-spined, imperforate, sinistral, decollate with up to nine finely ribbed whorls remaining, and an oval aperture, with margins strongly reflected all round and just free of the body whorl. Protoconch conical, of up to six very finely striated whorls, the first smooth, very narrow and high, coiled about an 'apical umbilicus'. Protoconch separated from the teleoconch by a growth line at 37° to the axis. Teleoconch with fine, colabral ribbing strengthening with growth, about seven whorls lost on decollation. Adult shell elongate and slightly fusiform, widest at second and third whorls back from the aperture. Body whorl about 20–25 % the total height after decollation, with a very distinct, rounded, basal keel continuing the line of the suture. Shell with delicate, sinuous, colabral ribbing throughout. Suture moderately impressed throughout, more strongly on the last three whorls. Whorls moderately tumid on protoconch, less so on juvenile and early adult shell, becoming quite tumid again on the last three whorls. Cross-section oval with long axis vertical. Aperture oval, entire, free of body whorl, with broadly reflected lip, widest laterally on both sides,

internally rounded above, but angular below, where the basal keel meets the lip. Planar in profile, plane parallel to axis and just free so that the aperture touches the surface when the spire rests on the substrate. Uniformly white in colour even when fresh.

*Occurrence:* Unknown from the cave deposits. Shells not uncommon in the vicinity of the cave and common throughout the Red Hills and eastern-central Jamaica. *Apoma* lives on exposed limestone surfaces, so its absence from the cave deposits is unexpected.

Genus *Geoscala* Pilsbry and Vanatta, 1898

***Geoscala costulata* (C. B. Adams, 1849c)**

(Pl. 22, figs. 2–4)

*Description:* Shell small (up to 8 mm), high-spined, decollate with seven to eight costate whorls remaining, uncoiled just before the aperture. Protoconch elongate, initially high-sided and coiled round an 'apical umbilicus', weakly striate and of about three whorls. Teleoconch initially with irregular growth lines, but characteristic costulations soon start and are present throughout the lower five or more whorls. About seven whorls lost on decollation. Costae relatively sparse, eleven per whorl, usually continuous from suture to suture although often better developed above, becoming more common, and tending to develop into a double row of costae above and below the periphery on the uncoiled portion of the shell. Sutures quite strongly impressed on protoconch and early teleoconch, becoming only moderately impressed on the adult shell. Correspondingly, the whorls are initially quite tumid, but become more planar in the adult, an impression reinforced by the profile of the costulations. Cross-section quadrate in adult shell. The last half whorl has a sulcus below the periphery which defines the upper limit of a distinct, rounded basal keel and becomes most obvious on the uncoiled portion of the shell, which is about a quarter whorl. The aperture is roughly semi-circular, but in contrast to most snails, the straight margin runs from the top of the outer lip down to the basal keel, while the basal, columellar and parietal margins form a fairly regular curve. The straight portion is sometimes weakly concave and corresponds to the sulcus on the uncoiled portion of the shell. The lip is entire, reflected, but scarcely thickened, planar in profile, the plane lying at about 17–18° to the axis.

*Occurrence:* Rather uncommon in the cave deposits and seemingly rather local in its occurrence. Some samples yield several complete adults and occasional juveniles, others none at all. Unknown living in the vicinity of the cave or anywhere in the Red Hills. The nearest locality recorded by Paul (1982) is over 30 km northwest. *Geoscala costulata* is characteristic of the higher, wetter parts of central and western Jamaica.

***Geoscala seminuda* (C. B. Adams, 1845)**

*Description:* Shell very similar to *G. costulata*. Protoconch and decollate teleoconch of similar size and shape, although the largest adult shell seen from Red Hills Road Cave is only 7 mm high and

the adults have about one whorl less. In contrast, about eleven whorls are lost on decollation. The principal differences are that the sutures are very deeply incised in the adult shell and the costulations are more common, 22 per whorl. Costulations tend to be a double series at the top and base of the whorls. Typically, the lower series is obsolete on the lower whorls before the shell uncoils, hence the trivial name. The base of the last whorl tends to be strongly undercut, giving it a triangular, rather than quadrate, cross-section. The sulcus and basal keel do not develop before the uncoiled portion of the shell and the aperture is more diamond-shaped than semi-circular. The margin is entire, flared and planar, the aperture plane lying at about 25° to the axis.

*Occurrence:* Unknown in the cave deposit, but living in the immediate vicinity of the cave. Common along the dry south coastal strip of Jamaica. Apparently spreading inland as habitats dry out with forest clearance to judge by comparison of the known modern distribution with the maps of Jarvis (*in* Pilsbry, 1903). *Geoscala* is a ground-dwelling urocoptid, often living directly on rock surfaces.

Genus *Spirostemma* Pilsbry and Vanatta, 1898

***Spirostemma* cf. *S. dunkeri* (Pfeiffer in Philippi, 1845)**

(Pl. 28, figs. 1, 3)

*Description:* Fragments of a large species of *Spirostemma*, which reach at least 13 mm long and nearly 3 mm in diameter, occur in the early samples collected from Red Hills Road Cave. They not only differ in size, but have more obvious ribs, an aperture which appears to have been attached to the penultimate whorl and no false umbilicus. *Spirostemma dunkeri*, the type species of *Spirostemma*, reaches 3.5 mm in diameter and 16–23 mm long. The fragmentary remains available are enough to confirm the presence of two species of *Spirostemma*, but not enough to be certain of the identity of this species.

*Occurrence:* Rare fragments known from the cave deposits; unknown living in the vicinity of the cave.

***Spirostemma tenellum* (C. B. Adams, 1849c)**

(Pl. 27, fig. 3; Pl. 28, figs. 2, 4–6)

*Description:* Shell small (up to 10.0 mm high by 1.7 mm in diameter), cylindrical, decollate, with ten to ten and a half, finely ribbed, planar whorls remaining in the adult shell, with a distinct basal keel and a rounded, diamond-shaped aperture, with an entire margin which is free of the penultimate whorl. Protoconch very much like that of *Anoma*, initially smooth, then finely ribbed and of just over three whorls, separated from the teleoconch by a distinct, impressed line at 35° to the axis. Early teleoconch with fine, colabral ribs, which strengthen with growth. Unknown number of whorls lost on decollation, but at least five. Adult shell elongate, very slightly fusiform, widest at second or third whorl back from the aperture. Body whorl just over a quarter the total height after

decollation, with distinct basal keel continuing the line of the suture. Shell with delicate, colabral ribs throughout. Suture weakly impressed, more so on protoconch and early teleoconch, not descending towards the aperture. Whorls almost planar, with square cross-section. Aperture rounded diamond-shaped, with a basal angle corresponding to the basal keel on the body whorl. Aperture margin entire and slightly produced from the penultimate whorl, with thickened, but scarcely reflected, lip. Aperture plane at 45° to the axis. Some shells still retaining their transparent, pale brown colour. The axis of coiling itself becomes a spiral in the last two whorls and gives rise to a so-called ‘false umbilicus’ when viewed through the aperture.

*Occurrence:* Rare shells occur in the cave deposits and most come from the first sample collected by Anita Warrington (University of Liverpool) in 1988, suggesting they are more common in the upper part of the section, now quarried away. Unknown living in the area.

Genus *Urocoptis* Beck, 1837

Subgenus *Spirocoptis* Pilsbry, 1902

***Urocoptis (Spirocoptis) sanguinea* (Pfeiffer in Philippi, 1845)**

= *Urocoptis rosea* (C. B. Adams, 1846),

*Urocoptis carnea* (C. B. Adams, 1849c)

*Description:* Shell moderately large (up to 28 mm high by 10 mm wide), high-spired, cylindrical, imperforate, decollate with eight to nine and a half ribbed whorls remaining, with rounded adnate aperture with reflected margins. Protoconch distinctly ribbed, cylindrical, of three to three and a half tumid whorls, the second slightly swollen, with distinctly pointed, smooth apex of a quarter whorl. After the first smooth part ribs start, initially exactly radial, coarsest on the second whorl, but becoming colabral in orientation and much finer on the last whorl. Protoconch separated from the teleoconch by a distinct lip at 40–50° to the axis. Teleoconch with colabral rounded ribs strengthening with growth. Whorls initially tumid, becoming more planar towards the adult portion of the shell, 12–13 whorls lost on decollation. Adult shell tapers slightly at the top and is more or less cylindrical in outline for the last six whorls, although some shells are fusiform and widest two to three whorls back from the aperture. Body whorl about a fifth of the total height of decollate shell, with very faint trace of a basal keel continuing the line of the suture, but no more than a slight thickening and inflection of the ribbing. Suture moderately impressed on protoconch and early teleoconch, scarcely impressed at all on the adult shell, not descending towards the aperture. Whorls initially quite tumid, almost planar on adult shell, with rectangular cross-section wider than high. Ornamented with distinct, slightly sinuous, oblique ribs that strengthen throughout growth and are most prominent on the body whorl. Always separated by grooves that are as wide as, or wider than, the ribs. Shells also have common damage and interruptions to growth. Aperture

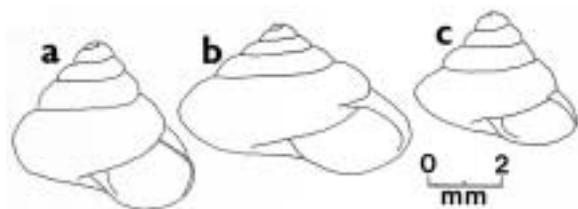


Fig. 10. Camera lucida drawings of apertural views of species of *Aerotrochus*. (a) *Aerotrochus mc nabianus* (Chitty) (RGM 456 316). (b) *Aerotrochus* sp. a (RGM 456 317). (c) *Aerotrochus* sp. b (RGM 456 318). Scale bar = 2 mm. (a, b) Fossil, (c) Recent, RHRC.

adnate, entire, rounded, with broadly reflected lip all round, but slightly thinner parietal callus. In profile planar, exactly tangential to the penultimate whorl and at 15–23° to the axis, higher values in more tumid shells. Shell coloured purple or pinkish purple when fresh with a distinct pruinescence. Internally the columella is twisted throughout the adult shell and has a central thickened rib in the lower three to four whorls when shell is fully mature. Pilsbry (1902) attributed such shells to the subgenus *Spirocoptis*.

**Occurrence:** Unknown in the cave deposits, but shells common on the ground in the vicinity of the cave. Far too large and conspicuous to be overlooked in the cave deposits. It is amazing that a limestone area apparently lacked a species of *Urocoptis* in the Pleistocene. Currently common in the Red Hills area to which it is endemic.

#### Family Sagdidae

#### Genus *Aerotrochus* Pilsbry, 1926

#### *Aerotrochus mc nabiana* (Chitty, 1853)

(Pl. 36, figs. 1, 2; Pl. 37, fig. 3; Fig. 10a)

**Description:** Shell small, conical (5 by 5 mm), with four and three quarter rounded whorls, a narrow umbilicus and a simple, unmodified aperture. Protoconch initially smooth and shiny; grades imperceptibly into the teleoconch with the appearance of irregular growth lines. Suture deep, not descending towards the aperture. Whorls well rounded with only the faintest tendency to peripheral angularity on the last whorl. Aperture not quite circular in outline due to peripheral angle, simple, columellar lip weakly reflected, otherwise unmodified. In profile the outer lip is planar and almost tangential to the penultimate whorl. The aperture plane lies at about 30° to the axis. Umbilicus very narrow and deep, about a tenth the diameter.

**Occurrence:** A very rare shell in the cave deposits, eleven examples known. Even rarer dead shells found within a few hundred metres of the cave.

**Remarks:** We believe that four fossil and Recent species of *Aerotrochus* occur at Red Hills Road Cave. Of these, *A. perdepressa* is almost discoidal, whereas the others are distinctly conical (Fig. 10). Two of the other three species have whorls with suban-

gular peripheries (Figs. 10b, c) and the third has distinctly rounded whorls (Fig. 10a). Recent shells of the more steeply conical species with subangular whorls, which is almost as high as wide (Fig. 10c), agree very closely with specimens identified as *A. turbiniformis* (Pfeiffer) by C. B. Adams and now in the Chitty-Adams collection at The Natural History Museum (BMNH Reg. Nos 54.3.18.315–319). This lot consists of four shells of the high-spined form, and a fifth shell with a low spire and rounded whorls that is clearly not even a species of *Aerotrochus*. To make matters more confused, lot 54.3.18.332–339 (also identified by C. B. Adams as *A. turbiniformis*), consists of a mixture of nine low- and high-spined shells. *Aerotrochus turbiniformis* was originally described from Cuba. Although the two islands are quite close to each other, very few if any species have been confirmed to occur on both islands. Thus, it seems doubtful that Adams was correct in identifying either Jamaican species as *A. turbiniformis*. However, if Adams was correct, the dimensions given in the original description suggest that *A. turbiniformis* is synonymous with the low-spined Jamaican species. The high-spined species with subangular whorls is identified as *A. mc nabiana* (Chitty) by Rosenberg and Drumm (2004) and the low-spined form as *A. subpyramidalis* (C. B. Adams). Unfortunately, the holotype of *A. mc nabiana* (BMNH) has rounded whorls and agrees better with the species with rounded whorls from Red Hills Road Cave. Furthermore, the lectotype of *A. subpyramidalis* selected by Jacobson and Boss (1973, pl. 78, figs. 9, 10) has a damaged spire so it is difficult to tell the true height, but it has rounded whorls, and an aperture with a reflected outer lip, which appears to have an internal rib with a possible basal tooth. None of the apertural characters is typical of any other species of *Aerotrochus* and certainly this shell does not represent either of the two Jamaican species with subangular peripheries. Here we identify the fossil and Recent shells with rounded whorls as *A. mc nabiana* (Fig. 10a), the lower-spined Recent and fossil shells with subangular whorls as *Aerotrochus* sp. a (Fig. 10b), and the high-spined Recent shells as *Aerotrochus* sp. b (Fig. 10c).

#### *Aerotrochus perdepressa* (C. B. Adams, 1849c)

= *Helix depressa* C. B. Adams, 1845, non *Helix*

*depressa* Férussac, 1821

(Pl. 37, figs. 1, 4)

**Description:** Shell fairly small (up to 10 mm diameter), discoidal with a flat spire, with three and three quarters to four whorls, a narrow umbilicus and an unmodified aperture. The protoconch is initially smooth, of one and a half whorls, separated from the teleoconch by a weak groove. Whole shell, from protoconch to adult, roughened with irregular growth lines. Underside of body whorl equally strongly striate and locally malleated. Striae periodically stronger giving the whole shell a rough surface. Spire almost planar, with impressed suture that does not descend towards the aperture. Whorls scarcely convex dorsally, but tops of succeeding whorls aligned to form planar spire. Cross-section of whorls very gently convex above, distinctly angular at the high periphery,

slightly flattened below and almost angular at the basal-columellar junction. The columellar margin is strongly reflected, but otherwise the aperture is unmodified. In profile the outer lip is planar, almost tangential to the penultimate whorl, and the aperture plane lies at 44° to the axis. Umbilicus narrow and broad, about a quarter the diameter.

*Occurrence:* A very rare shell in the cave deposits, with only about six seen. Fresh Recent shells not uncommon in leaf litter from the vicinity of the cave.

*Remarks:* The fossil shells agree well with *A. perdepressa brevior* (C. B. Adams, 1851b), which Rosenberg and Muratov (2004) regarded as a subspecies of *A. perdepressa*.

#### ***Aeretrochus* sp. a**

(Pl. 37, fig. 2; Pl. 38, fig. 4; Fig. 10b)

*Description:* Shell very similar to that of *A. mc nabiana*, but slightly larger (Recent shells up to 7 mm diameter by 5 mm high, fossils up to 5.5 mm diameter), with up to five whorls forming a lower spire, with more depressed cross-section and distinctly angular periphery. The protoconch is initially smooth, of about one and a half whorls, often passing imperceptibly into the teleoconch as irregular growth lines strengthen. The teleoconch is shiny when fresh, but the surface is roughened by irregular growth lines. Suture moderately impressed, not descending towards the aperture, positioned a little below the periphery of the whorls, giving the lower whorls an undercut profile. Whorls gently convex above and below, with a distinctly angular periphery, so forming an oval cross-section with the long axis horizontal. The aperture is oval, unmodified, with a sharp lip very slightly reflected adjacent to the umbilicus. The parietal callus is very thin. In profile the outer lip is planar, not tangential to the penultimate whorl and the aperture plane lies at about 32° to the axis, slightly higher (38°) in Recent shells. The umbilicus is narrow and deep, between a seventh and an eighth of the diameter. Dirt often adheres to the thin, yellowish periostracum.

*Occurrence:* Rare in the cave deposits, about ten examples seen, most from the first sample taken. Fresh shells found commonly within a few hundred metres of the cave.

#### ***Aeretrochus* sp. b**

(Fig. 10c)

*Description:* The shell is somewhat intermediate between those of the other two conical species, with a proportionately higher spire than *A. sp. a*, but slightly lower than that of *A. mc nabiana*. The base is more rounded than in *A. sp. a*, but distinctly flatter than in *A. mc nabiana*. The periphery is more angular and the aperture plane at a higher angle to the axis of coiling (39° and 45° in the two examples known) than in either comparable species.

*Occurrence:* Two Recent shells found within the vicinity of the cave. Unknown in the fossil fauna.

Genus *Corneosagda* Schileyko, 1998

#### ***Corneosagda ptychodes* (Pfeiffer, 1846c)**

(Pl. 38, figs. 1–3)

*Description:* Shell small (up to 5 mm diameter), discoidal, with three and a quarter rapidly expanding whorls, an unmodified aperture and moderate umbilicus. Protoconch smooth, up to one and a third whorls, separated from the teleoconch by a distinct groove. Both bear strong, irregular growth lines. Whorls with scarcely convex upper surfaces, although with moderately deep sutures, well rounded below. Aperture unmodified, flattened above, angular at the periphery and rounded below, damaged in both examples so a cannot be determined. Umbilicus about a fifth of the shell diameter, expanding regularly.

*Occurrence:* Very rare in the cave fauna, two shells seen. Unknown living in the vicinity of the cave.

Genus *Microsagda* H. B. Baker, 1935b

#### ***Microsagda angustispira* (C. B. Adams, 1849c)**

(Pl. 36, figs. 3–5)

*Description:* Shell small (up to 4 mm diameter by 3 mm high), globular with a distinctly raised spire, with four and a half rounded and deep whorls, a relatively narrow umbilicus and an unmodified aperture. The last whorl tends to be a little lower than preceding whorls, but as the spire is more raised this is much less obvious than in the preceding species. Protoconch shiny, smooth, but with irregular growth lines towards the end, and of one and a quarter whorls. Teleoconch with irregular growth lines, rather silky, with slowly expanding whorls. The suture is strongly impressed and does not descend towards the aperture. Whorls strongly convex above, almost angular, then curving regularly round to the umbilicus, with circular cross-section. Aperture totally unmodified, with sharp lips, basal slightly sinuous viewed from below, with thin parietal callus. In profile the outer lip is very slightly concave. The plane of the aperture lies at about 6° to the axis and is not at all tangential; from below it is almost perfectly radial. Umbilicus narrow, about a sixth of the diameter. As with the preceding species it starts relatively wide and then expands little.

*Occurrence:* The commonest of the small, smoothish, low-spired shells in the cave deposits. Unknown living in the vicinity of the cave.

#### ***Microsagda inconspicua* (C. B. Adams, 1849c)**

*Description:* Shell small (up to 3 mm diameter), discoidal, with four and a half irregularly striate, rounded whorls forming a rather flat spire, but the last whorl distinctly lower than the penultimate, with a narrow, deep umbilicus, each whorl enveloping the preceding below, and with a simple, unmodified aperture. The protoconch is shiny, smooth, one and a quarter whorls, coiled regularly and separated from the teleoconch by a weak groove. The teleoconch has an ornament of irregular growth lines that make the surface

distinctly rough and not shiny. Very fine, impressed spiral lineations are also present and best seen on the underside of the body whorl. The whorls enlarge very gradually, but the last is distinctly lower on the spire than preceding whorls. The suture is strongly impressed and does not descend towards the aperture. Whorls strongly convex above, but with a deep cross-section so that, although no angularity is developed, the whorls appear shouldered. The outer and basal margins are slightly flattened, and the basal continues well under the preceding whorl, so that the cross section appears lunate-subquadrate. The aperture is neither thickened nor reflected, but has a distinct parietal callus. In profile the outer lip is distinctly sinuous, and the aperture plane lies at about 32° to the axis of coiling and is not tangential to the penultimate whorl. The umbilicus is moderate, about a sixth the diameter. It reaches a maximum width early in growth and then expands very little, so it appears to be narrow and deep.

*Occurrence:* Common in the cave deposits, but unknown living in the vicinity of the cave.

Genus *Proserpinula* Albers, 1860

***Proserpinula discoidea* (C. B. Adams, 1850a)**

(Pl. 39, figs. 2, 3)

*Description:* Shell small (up to 6 mm diameter), discoidal, very shiny, with pinhole umbilicus that tends to be sealed by secondary shell deposits, with a simple, almost totally unmodified aperture. Protoconch smooth, with occasional growth lines, of one and a half whorls, separated from the teleoconch by a weakly impressed line. Teleoconch shiny, with very weak growth lines. Suture scarcely impressed, not descending towards the aperture. Whorls only slightly convex dorsally; the outline of the spire made even smoother by secondary shell deposits and with rounded suboval cross-section. Aperture lunate with a sharp lip and very slightly thickened columellar margin. Seen from below there is a slight sinus adjacent to the umbilicus which is a shallow, very narrow pinhole partly filled by a secondary shell coating which covers the entire shell. In profile the outer lip is slightly concave, not at all tangential to the penultimate whorl and the aperture plane lies at 17–18° to the axis.

*Occurrence:* A fairly common shell in the cave deposits. Unknown living in the vicinity of the cave.

***Proserpinula infortunata* (Bland, 1854)**

= *Helix opalina* C. B. Adams, 1845,

non *Helix opalina* G. B. Sowerby I, 1841

= *Helix margarita* Pfeiffer, 1845c,

non *Helix margarita* Montagu, 1808

*Description:* Virtually identical to *P. discoidea*, but a little larger (up to 6.5 mm in diameter) with a slightly angular outer lip and slightly flattened basal lip, giving the aperture a squarish outline, and with a small lamella inside the basal lip at the edge of the umbilical pad of callus. In profile the aperture is slightly sinuous

and = 25°, intermediate between the other two forms.

*Occurrence:* Unknown in the cave deposits, but fresh shells found within a few hundred metres of the cave. Rosenberg (written communication, September, 2005) has recorded *P. infortunata* from elsewhere in the Red Hills. Recent shells all appear to be this species, whereas the fossils with an umbilical pad of callus all appear to be *P. margaritella*.

***Proserpinula margaritella* Pilsbry and Brown, 1910**

(Pl. 39, figs. 1, 4)

*Description:* Shell very similar to *P. discoidea*, but without any trace of an umbilicus because the umbilical area is covered with a central disc of secondary shell deposits, which are continuous with the parietal callus. The spire is also more thickly covered with secondary shell so that sutures can be difficult to detect, but shells seem to have about three and a half whorls at 5 mm diameter and the suture does not descend towards the aperture. Although a faint spiral line is visible externally on the base in the shells, there is no trace of an internal lamella or denticle within the aperture, as in *P. infortunata*, and the sinus is not developed in the columellar lip. The profile of the aperture is as in *P. discoidea*, but the aperture plane lies at a steeper angle to the axis, about 30°.

*Occurrence:* Rare in the cave deposits; only about twenty shells definitely identified so far. Unknown living in the vicinity of the cave, but see the previous species.

Genus *Sagda* Beck, 1837

***Sagda cookiana* (Gmelin in Linné, 1791)**

(Pl. 7, figs. 1–5)

*Description:* Shell domed, imperforate, with rounded profile to the spire, a narrow apex and strongly rounded base to the whorls, so that the outline of the aperture is an almost perfect segment of circle, with up to eight and a quarter whorls at 24 by 21 mm. Protoconch shiny, initially with widely spaced, impressed growth striae which become more closely spaced with growth and not obviously distinct from the teleoconch. Growth lines increase in strength gradually to form a characteristic ornament of weak, irregular colabral ridges and grooves, but the ornament is relatively weak. A distinct, woven microsculpture lies beneath the uniformly yellow-brown periostracum. The aperture plane lies at 27° to the axis of coiling. Internally there are two spiral lamellae. The unique character of *S. cookiana* is that the basal lamella consists of three to five discrete lamellae, arcuate in profile and sinuous in plan view, which start about three quarters of a whorl (four lamellae) or fully one whorl (five lamellae) back from the aperture. No other species of *Sagda* has a discontinuous basal lamella. The columellar lamella is normal and starts a little before (four) or after (five) the oldest basal lamella. The shell is thin and the basal lamellae are often visible externally. When five are present, the last formed enters the aperture.

*Occurrence:* A common species living in the vicinity of the

cave. So far not one example has been found in the cave deposits.

*Remarks:* We recognize four species of *Sagda*, of which the Recent *S. cookiana* is unique in having a discontinuous basal lamella in four or five rounded portions. Of the remaining three species, *S. jayana* is the largest, reaching 23–28 mm diameter and has a very fine woven microsculpture between the regular radiating ribs. Both fossil and Recent examples are known (but note the differences between them, below). *Sagda spei* is smaller (18.5–20.5 mm diameter) and lacks the woven microsculpture, but has very weak, impressed spiral lines between the radial ribs. *Sagda spiculosa* Pfeiffer is the smallest, being only 16–17 mm in diameter, and has a unique surface sculpture of anastomosing radial ribs quite unlike any other species of *Sagda*. The latter two species are only known as fossils.

#### ***Sagda jayana* (C. B. Adams, 1845)**

(Pl. 6, figs. 1–5)

*Description:* Shell of moderate size (up to 28 mm diameter; 24 mm is more common), domed, imperforate, with up to eight whorls and a simple aperture within which the distal extremities of the basal and columellar lamellae are visible. Protoconch and teleoconch as in *S. cookiana*, but the striation is stronger. On lower whorls the shell becomes distinctly ribbed and traces of an exceedingly fine, woven microsculpture can be seen in the grooves on well preserved, shiny shells, but this microsculpture is less obvious on the body whorl. Suture moderately impressed, not descending towards the aperture. Whorls moderately convex, forming a regularly domed spire with straight sides and a broad top. The last whorl not enlarged, regularly rounded, but with a slightly flattened inner basal margin. The aperture is lunate in outline and virtually unmodified. The outer lip is thin, the basal margin sinuous when viewed from below and thickened towards the columella, and the parietal callus is thin. In profile the outer lip is planar, the aperture plane is at about 38–40° to the axis, yet not at all tangential to the penultimate whorl. Internally the basal lamella lies at the lowest point of the whorl and continues back for only half a whorl. It is sharply truncated posteriorly, declining gradually anteriorly and almost reaches the basal lip. It leans slightly outwards and is thickened at the top, especially near the posterior end where it curves in towards the columella at the top in some specimens. It reaches about two thirds the height of the whorl at its highest point. The columellar lamella is scarcely more than a thickening and starts at about the same position as the basal lamella. It has a horizontal upper surface, is slightly undercut below and sharply truncated by resorption posteriorly. It is just visible in the aperture as a slight swelling of the columella.

*Occurrence:* A very common shell in the cave deposits. This, or a very similar species, still lives in the vicinity of the cave. Recent shells are on average slightly larger than fossils, about 27 mm diameter (Abbott, 1989, p. 138, figured a Recent specimen 25 mm high from the John Crow Mountains, eastern Jamaica), with up to nine whorls. The plane of the aperture is slightly less steeply

inclined ( $\alpha = 33\text{--}36^\circ$ ). The basal lamella extends back three quarters of a whorl, does not lean outwards as much, and is more obviously thickened at the top and higher, reaching three quarters the height of the whorl. The columellar lamella is very obvious, concave above, strongly undercut below, rather irregular in plan view and sharply truncated by resorption posteriorly.

#### ***Sagda spei* Pilsbry and Brown, 1910**

(Pl. 5, figs. 1–5)

*Description:* Shell very similar to *S. jayana*, but smaller (up to 20.5 mm diameter), and proportionately narrower and taller (H:D reaches 1.10:1 in largest shells), with up to nine whorls. The surface has weaker colabral striations and ribs than *S. jayana*, and only very faint lineations, not woven microsculpture. The spiral angle is narrower and the apex more sharply curved, while the base is more strongly rounded than in *S. jayana*. In profile the outer lip is planar, the aperture plane is decidedly not tangential to the penultimate whorl and lies at about 35° to the axis. Basal and columellar lamellae are visible in the aperture and in the same relative positions, but the basal runs back at least three quarters of a whorl and starts well before the columellar which extends for almost exactly half a whorl. The basal lamella is quite sharply truncated posteriorly and gently declines anteriorly, leans out slightly, is thickened on top and proportionately as high as that in fossil *S. jayana*. The columellar is more obviously a lamella, horizontal above and quite strongly undercut below.

*Occurrence:* A very common shell in the cave deposits. Not found living in the vicinity of the cave so far.

#### ***Sagda spiculosa* Pfeiffer, 1859**

*Description:* Shell even smaller than *S. spei*, but of the same general shape, with up to eight and a half whorls. The protoconch is smooth and of one and a half whorls. The most characteristic feature is the irregular ribbing, which starts immediately after the protoconch and continues until the body whorl. Between the irregular ribs are suggestions of hair pits, which makes the surface very irregular. The basal lamella is just outside the greatest curvature of the whorl, leans outwards and is not thickened above. The columella lamella is concave above, undercut and extends back half a whorl. The basal lamella starts before the columellar lamella and is less steeply truncated behind than that of *S. spei*. The aperture is typical of *Sagda* with a relatively high ( $\alpha = 50^\circ$ ).

*Occurrence:* A very common shell in the cave deposits. Unknown living in the vicinity of the cave.

Genus *Stauroglypta* H. B. Baker, 1935b

#### ***Stauroglypta peraffinis* (C. B. Adams, 1845)**

*Description:* Shell like a larger, less conical version of *Microsagda angustispira* reaching 6.0 by 3.5 mm, with five regularly increasing tumid whorls, an unmodified aperture and moderate umbilicus. Protoconch smooth and shiny, of one and a third

whorls and separated from the teleoconch by a lip. Irregular growth lines begin with the teleoconch. Suture distinctly impressed, not descending towards the aperture. Whorls strongly tumid above, less so below, with rounded cross-section. Aperture round, unmodified, lips thin and very slightly reflected only adjacent to the umbilicus, basal lip sinuous viewed from below, parietal callus thin, but distinct. In profile the outer lip is sinuous and the aperture plane lies at about 15° to the axis, but is not tangential to the penultimate whorl. Umbilicus moderate, expanding regularly, about a sixth to a fifth the shell diameter.

*Occurrence:* Unknown in the cave deposit. Rare fresh shells found within a few hundred metres of the cave. Widespread throughout much of Jamaica.

Genus *Strialuna* Pilsbry, 1926

***Strialuna sincera* (C. B. Adams, 1845)**

*Description:* Shell like a strongly ribbed version of *Microsagda inconspicua*. The shell is small (up to 3 mm diameter), discoidal with a low spire, of just over four whorls, ornamented with strong radial ribs, an unmodified aperture and a moderate umbilicus. Protoconch smooth, distinctly oval in outline, of about one and an eighth whorls, separated from the teleoconch by a weak groove. Teleoconch smooth for another eighth of a whorl, then characteristic radial ribbing starts (at one and a quarter whorls) and strengthens with growth; last whorl a little lower on the spire than preceding whorls. Ribs are solid, raised, colabral ridges half the width of intervening grooves, and equally developed above and below. No trace of other ornament can be seen in the grooves. Suture is distinctly impressed and does not descend towards the aperture. Whorls tumid above, almost perfectly circular in cross-section. Aperture flatter above, rounded, unmodified, with sharp lips, parietal callus very thin. In profile the outer lip is planar, the aperture plane lies at about 10° to the axis and is not tangential to the penultimate whorl. Umbilicus moderate, expanding fairly regularly, about a fifth to a quarter of the shell diameter. Dirt often clings to the thin, yellowish periostracum.

*Occurrence:* Unknown in the cave deposits. Recent shells found within a few hundred metres of the cave. Widespread in Jamaica.

Genus *Zaphysema* Pilsbry, 1894

***Zaphysema tenerrimum* (C. B. Adams, 1845)**

(Pl. 8, figs. 1–6)

*Description:* Shell moderate sized (21 mm diameter by 17 mm high), thin, globular, imperforate, with five convex whorls and an unmodified aperture with thin margins. Protoconch smooth, but not distinguishable from the teleoconch; growth lines simply increase in strength. Later whorls have very weak spiral ornament. Suture distinctly impressed, just turning down before the aperture, but only in the largest examples. Whorls distinctly tumid, almost perfectly circular in cross section. Aperture obliquely ovate, some-

times very slightly flattened near suture, but otherwise smoothly rounded; margins neither thickened nor reflected, parietal callus very thin. In profile the outer lip is planar. The aperture plane is not tangential to the penultimate whorl, but set at about 32° to the axis.

*Occurrence:* An abundant shell in the cave deposits despite its thin and fragile nature. Fresh shells with the uniform pale brown periostracum still attached can be found in the vicinity of the cave and the species almost certainly still lives in the area. Recent shells are smaller and even more delicate than the fossils, and reach 17 mm diameter by 15 mm high, and the plane of the aperture is at a higher angle (about 36°) to the shell axis.

Family Systrophiidae

Genus *Happiella* H. B. Baker, 1925

***Happiella brevis* (C. B. Adams, 1849c)**

(Pl. 35, figs. 2, 4)

*Description:* Shell minute (up to 2.5 mm diameter), discoidal, but with slightly raised spire, with three and three quarters smooth, rounded whorls, an unmodified aperture and a wide umbilicus. Protoconch smooth, of one and a quarter whorls, distinctly oval and separated from the teleoconch by an impressed line. Fine irregular growth lines start with the teleoconch and strengthen with growth. Last whorl a little lower on the spire than preceding. Suture deep, not descending towards the aperture. Whorls rounded above, very slightly flattened above the periphery, especially on the last whorl, then regularly rounded, hence not quite circular in cross-section. Aperture rounded, unmodified, with sharp lips and obvious parietal callus. In profile the outer lip is slightly sinuous, the aperture plane at about 18° to the axis and not tangential to the penultimate whorl. Umbilicus very wide, more than a third shell diameter, expanding regularly.

*Occurrence:* Abundant in the cave deposits, but unknown living in the vicinity of the cave.

Family Camaenidae

Genus *Eurycratera* Beck, 1837

***Eurycratera jamaicanesis* (Gmelin in Linné, 1791)**

(Pl. 9, figs. 1–6)

*Description:* Shell large (up to 45 mm diameter), globular, imperforate, with three convex whorls, rounded almost tangential aperture and simple thickened lip. The protoconch is smooth and of one whorl, but not always distinct from the teleoconch, which develops weak growth lines after about one and a quarter whorls accompanied by the characteristic oblique, spiral striations after just over one and a half whorls. The spiral striations are very distinctive. They are perpendicular to less prominent growth lines and thus oblique to the sutures. They descend from the upper suture to the lower as growth proceeds. On some shells two ridges and grooves, the upper ridge wider, run parallel and immediately adja-

cent to the suture. The suture is impressed, turns down gently before the aperture and continues uninterrupted as the upper margin of the parietal callus. The aperture is large, rounded, with an outer lip that is thickened by an internal rib, but not reflected; the columellar margin is less strongly curved and has a broad callus; the parietal callus is thick and obvious. In profile the outer lip is planar, the aperture plane almost tangential to the penultimate whorl and at 40° to the axis of coiling.

*Occurrence:* A rather rare shell in the cave deposits, although very obvious because of its size. Recent shells can be found in the vicinity of the cave, although it is uncertain that the species has survived forest clearance and still lives in the area. Recent shells are shiny and have thick, dark, spiral bands separated by two or three narrow paler bands. They seem to be larger, reaching 51.5 mm diameter. Fossil shells do not retain the colour pattern. They are generally smaller and thinner shelled, but the surface ornament is more obvious.

Genus *Pleurodonte* Fischer von Waldheim, 1807

***Pleurodonte candescens* (C. B. Adams, 1850a)**

(Pl. 13, figs. 1–6)

*Description:* Shell medium sized (up to 30 mm diameter), lenticular, distinctly perforate even in adults, with four and a half rounded whorls with a pale peripheral keel and an oval aperture furnished with four almost equally spaced basal lamellae (here numbered 1–4 from the axis outwards). The protoconch is not normally distinguishable from the teleoconch, growth lines becoming progressively more strongly developed. Equally, after about one and a half whorls a distinct granular ornament appears and becomes progressively more obvious. The suture is only weakly impressed and descends sharply just before the aperture, the plane of which is exactly tangential to the penultimate whorl and lies at about 63–64° to the axis of coiling. Behind the aperture externally are one elongate groove above the peripheral keel and four below, the innermost within the umbilicus. The parietal callus is very thick and distinctly raised, making the lip of the aperture entire and slightly protruding in fully developed adults, and with all four basal lamellae corresponding to external grooves in the shell. The apertural lamellae are equally spaced and all tend to turn inwards (that is, towards the columella), but 4 is reflected outwards at the back. The basal lip is reflected, but not cemented to the outside of the shell at all. Even in just fully grown shells the lip is only cemented to the penultimate whorl along the inner half of the parietal margin. When fully mature the lip is entire, much thickened and free of the shell all round. The umbilicus is obvious even in mature adult shells and about 13–14 % of the diameter.

*Occurrence:* Very rare fossil in the cave deposits, only three specimens found so far. Rare, dead and bleached shells of this species have been found in the vicinity of the cave, suggesting it survived into historic times, but it is not yet confirmed still living in the area. Recent shells are slightly larger (30–33 mm versus

28–29 mm diameter).

***Pleurodonte catadupae* (H. B. Baker, 1935c)**

(Pl. 14, figs. 1–3)

*Description:* Shell moderately large (up to 32 mm diameter), acutely lenticular, perforate, with a subtriangular aperture with two pairs of short lamellae on the basal lip. Protoconch and teleoconch not distinguishable; irregular growth lines simply increase in strength. Weak granular ornament of the teleoconch appears after about one and a half whorls, increases in strength, and is present above and below on the body whorl. Generally, it is subordinate to irregular growth lines, but strongest behind the aperture and below the periphery on the body whorl. The suture is only weakly impressed and does not descend before the aperture. The whorl cross-section is planar or even slightly concave on the outer part of the upper surface, with an acute keel, and slightly concave adjacent to the keel, then gently convex on the lower surface, giving the whorl profile a pinched appearance. Aperture planar above, gently curved below, with thickened and reflected margins. Basal lamellae in two pairs, outer pair (3 and 4) prominent, lamella 3 the thicker of the two; the inner pair consist of an outer lamella (2) with a weaker node (1). On one example there is the faintest hint of another denticle nearer the columella. Lamella 1 is entirely on the thickened basal lip, 2–4 correspond to grooves on the external surface, and 3 and 4 occur together in a single, broad depression. In profile the outer lip is almost perfectly planar and exactly tangential to the penultimate whorl. The aperture plane lies at about 50° to the axis of coiling.

*Occurrence:* A very rare shell in the cave deposits. Unknown living in the vicinity of the cave. *Pleurodonte catadupae* was originally described by Baker (1935c, p. 24, as a subspecies of *P. cara*) from Catadupa on the western edge of the Cockpit Country. Its occurrence at Red Hills Road Cave represents a significant extension of its geographical range.

***Pleurodonte invalida* (C. B. Adams, 1850a)**

*Description:* Shell resembles *P. candescens*, but is significantly smaller (not more than 22 mm diameter), proportionately taller ( $H/D = 55\%$ ), has shallow sutures so that the spire is regularly domed and the lip covers the umbilicus. All the apertural lamellae are much shorter and 4, in particular, is pointed, 3 and 4 tend to be closer together, 2–4 correspond to external grooves, and 1 is entirely on the basal lip which is cemented to the external surface out to a position between lamellae 1 and 2. Behind the aperture a dorsal groove is present, but shallow. The parietal callus is relatively weak, especially close to the covered umbilicus. Growth lines are not obvious and granulation fine. The protoconch is white, the shell generally uniformly brown, but with a white band along the keel on the body whorl, which is especially prominent on the side opposite the aperture (that is, it starts thin, broadens, and then narrows and darkens towards the aperture). The suture turns down sharply just before the aperture, the plane of which is tangential to

the penultimate whorl and at  $61^\circ$  to the axis.

*Occurrence:* Unknown in the cave deposits, but rare fresh shells have been found within a few hundred metres of the cave. Rosenberg (written communication, September, 2005) has collected live specimens elsewhere in the Red Hills.

***Pleurodonte sinuata* (Müller, 1774)**

(Pl. 12, figs. 1–4)

*Description:* Shell medium sized (27.5 mm diameter), lenticular, imperforate as adult, with four and a half rounded whorls with a pale peripheral keel and an oval aperture furnished with four almost equally spaced basal lamellae. Protoconch not distinguishable from teleoconch, growth lines become progressively more strongly developed. Distinct granular ornament appears at about one and a half whorls and becomes progressively more obvious, but less strongly developed than on *P. invalida*. The suture is distinctly impressed and descends quite sharply just before the aperture, the plane of which is exactly tangential to the penultimate whorl and lies at about  $57^\circ$  to the axis of coiling. The whorls are moderately convex above, giving the spire a distinctly stepped profile, and rounded below. The whorl cross-section is rounded, but a distinct, narrow, sharp keel on juvenile whorls is only slightly weaker on the body whorl. The aperture is elongate-oval with a sharply reflected and thickened outer lip, reflected and thickened basal lip armed with four lamellae, and a relatively weak parietal callus that entirely covers the umbilicus in adults. The upper external groove is evident as a weak lamella inside the outer lip and three below correspond to basal lamellae 2–4. The innermost basal lamella (1) is entirely on the thickened basal lip and is basically straight; 2 and 3 are folds in the basal shell, and their inner ends curve in towards the columella; the outermost (4) is also a fold of the basal shell and curves out sharply at its inner end. The basal lip is reflected and cemented to the outside of the whorl near the axis, and out to a point between lamellae 1 and 2. Rarely shells have an incompletely closed umbilicus, in which case it is about 10 % of the diameter.

*Occurrence:* A not uncommon large shell in the cave deposits, more obvious because of its size. Unknown living in the vicinity of the cave.

***Pleurodonte subacuta* (Pfeiffer, 1868)**

(Pl. 10, figs. 1–5)

*Description:* Shell large (45 mm diameter), lenticular, imperforate, with four almost planar whorls, oval, nearly tangential aperture, with reflected and scarcely thickened lip. The protoconch is indistinguishable from the teleoconch; both are ornamented with distinct, irregular growth lines, but no trace of granular ornament. Sutures hardly impressed at all, more so between later whorls, turning down very slightly, but sharply, just before the aperture. Whorl cross-section sharply keeled in juveniles, merely angular on the body whorl, although a weak keel continues to the aperture, and more convex below in the last third of a whorl. The shell has a

distinctly oval outline in plan view. Aperture obliquely oval, outer lip weakly reflected and thin, basal lip slightly thickened, weakly reflected and cemented to the outer surface about two thirds the way out from the axis to the periphery. Basal lip occasionally with a hint of a tooth or very weak local swelling near the angular columellar margin, only exceptionally with a tooth near the outer margin of the basal lip (three shells out of 163 examined). Parietal callus thin, covering umbilicus, but juvenile shells are distinctly perforate. In profile the outer lip is slightly concave and the plane of the aperture not quite tangential to the preceding whorl, set at  $50^\circ$  to the axis of coiling. The shell silky when fresh, without traces of colour in fossils.

*Occurrence:* The commonest large shell in the cave deposits. Unknown living in the vicinity of the cave or elsewhere in the Red Hills, where presumably it has been replaced by the next species.

***Pleurodonte sublucerna* (Pilsbry, 1889a)**

(Pl. 11, figs. 1–7)

*Description:* Shells very similar to the above, but larger (mean diameter 50.7 mm,  $n = 20$  versus 44.9 mm,  $n = 22$ ), proportionately taller (mean H/D 51.5 %,  $n = 20$  versus 46.4 %,  $n = 22$ ). There is an obvious tooth on the basal lip about 10 mm from its outer extremity, rarely a second tooth close to the columella, and the reflected basal lip is only cemented to the outer surface for a very short distance from the columellar axis. In addition, the shell surface is distinctly granular, especially below the periphery of the body whorl and just behind the aperture. The protoconch is more strongly ornamented from the beginning, with irregular growth lines, and malleated, especially towards the outer margin. Weak granular ornament starts between one and one and a quarter whorls, but is subordinate to growth lines and never as strongly developed as in the *P. sinuata* group. In profile the outer lip is almost planar, the aperture plane nearly tangential to the penultimate whorl, and at  $52^\circ$  to the axis of coiling. The colour is dark chestnut brown above, paler below, sometimes with a sharp colour change giving a dark peripheral band on the underside.

*Occurrence:* Unknown in the cave deposits, but living in the vicinity of the cave and widely distributed in southern and central Jamaica (see Goodfriend, 1986b).

Family Helminthoglyptidae

Genus *Dialeuca* Albers, 1850

***Dialeuca conspersula* (Pfeiffer, 1846b)**

(Pl. 14, figs. 4–8)

*Description:* Shell of moderate size (up to 24 mm diameter), trochiform, imperforate, with five whorls, an obliquely ovate, almost tangential aperture with a scarcely reflected and thickened lip. The smooth protoconch is not clearly distinguishable from the teleoconch, which has growth lines that gradually become more obvious. Suture is moderately impressed and descends very slightly just before the aperture. The whorls are moderately convex

above, weakly shouldered near the suture and slightly angular at the periphery, with a gently flattened base. The aperture is obliquely oval, with a distinct angle between the basal and columellar margins. The lip is scarcely thickened or reflected and the parietal callus is thin. In profile the outer lip is slightly concave, the plane of the aperture is nearly tangential to the penultimate whorl and at about 40° to the axis. Colour patterns survive in fossil shells and consist of (usually five) spiral bands of dark brown, separated by narrow white bands. A very thin band at the suture and another slightly thicker band above the periphery are always darkest, and persist longest in fossils. The broad band above the periphery and the two broad bands below are usually paler brown. The lowest band surrounds the columellar axis.

*Occurrence:* Not an uncommon shell in the cave deposits. Fresh shells can be found in the vicinity of the cave and it is almost certain that the species survives locally even though we have yet to find it alive. Despite the persistence of colour in the fossils, they are not contaminants. Several brightly coloured specimens have been collected thoroughly cemented into a fossil conglomerate of bones and shells. Recent shells are more darkly coloured with a narrow pale band at the suture above the upper dark band, another just below the peripheral dark band and a less obvious one in the middle of the base. Recent shells are also slightly more steeply conical and have the plane of the aperture at about 45° to the axis

of coiling.

Family Euconulidae

Genus *Guppya* Mörch, 1867

***Guppya gundlachi* (Pfeiffer, 1840)**

(Pl. 26, figs. 1, 3, 4; Pl. 31, fig. 6)

*Description:* Shell perforate, very small (up to 2.5 mm diameter), conical, with up to four subangular whorls and a simple aperture. Protoconch and teleoconch indistinguishable. All whorls ornamented within distinct spiral lineations, which are equally obvious, but slightly more widely spaced below the periphery, and with weaker, irregular growth lines. Whorls initially scarcely convex above, becoming more so with growth, more rounded below and with a subangular periphery. Sutures weakly impressed, not descending towards the aperture, which is unmodified except for being slightly reflected over the pinhole umbilicus. Aperture profile planar and at about 26° to the axis of coiling. Shell transparent and pale brown.

*Occurrence:* Unknown in the cave deposits, but shells and live snails not uncommon in litter samples from around the cave. *Guppya gundlachi* is widespread in the neotropics (Rosenberg and Muratov, 2004) and is probably not native to Jamaica, but a recent human introduction.

Table 1. Occurrence of snails in the fossil and Recent faunas at Red Hills Road Cave, St. Andrew, Jamaica. Key: Size = largest dimension in mm; very rare = <10 specimens; rare = 10–25; frequent = 26–50; common 50–100; abundant >100; elsewhere = known from other sites in the Red Hills; \* Indicates species which are possibly recent human introductions and are excluded from the analyses in Table 2.

Species	Size	Fossil fauna	Recent fauna
1 <i>Alcadia</i> (? <i>Hjalmarsona</i> ) <i>solitaria</i> (C. B. Adams, 1845)	10	common	elsewhere
2 <i>Alcadia</i> ( <i>Palliata</i> ) <i>brownii</i> (Gray, 1824)	15	common	living
3 <i>Alcadia</i> ( <i>sensu lato</i> ) <i>jamaicensis</i> (G. B. Sowerby II, 1842)	12	frequent	rare shells
4 <i>Eutrochatella</i> ( <i>Eutrochatella</i> ) <i>pulchella</i> (Gray, 1824)	13	abundant	common
5 <i>Helicina</i> <i>neritella</i> Lamarck, 1801	14	frequent	rare shells
6 <i>Lucidella</i> ( <i>Lucidella</i> ) <i>aureola</i> (J. Férussac, 1821)	10	rare	living
7 <i>Lucidella</i> ( <i>Perenna</i> ) <i>lineata</i> (C. B. Adams, 1845)	4	rare	
8 <i>Lucidella</i> ( <i>Poenia</i> ) <i>depressa</i> (Gray, 1824)	5	rare	rare shells
9 <i>Fadyenia</i> <i>blandiana</i> (C. B. Adams, 1849a)	1.5	abundant	rare shells
10 <i>Fadyenia</i> <i>jayana</i> (C. B. Adams, 1849a)	2	abundant	
11 <i>Fadyenia</i> <i>leana</i> (C. B. Adams, 1849a)	2	abundant	
12 <i>Fadyenia</i> <i>lindsleyana</i> (C. B. Adams, 1849a)	2	common	rare shells
13 <i>Poteria</i> ( <i>Bartschivindex</i> ) <i>varians</i> (C. B. Adams, 1851c)	25	frequent	
14 <i>Poteria</i> ( <i>sensu lato</i> ) sp.		rare	
15 <i>Adamsiella</i> ( <i>Adamsiella</i> ) <i>grayana</i> (Pfeiffer, 1846a)	15	common	living
16 <i>Colobostylus</i> ( <i>Colobostylus</i> ) <i>thysanoraphe</i> (G. B. Sowerby II, 1843)	21	common	
17 <i>Colobostylus</i> ( <i>Tudorops</i> ) <i>yallahensis</i> (C. B. Adams, 1851a)	14	abundant	
18 <i>Parachondria</i> ( <i>Parachondrella</i> ) <i>mutica</i> (C. B. Adams, 1849b)	17		living
19 <i>Parachondria</i> ( <i>Parachondria</i> ) <i>fascia</i> (Wood, 1828)	25	very rare	rare shells
20 <i>Geomelania</i> ( <i>Merrilliana</i> ) <i>parvula</i> Pilsbry and Brown	6	abundant	elsewhere
21 <i>Carychium</i> <i>jardineanum</i> (Chitty, 1853)	2	abundant	
22 <i>Ptychopatala</i> <i>dioscoricola</i> (C. B. Adams, 1845)	<2		living*
23 <i>Ptychopatala</i> <i>macneilli</i> (Clapp, 1918)	<2	very rare	very rare

	Species	Size	Fossil fauna	Recent fauna
24	<i>Ptychopatala</i> sp. a	<2	rare	
25	<i>Ptychopatala</i> sp. b	<2	very rare	
26	<i>Bothriopupa tenuidens</i> (C. B. Adams, 1845)	<2		living*
27	<i>Vertigo gouldii</i> (Binney, 1843)	<2	very rare	
28	<i>Vertigo milium</i> (Gould, 1840)	<2	very rare	very rare
29	<i>Punctum (Punctum)</i> sp. a	1.1	frequent	
30	<i>Punctum (Toltecia) vitreum</i> Baker, 1930	1.1	common	living
31	<i>Radiodiscus</i> sp. a	1.5	very rare	
32	<i>Radiodiscus?</i> sp. b	2.2	very rare	
33	<i>Karolus iota</i> (C. B. Adams, 1845)	2		rare shells*
34	<i>Allopeas micra</i> (d'Orbigny, 1835)	4.5		common*
35	<i>Opeas hannense</i> (Rang, 1831)	6		rare*
36	<i>Micromena problematica</i> (Pilsbry, 1907)	2.5		very rare
37	<i>Spiraxis (Repressaxis) terebella</i> (C. B. Adams, 1849c)	7	very rare	? 2 shells
38	<i>Costavarix costulatus</i> (C. B. Adams, 1845)	7	rare	elsewhere
39	<i>Costavarix gossei</i> (Pfeiffer, 1846c)	8	rare	
40	<i>Euvaricella nemorensis</i> (C. B. Adams, 1849c)	20	rare	elsewhere
41	<i>Euvaricella</i> sp. a	7	very rare	
42	<i>Euvaricella venusta</i> (Pfeiffer, 1841)	28	common	one shell
43	<i>Sigmataxis</i> cf. <i>S. pauperculus</i> (C. B. Adams, 1849c)	6	frequent	
44	<i>Sigmataxis procerus</i> (C. B. Adams, 1845)	16	common	rare
45	<i>Sigmataxis</i> sp. a	8.5	very rare	
46	<i>Sigmataxis</i> sp. b	5		rare shells
47	<i>Varicella (Varicellaria) griffithii</i> (C. B. Adams, 1845)	26	frequent	rare shells
48	<i>Drymaeus (Mesembrinus) immaculatus</i> (Reeve, 1850)	30		rare shells
49	<i>Anoma fuscolabris</i> (Chitty, 1853)	20	common	one shell
50	<i>Apoma chemnitzianum</i> (J. Férussac, 1821)	28		living
51	<i>Geoscala costulata</i> (C. B. Adams, 1849c)	8	frequent	
52	<i>Geoscala seminuda</i> (C. B. Adams, 1845)	7		living
53	<i>Spirostemma</i> cf. <i>S. dunkeri</i> (Pfeiffer in Philippi, 1845)	c. 20	rare	
54	<i>Spirostemma tenellum</i> (C. B. Adams, 1849c)	10	rare	
55	<i>Urocoptis (Spirocoptis) sanguinea</i> (Pfeiffer in Philippi, 1845)	28		common
56	<i>Aerotrochus mcNabiana</i> (Chitty, 1853)	10	very rare	very rare
57	<i>Aerotrochus perdepressa</i> (C. B. Adams, 1849c)	5	very rare	rare shells
58	<i>Aerotrochus</i> sp. a	7	rare	rare shells
59	<i>Aerotrochus</i> sp. b	6		two shells*
60	<i>Corneosagda ptychodes</i> (Pfeiffer, 1846c)	5		two shells
61	<i>Microsagda angustispira</i> (C. B. Adams, 1849c)	4	abundant	
62	<i>Microsagda inconspicua</i> (C. B. Adams, 1849c)	3	common	
63	<i>Proserpinula discoidea</i> (C. B. Adams, 1850a)	6	common	
64	<i>Proserpinula infortunata</i> (Bland, 1854)	6		shells
65	<i>Proserpinula margaritella</i> Pilsbry and Brown, 1910	6.5	rare	
66	<i>Sagda cookiana</i> (Gmelin in Linné, 1791)	24		living
67	<i>Sagda jayana</i> (C. B. Adams, 1845)	28	common	living
68	<i>Sagda spei</i> Pilsbry and Brown, 1910	20	abundant	
69	<i>Sagda spiculosa</i> Pfeiffer, 1859	17	common	
70	<i>Stauroglypta peraffinis</i> (C. B. Adams, 1845)	6		rare shells
71	<i>Strialuna sincera</i> (C. B. Adams, 1845)	3		rare shells
72	<i>Zaphysema tenerrimum</i> (C. B. Adams, 1845)	21	abundant	living
73	<i>Happiella brevis</i> (C. B. Adams, 1849c)	2.5	abundant	
74	<i>Eurycratera jamaicanensis</i> (Gmelin in Linné, 1791)	45	rare	rare shells
75	<i>Pleurodonte candescens</i> (C. B. Adams, 1850a)	28	very rare	very rare shells
76	<i>Pleurodonte catadupae</i> (H. B. Baker, 1935c)	30	very rare	
77	<i>Pleurodonte invalida</i> (C. B. Adams, 1850a)	22		rare shells
78	<i>Pleurodonte sinuata</i> (Müller, 1774)	28	frequent	
79	<i>Pleurodonte subacuta</i> (Pfeiffer, 1868)	45	abundant	
80	<i>Pleurodonte sublucerna</i> (Pilsbry, 1889a)	50		common living
81	<i>Dialeuca conspersula</i> (Pfeiffer, 1846b)	24	frequent	frequent shells
82	<i>Guppya gundlachi</i> (Pfeiffer, 1840)	2.5		living*

Table 2. Comparison of the Recent and fossil faunas at Red Hills Road Cave, excluding possible recent introductions.

		Total fauna	Fossil fauna	Recent fauna	Common to both	Unique to fossil fauna	Unique to Recent fauna
Total fauna	Number	80	62	48	30	32	13
	Percent	100 %	77.5 %	60.0 %	37.5 %	40.0 %	16.3 %
Operculates	Number	20	19	13	12	7	1
	Percent	100 %	95 %	65 %	60 %	35 %	5 %
Pulmonates	Number	60	43	35	18	25	12
	Percent	100 %	71.7 %	58.3 %	30.0 %	41.7 %	20.0 %

### Discussion

The fossil fauna of terrestrial gastropods from Red Hills Road Cave is the richest yet reported from Jamaican caves with 62 species. Goodfriend (1986a) reported 47 species from Sheep Pen Cave, in the Cockpit Country, whereas Goodfriend and Mitterer (1993) recorded 39 species from Coco Ree Cave in central Jamaica. Other fossil snail faunas from the north coastal area yielded between 12 and 26 species (Goodfriend and Mitterer, 1988). Two other cave faunas we have collected did not exceed 30 species (Paul, unpublished data). The fossil fauna is also more diverse than the Recent fauna in the area (Table 2), although the latter may have suffered from recent forest clearance. One possible reason for the richness is that the Red Hills Road Cave fauna accumulated over a very long time period. This seems unlikely, however. The only published radiocarbon date for the cave (McFarlane and Blake, 2005) gave an age of  $31,960 \pm 1220$  yr BP from a *Pleurodonte* shell. In 1995 Glenn Goodfriend ran amino acid analyses on four *Pleurodonte* shells from the cave, which gave the following D-alloisoleucine/L-isoleucine (or A/I) values:

3.0 m above the road	0.360 and 0.348
0.5 m above the road	0.459 and 0.396

We have no radiocarbon dates to calibrate the local A/I curve, but assuming the diagenetic history of Red Hills Road Cave was similar to that of Coco Ree Cave, the nearest cave fauna investigated by Goodfriend, then these ratios would correspond to dates between about 30,000 and 50,000 years B.P. Fossils from Coco Ree Cave gave a spread of ages from about 15,000 to 45,000 years BP (Goodfriend and Mitterer, 1993, fig. 3). Coco Ree Cave is at an

elevation of 410 m, whereas the Red Hills Road Cave lies at approximately 520 m elevation. It seems unlikely that the difference in elevation would result in significantly different rates of amino acid epimerization. Limited though our evidence as to the age of deposits is, it is difficult to argue that the Red Hills Road Cave deposits accumulated over a significantly longer time period than those at other Jamaican caves.

One reason for the high diversity of the cave fauna is the occurrence of several species not previously reported from Jamaica. *Ptychopatala* spp. a and b, *Punctum* sp. a, *Punctum vitreum*, *Radiodiscus* sp. a and *Radiodiscus?* sp. b have not previously been recorded as part of the Jamaican fauna. We suspect that the last four may be conspecific with recently discovered living species.

Jamaica has a very diverse fauna of extant terrestrial gastropods (Vendryes, 1899; Groh and Parkinson, 1987; Rosenberg and Drumm, 2004). The last present the most up to date list of 561 species, which does not include subspecies, nor at least four of the species described here. Many species are endemic to small areas within the island (Goodfriend and Mitterer, 1993 and references therein). Previous studies of Pleistocene and Holocene fossil snail faunas (Goodfriend, 1986a, 1989; Goodfriend and Mitterer, 1988, 1993) have generally concluded that these local endemics had maintained their distributions over the last 40,000 years, apart from Holocene and Recent extinctions due probably to the development of drier conditions, in some cases as a result of forest clearance by humans within historic times (Table 3). Red Hills Road Cave has the lowest proportion of fossil species known to occur in the immediate vicinity of the cave of the four localities except for Green Grotto Cave on the north coast. There, the principal differ-

Table 3. Comparison with other fossil cave faunas from Jamaica.

Locality	Total fossil fauna	Living in area	Living elsewhere	extinct	Locally extinct Late Glacial	Locally extinct Latest Glacial	Locally extinct Late Holocene	Unknown
Coco Ree Cave	41	36 (87.8 %)	3 (7.3 %)	0				2* (4.9 %)
Sheep Pen Cave	47	34 (72.3 %)	6 (12.8 %)	3 (6.4 %)				4 (8.5 %)
Green Grotto Cave	38	13 (34.2 %)	24 (63.2 %)	0	7 (18.4 %)	4 (10.5 %)	13 (34.2 %)	1° (2.6 %)
Red Hills Road Cave	62	30^ (48.4 %)	24 (38.7 %)	0				8 (12.9 %)

\*Includes one indeterminate fossil species and one freshwater species. °The original table states that 14 species are known living in the area of Green Grotto Cave, but only 13 are identified. ^Includes 4 species not known from the vicinity of Red Hills Road Cave, but recorded living elsewhere in the Red Hills. Data from Goodfriend and Mitterer, 1993 (Coco Ree Cave); Goodfriend, 1986a (Sheep Pen Cave); Goodfriend and Mitterer, 1988 (Green Grotto Cave).

ences are due to late Pleistocene to late Holocene extinctions, which Goodfriend and Mitterer (1988) were able to date fairly precisely.

Regrettably, these previous publications only discussed the fate of the fossil fauna and did not record data on living species not found in the fossil faunas. One cause of such differences between fossil and Recent faunas is the introduction, probably by humans within historic times, of a number of species with widespread distributions in the tropics or Caribbean (indicated with an asterisk in Table 1). Clearly these recent introductions reveal nothing about natural changes in snail faunas, and they are ignored in further discussion here and not included in the statistics in Table 2. Comparison of the fossil and Recent faunas at Red Hills Road Cave (Tables 1, 2) shows that not only are there local endemic species in the fossil fauna that no longer live in the area, but there are also several local endemic species in the Recent fauna that are unknown from the cave deposits. Table 2 summarizes the differences. Of a total of 80 endemic species recognized, only 30 (37.5%) are common to both the fossil and Recent faunas. This suggests that significant migration of snails has occurred in the Red Hills area and that the geographic distributions of local endemic snails are not as stable as had previously been assumed. Distribution data for Jamaican local endemic snails are generally poor. Virtually no locality data were recorded when species were first described. However, it is possible to state where nearest known localities are for several of the fossil species. The nearest locality for *Tudora yallahense* and *Geoscala costulata* is Mount Diablo, approximately 30 km to the northwest (BMNH collection and Paul, 1982, respectively). *Pleurodonte subacuta* also occurs in the higher hills around Moneague and Mount Diablo to the northwest of the Red Hills Road Cave. Rosenberg (personal communication, September, 2005) informed us that he has found what are probably the same two species of *Radiodiscus* on John Crow Peak, the highest point on the island and about 20 km east of Red Hills Road Cave. These limited records suggest that the climate was probably wetter when the cave deposits were forming. To some extent this is supported by size differences between fossil and Recent examples of species common to both faunas (Table 4). Goodfriend and Mitterer (1988) discussed size differences between Pleistocene and Recent examples of the land snails *Pleurodonte lucerna* and *Alcadia major*, and

their relationship to palaeoclimate. Both species exhibit a positive correlation between shell size and rainfall. Using this relationship, they were able to interpret the climatic history of the north coastal area as one of drier conditions during the Late Pleistocene and wetter conditions during the Holocene. Our evidence is more limited and somewhat equivocal. Assuming a positive correlation between shell size and rainfall for our species, the largest species common to both faunas, *Eurycratera jamaicensis*, was smaller in the cave fauna suggesting drier conditions in the Pleistocene. The other four species are all larger in the cave fauna, suggesting wetter conditions in the Pleistocene. These include both ground-dwelling (*Alcadia brownii*, *Eutrochatella pulchellai* and *Adamsiella grayana*) and arboreal (*Lucidella aureola*) species. However, the difference between the two means for *A. grayana*, the species for which we have the best data, is not statistically significant and so it would be unwise to infer very much from such limited information.

To some extent the species of living snails unknown in the fossil fauna also suggest drier conditions at present than in the Pleistocene, possibly due to recent forest clearance by humans. Of the 13 such species, *Parachondria mutica*, *Geoscala seminuda* and *Pleurodonte invalida* are characteristic of the dry southern coastal plain, and appear to be extending their ranges inland. *Stauroglypta peraffinis* and *S. sincera* may also support this interpretation as they occur frequently in disturbed ground. However, other members of the Recent fauna not found in the cave deposits do not support such an interpretation. In particular, *Drymaeus immaculatus* is arboreal and its appearance in the Recent fauna around Red Hills Road Cave cannot be due to forest clearance. Equally puzzling is the occurrence of *Apoma chemnitzianum* and *Urocoptis sanguinea*. Both are characteristic of limestone areas. *Apoma chemnitzianum* occurs in a broad area of south and east central Jamaica, and is widely distributed in wetter areas than the Red Hills. *Urocoptis sanguinea* is endemic to the Red Hills and it is extremely puzzling that this large, conspicuous urocoptid should be absent from what appears to have been an ideal locality during the Pleistocene. The changes in the species of *Proserpinula* and *Sagda* are also puzzling. As far as we are aware the distributions of the species involved are not controlled by rainfall.

Finally, comparison of the prosobranch and pulmonate faunas

Table 4. Size differences between species common to the Recent and fossil faunas at Red Hills Road Cave.

Species	diameter (mm)				Height (mm)			
	Fossil	N	Recent	N	Fossil	N	Recent	N
<i>E. jamaicensis</i>	44.70	10	51.46	3	41.40	10	48.39	3
<i>L. aureola</i>	9.19	9	7.88	6				
<i>A. brownii</i>	14.78	15	13.54	8				
<b><i>A. grayana</i></b>					13.20	15	12.36	15
<i>E. pulchella</i>	10.95	18	11.82	4	9.67	18	10.76	4

suggests that the former are more conservative in their distributions. A greater proportion of the fossil species still occur in the vicinity of the cave compared with pulmonates, and only one endemic prosobranch, *Parachondria mutica*, has invaded the area since the cave deposits stopped forming.

### Acknowledgements

This site was discovered in the summer of 1988 by Dr Anita G. Warrington (née Godwin, formerly of the University of Liverpool) and Ms Marlene M. Britten (formerly University of the West Indies, Mona (UWI)). Dr Warrington was supported by a Natural Environment Research Council studentship. Much of the fieldwork for this research was completed while CRCP was on study leave at the Department of Geology, UWI (where SKD was formerly a faculty member), supported by an award from the Leverhulme Trust to both authors. All of these sources of funding are gratefully acknowledged. We thank Mr. Cornelis J. Veltkamp (University of Liverpool) for taking the SE micrographs. The late Hal Dixon, Eamon Doyle and Carla Gordon (all formerly UWI), amongst many others, provided invaluable help in the field. The late Glenn Goodfriend provided advice on taxonomy as well as running the amino acid analyses. The original manuscript was greatly improved by the comments of Dr E. Gittenberger, Dr A. J. de Winter (both Nationaal Natuurhistorisch Museum, Leiden) and Dr G. Rosenberg, Academy of Natural Sciences, Philadelphia, who we also thank for providing us with his unpublished distribution records of species from Jamaica. Thanks are also due to Dr P. Mordan, F. Naggs, J. Ablett and Dr D. T. J. Littlewood (all BMNH) for access to collections in their care and help with identifying relevant literature.

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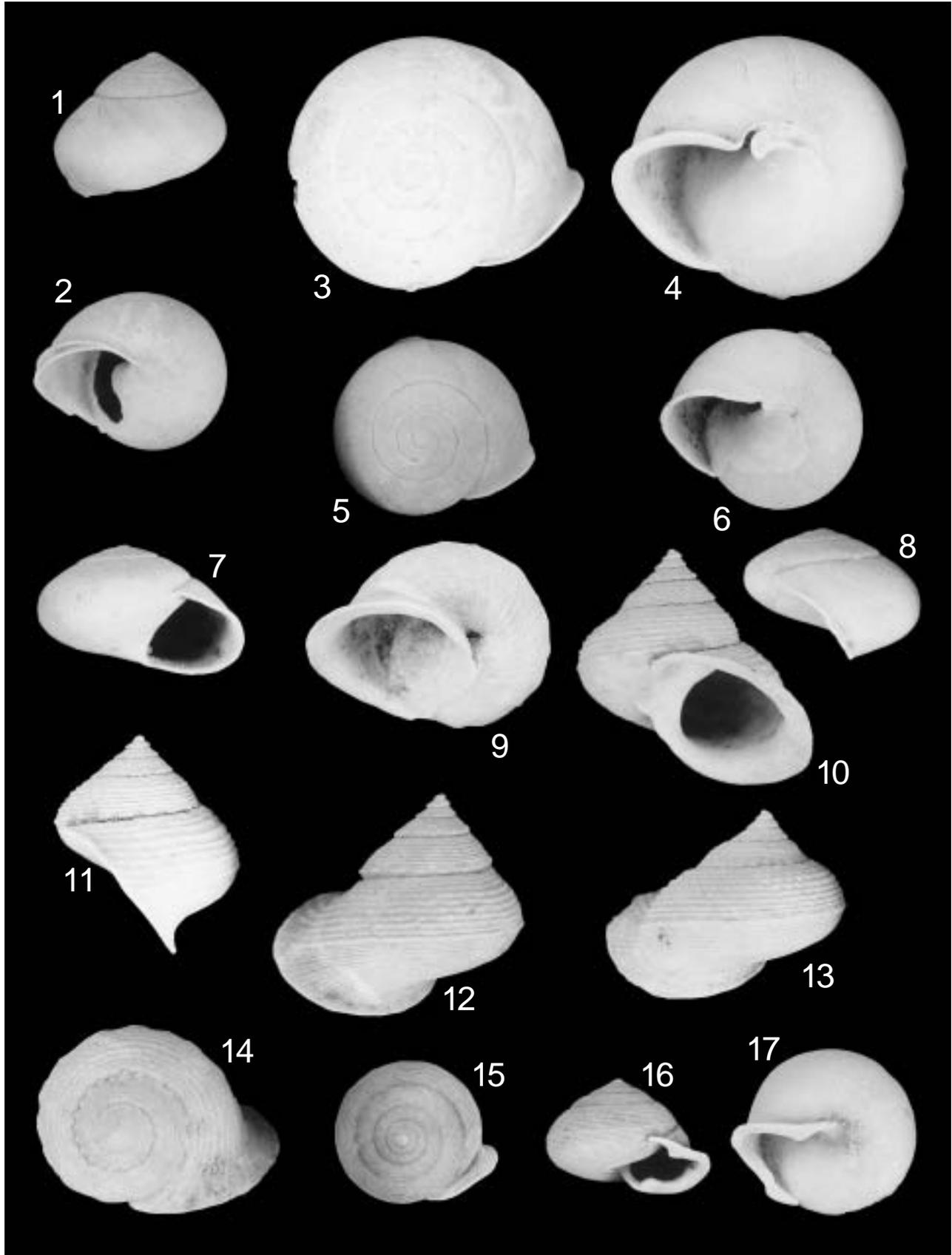
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### Explanation of Plate 1

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Figs. 1–2. *Alcacia (sensu lato) jamaicensis* (G. B. Sowerby II), RGM 188 702. 1, posterior lateral view. 2, umbilical view.
- Figs. 3–4. *Alcacia brownii* (Gray), RGM 188 703. 3, apical view. 4, umbilical view.
- Figs. 5–8. *Alcacia (?Hjalmarsona) solitaria* (C. B. Adams), RGM 188 704. 5, apical view. 6, umbilical view. 7, apertural view. 8, lateral view.
- Figs. 9–14. *Eutrochatella (Eutrochatella) pulchella* (Gray). 9–11, RGM 188 705. 9, umbilical view. 10, apertural view. 11, lateral view. 12, RGM 188 796, posterior lateral view. 13, 14, RGM 188 707. 13, posterior lateral view. 14, apical view.
- Figs. 15–17. *Lucidella (Lucidella) aureola* (Férussac). 15, 16, RGM 188 708. 15, apical view. 16, apertural view. 17, RGM 188 709, umbilical view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

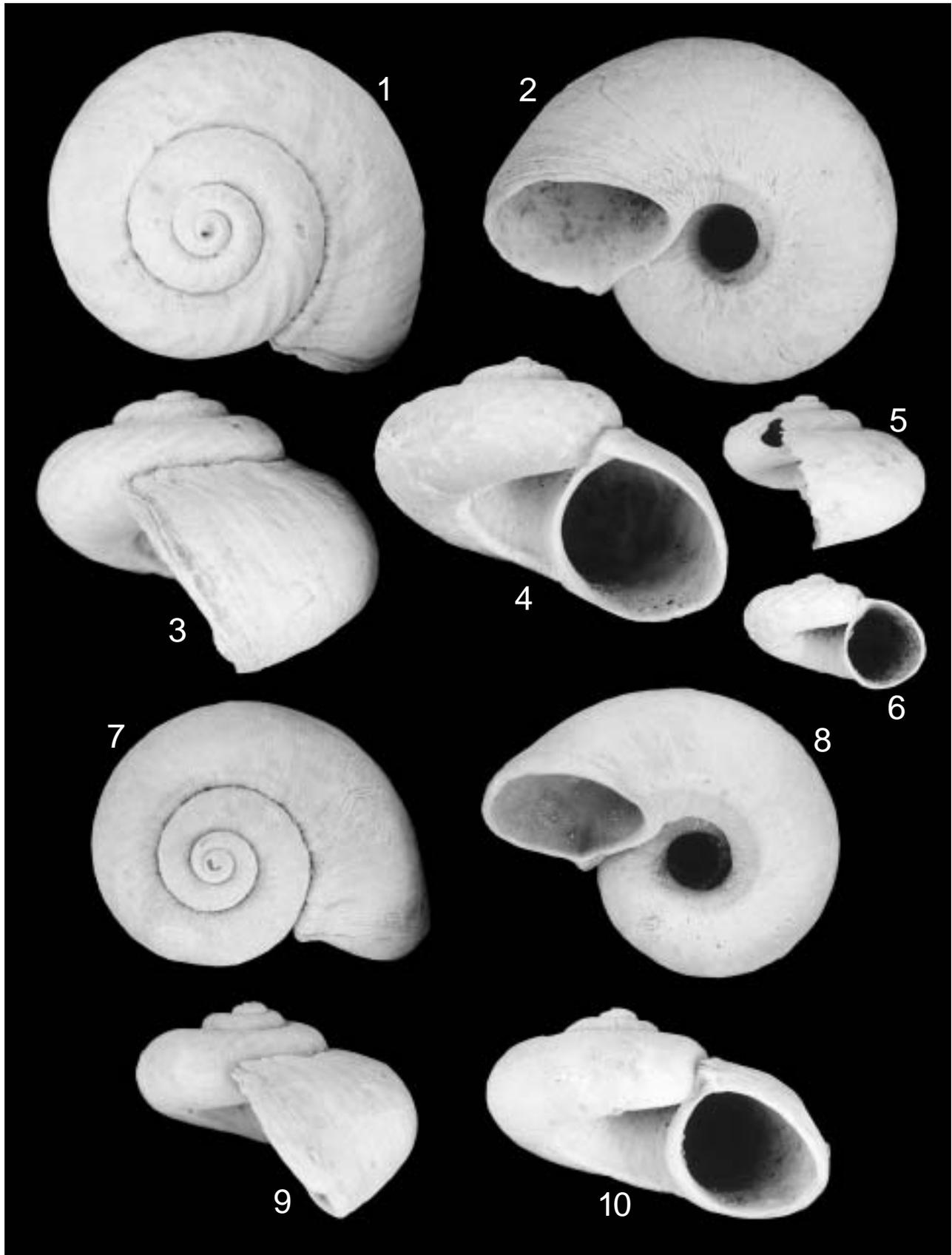


## Plate 2

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Figs. 1–6. *Poteria (Bartschivindex) varians* (C. B. Adams). 1–4, adults; 5, 6, juveniles. 1–3, RGM 188 710. 1, apical view. 2, umbilical view. 3, lateral view. 4, RGM 188 711, apertural view. 5, RGM 188 712, lateral view. 6, RGM 188 713, apertural view.
- Figs. 7–10. *Poteria (sensu lato)* sp., RGM 188 714. 7, apical view. 8, umbilical view. 9, lateral view. 10, apertural view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

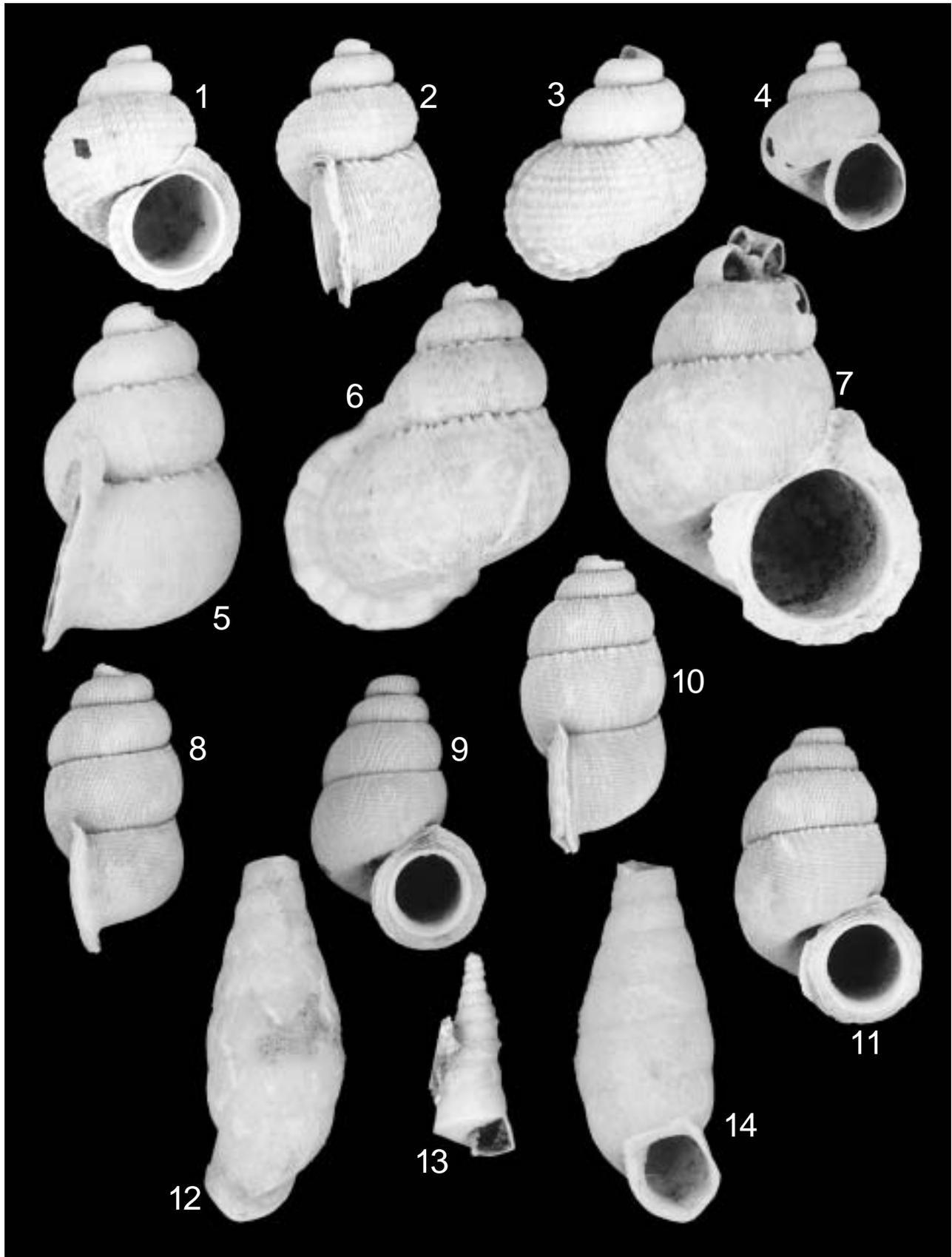


### Plate 3

Recent (Figs. 8, 9) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Figs. 1–3. *Colobostylus (Tudorops) yallahensis* (C. B. Adams). 1, 3, RGM 188 715. 1, apertural view. 3, posterior lateral view. 2, RGM 188 716, lateral view.
- Figs. 4–7. *Colobostylus (Colobostylus) thysanoraphe* (G. B. Sowerby II). 4, RGM 188 717, juvenile, apertural view. 5–7, adults. 5, RGM 188 718, lateral view. 6, RGM 188 719, posterior lateral view. 7, RGM 188 720, apertural view.
- Figs. 8–11. *Adamsiella (Adamsiella) grayana* (Pfeiffer). 8, RGM 188 721, lateral view. 9, RGM 188 722, apertural view. 10, 11, RGM 188 723. 10, lateral view. 11, apertural view.
- Figs. 12–14. *Anoma fuscolabris* (Chitty). 12, 14, RGM 188 724, adult. 12, posterior lateral view. 14, apertural view. 13, RGM 188 725, juvenile, apertural view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .



## Plate 4

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

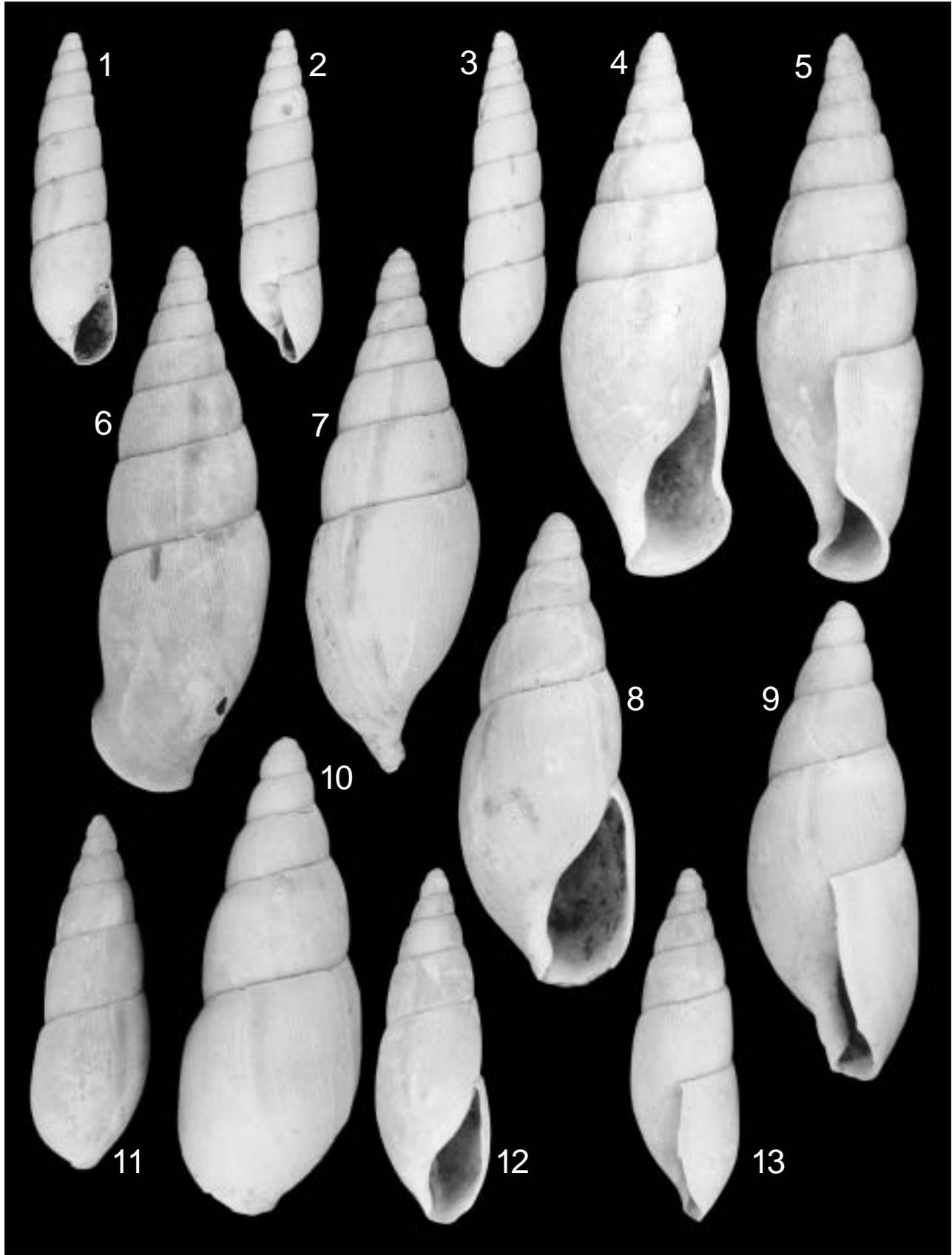
Figs. 1–3. *Sigmataxis procerus* (C. B. Adams), RGM 188 726. 1, apertural view. 2, lateral view. 3, apertural view.

Figs. 4–7. *Varicella (Varicellaria) griffithii* (C. B. Adams). 4–6, RGM 188 727. 4, apertural view. 5, lateral view. 6, posterior lateral view. 7, RGM 188 728, oblique posterior lateral view.

Figs. 8–10. *Euvaricella venusta* (Pfeiffer), RGM 188 729. 8, apertural view. 9, lateral view. 10, posterior lateral view.

Figs. 11–13. *Euvaricella nemorensis* (C. B. Adams), RGM 188 730. 11, posterior lateral view. 12, apertural view. 13, lateral view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

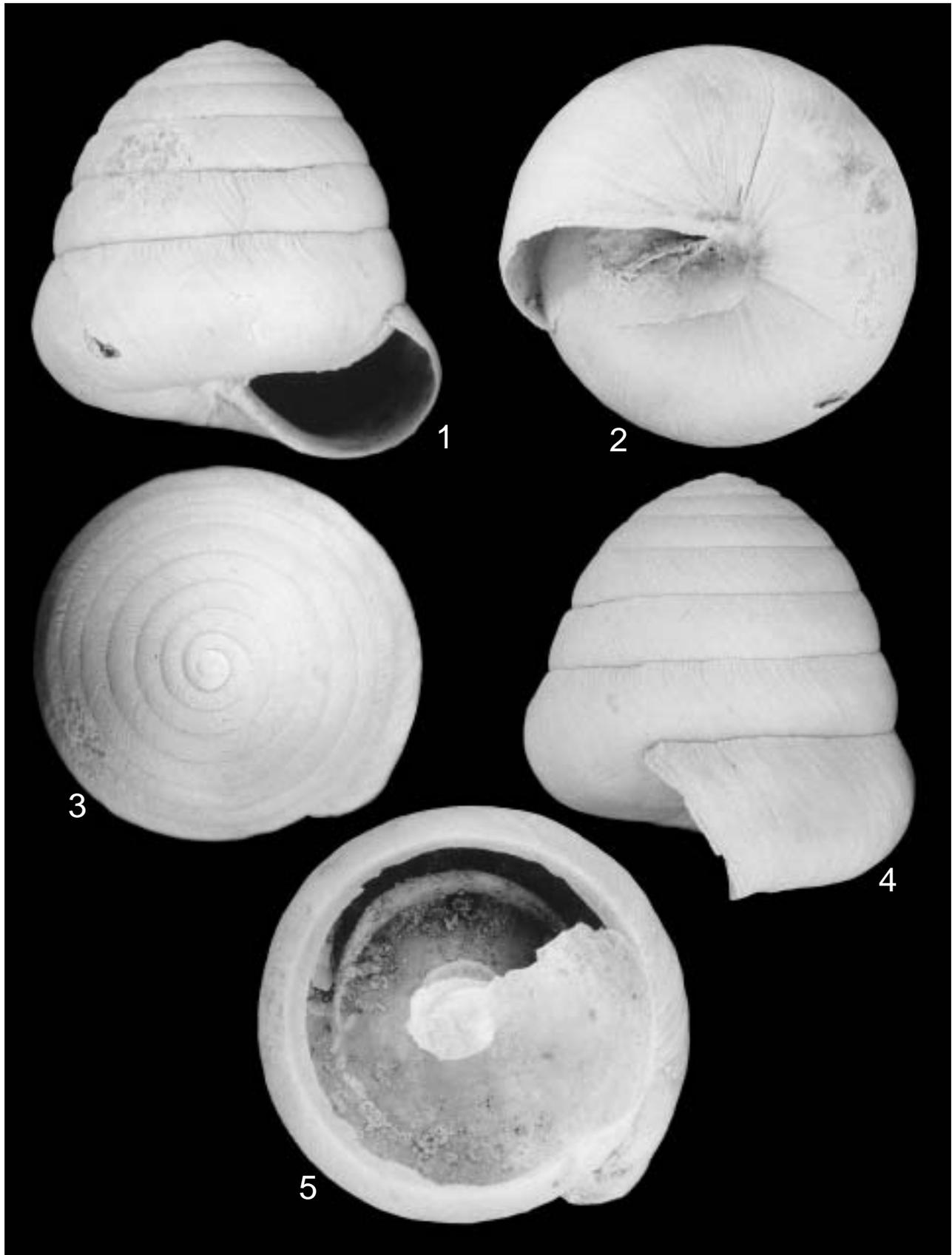


**Plate 5**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-5. *Sagda spei* Pilsbry and Brown. 1-4, RGM 188 731. 1, apertural view. 2, umbilical view. 3, apical view. 4, lateral view. 5, RGM 188 732, shell opened to reveal internal lamellae.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

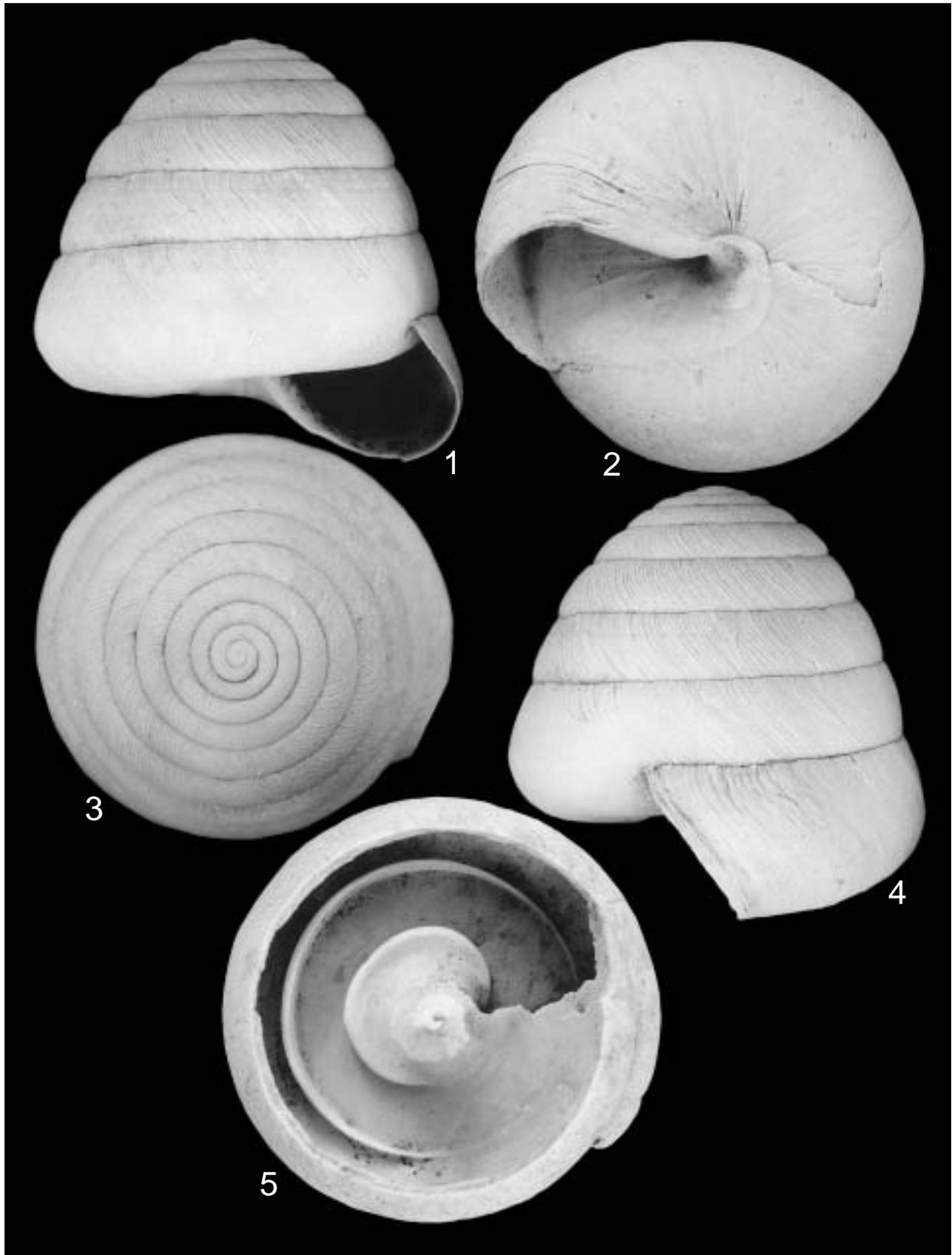


**Plate 6**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-5. *Sagda jayana* (C. B. Adams). 1, 4, RGM 188 733. 1, apertural view. 4, lateral view. 2, 3, RGM 188 734. 2, umbilical view. 3, apical view. 5, RGM 188 735, shell opened to reveal internal lamellae.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

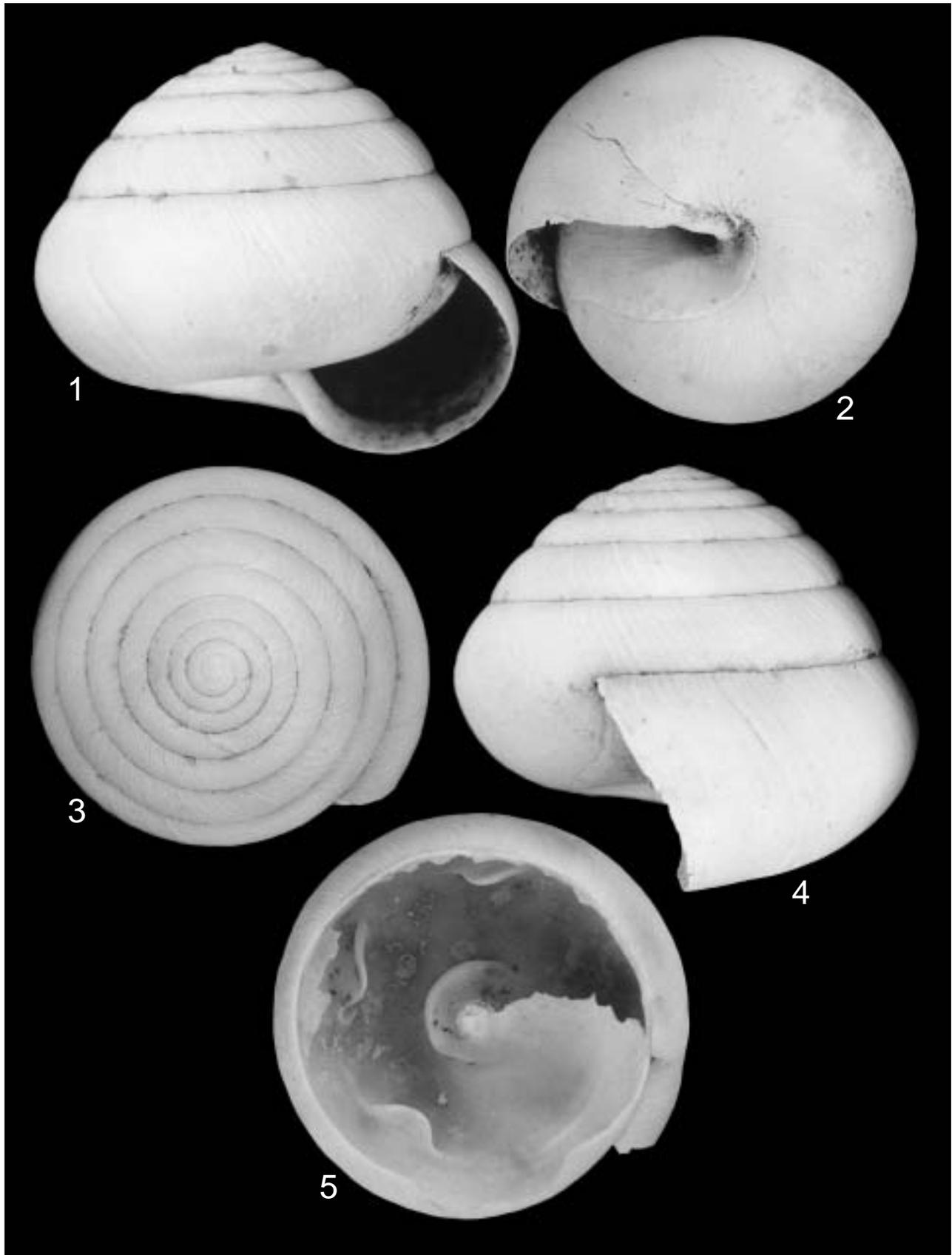


**Plate 7**

Recent gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-5. *Sagda cookiana* (Gmelin). 1-4, RGM 188 736. 1, apertural view. 2, umbilical view. 3, apical view. 4, lateral view. 5, RGM 188 737, shell opened to reveal internal lamellae.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

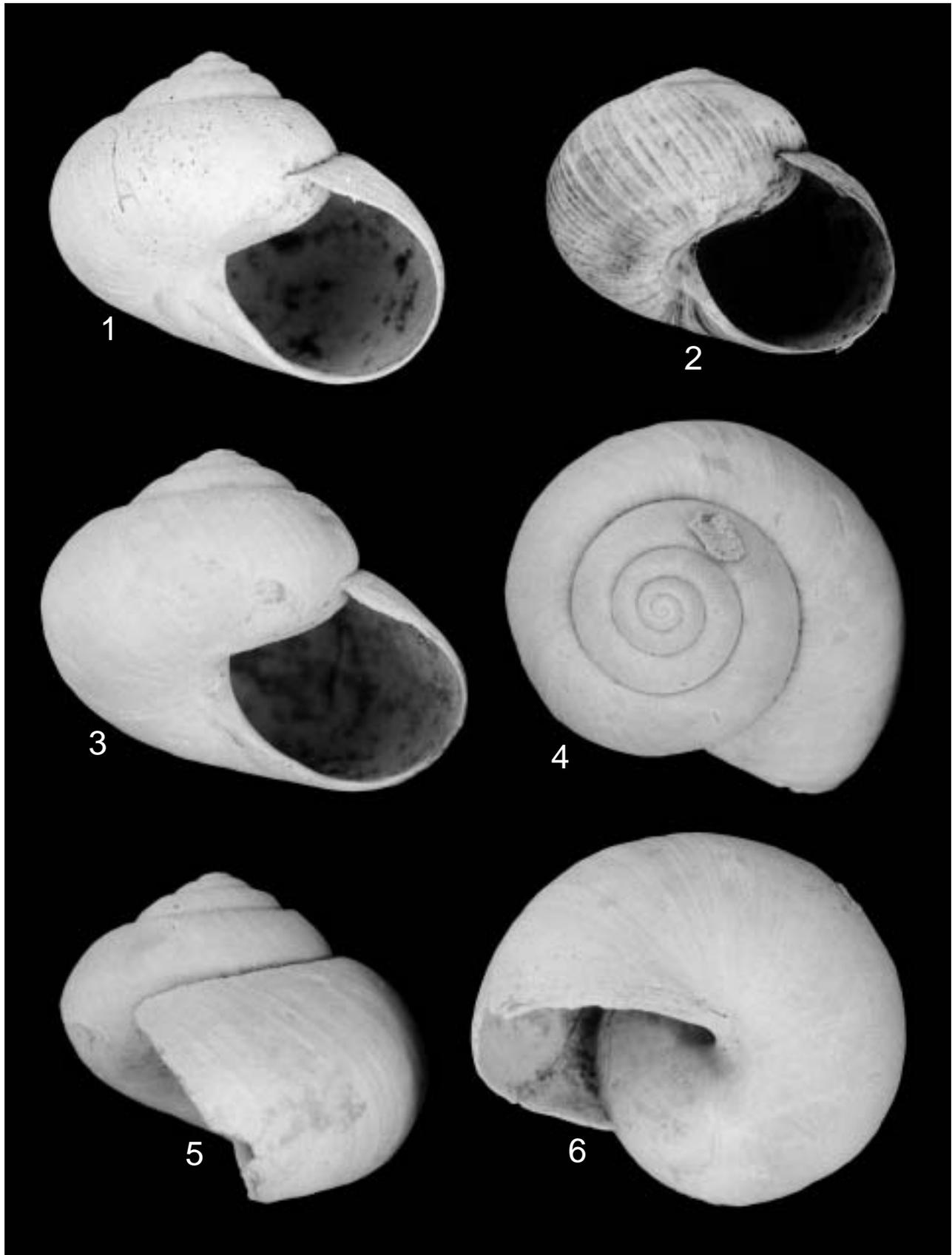


**Plate 8**

Recent (Fig. 2) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1–6. *Zaphysema tenerrimum* (C. B. Adams). 1, RGM 188 738, apertural view. 2, RGM 188 739, apertural view. 3–6, RGM 188 740. 3, apertural view. 4, apical view. 5, lateral view. 6, umbilical view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$ .

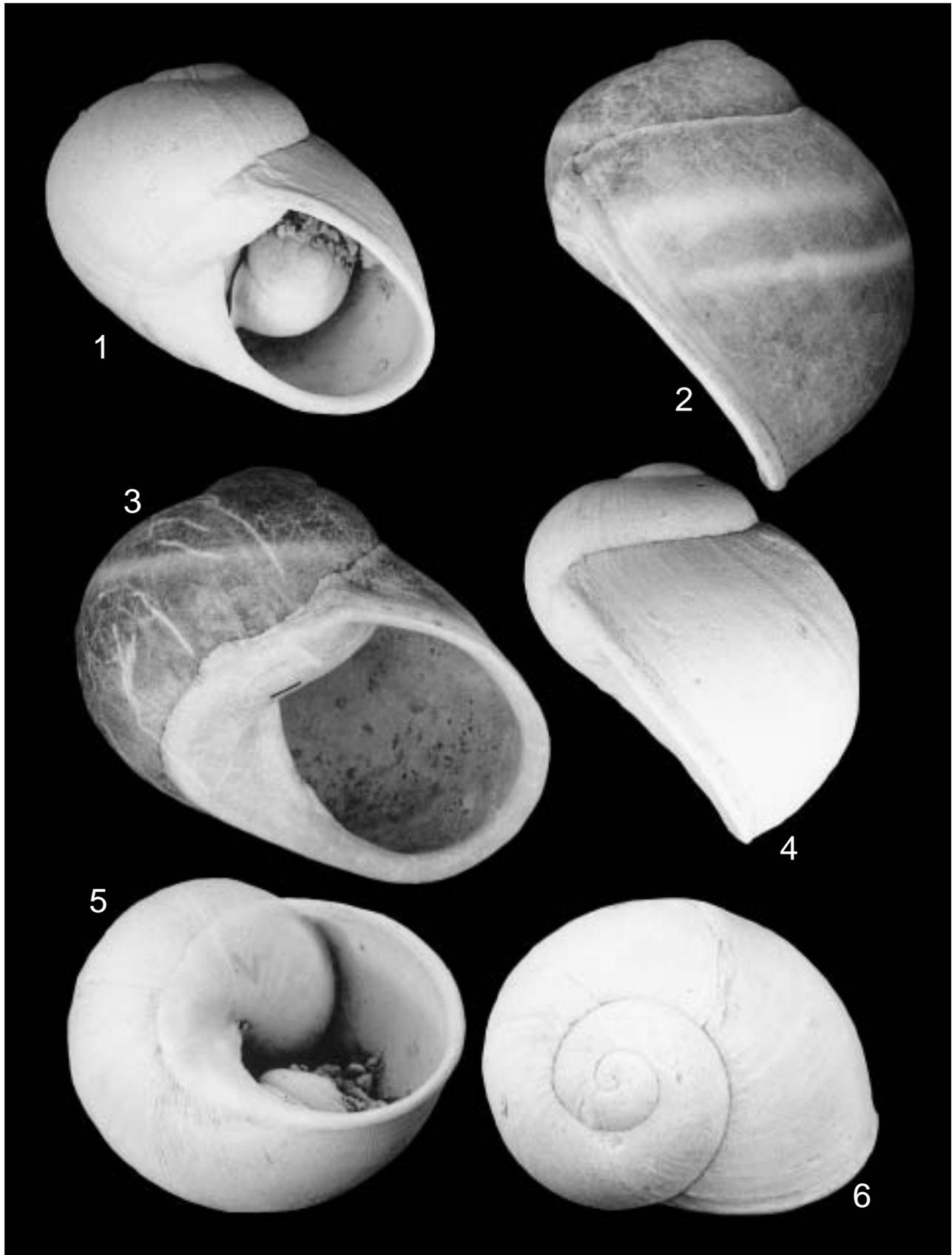


## Plate 9

Recent (Figs. 2, 3) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1–6. *Eurycratera jamaicensis* (Gmelin). 1, 4–6, RGM 188 741. 1, apertural view. 4, lateral view. 5, umbilical view. 6, apical view.  
Figs. 2, 3 RGM 188 742. 2, lateral view. 3, apertural view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 2$ .

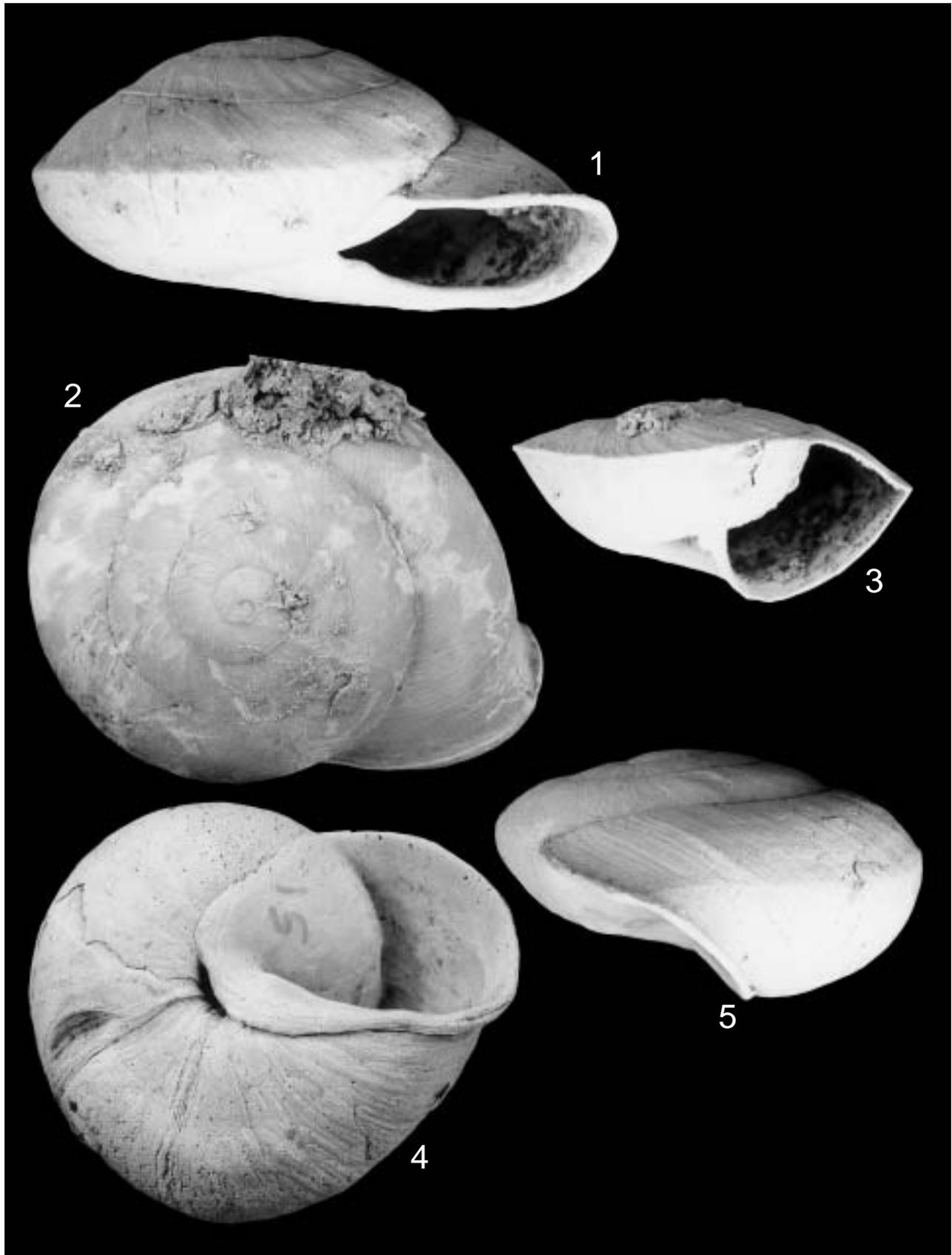


**Plate 10**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica. Adults unless stated otherwise.

Figs. 1-5. *Pleurodonte subacuta* (Pfeiffer). 1, RGM 188 743, apertural view,  $\times 2.4$ . 2, RGM 188 744, apical view,  $\times 2.2$ . 3, RGM 188 745, juvenile, apertural view,  $\times 3.7$ . 4, RGM 188 746, umbulical view,  $\times 2.2$ . 5, RGM 188 747, lateral view  $\times 2.4$ .

All specimens coated with ammonium chloride sublimate.

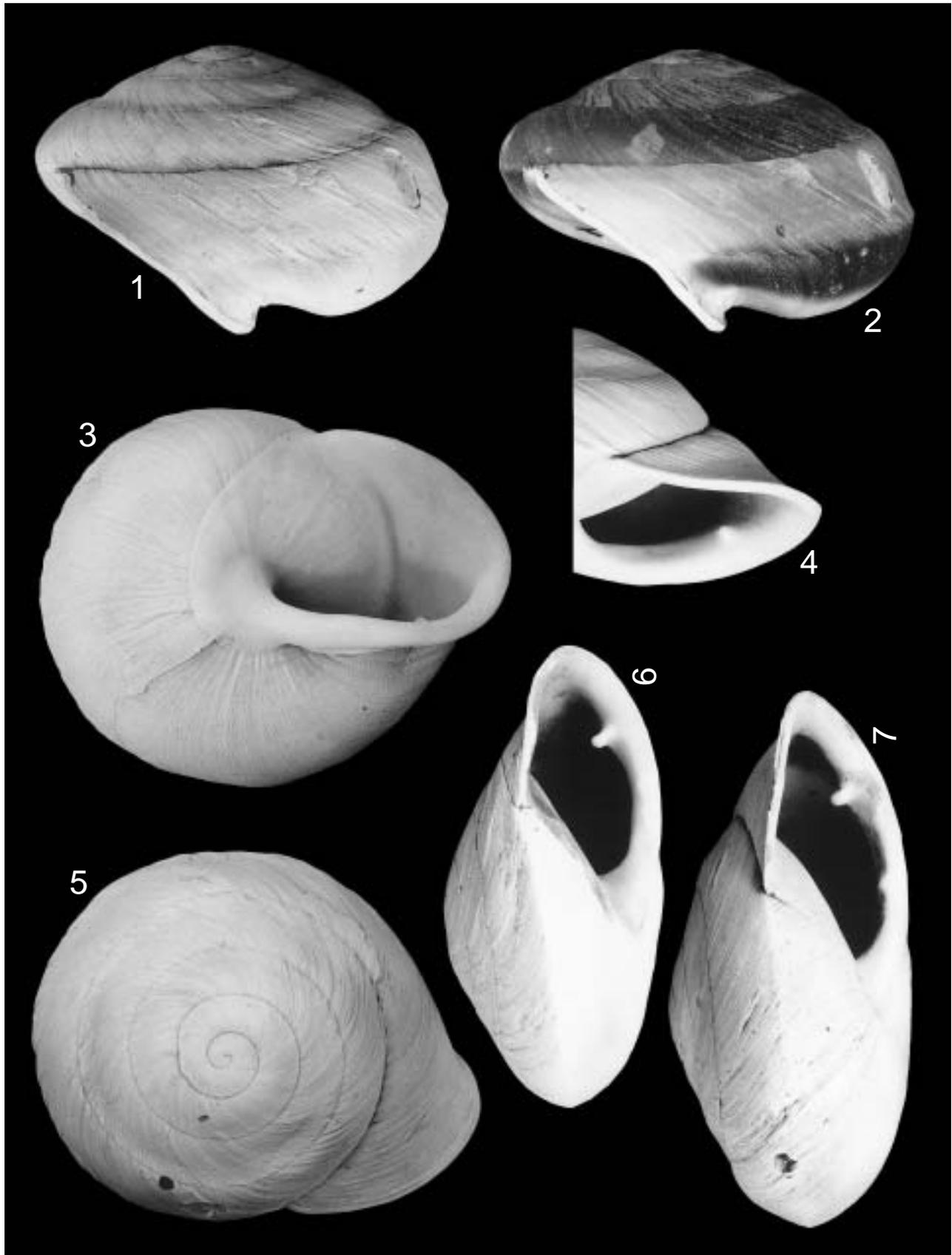


## Plate 11

Recent gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-7. *Pleurodonte sublucerna* (Pilsbry). 1, 2, 7, form with two teeth. 1, 2, RGM 188 748. 1, lateral view. 2, same view, specimen uncoated. 7, RGM 188 751, apertural view. 3-5, RGM 188 749, form with one weak tooth. 3, umbilical view. 4, apertural view. 5, apical view. 6, RGM 188 750, form with one well-developed tooth, apertural view.

All specimens, except Fig. 2, coated with ammonium chloride sublimate and all approximately  $\times 2$ .

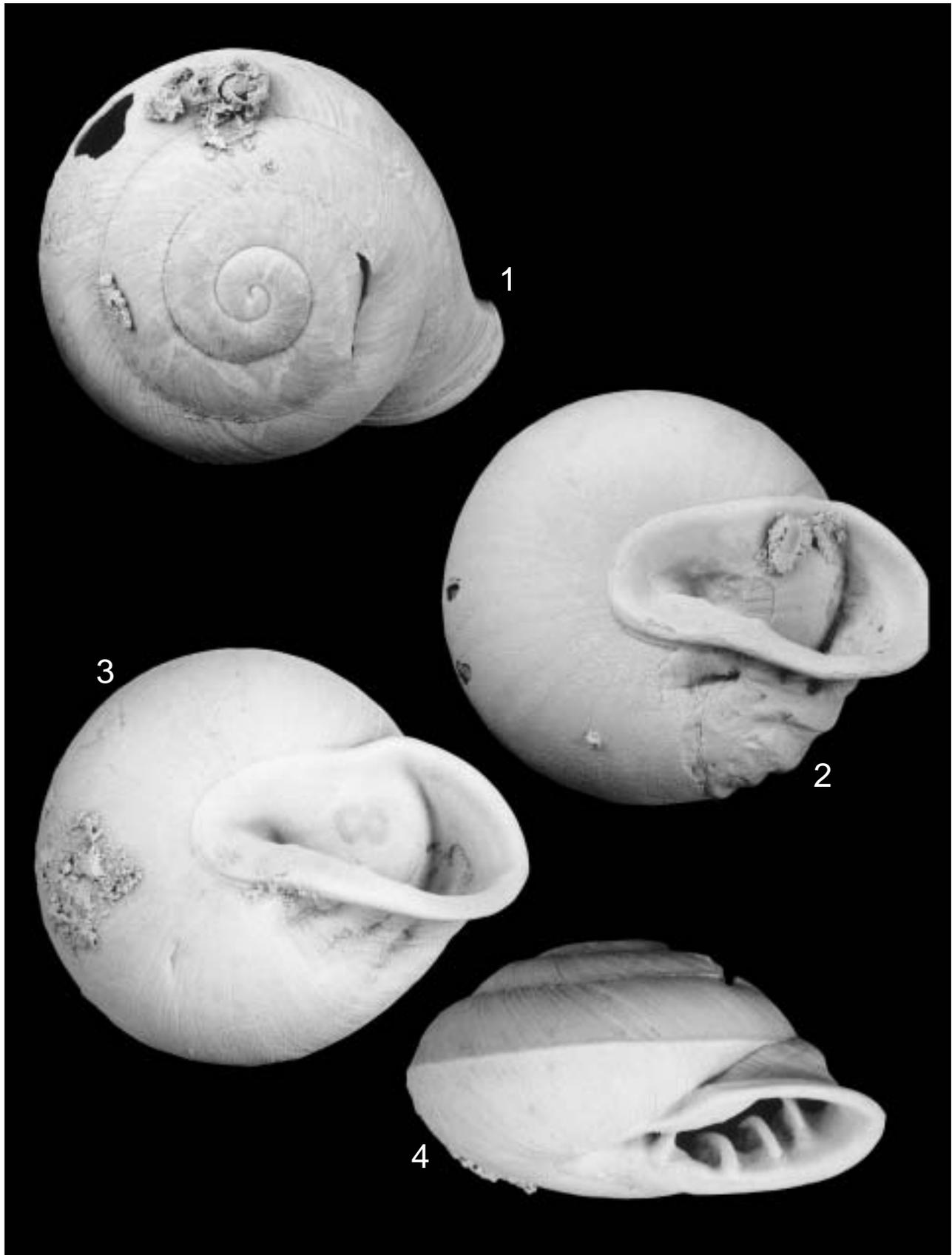


**Plate 12**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-4. *Pleurodonte sinuata* (Müller). 1, 3, 4, RGM 188 752. 1, apical view, × 3.8. 3, umbilical view, × 3.4. 4, apertural view, × 3.8. 2, RGM 188 753, umbilical view, × 3.4.

All specimens coated with ammonium chloride sublimate.

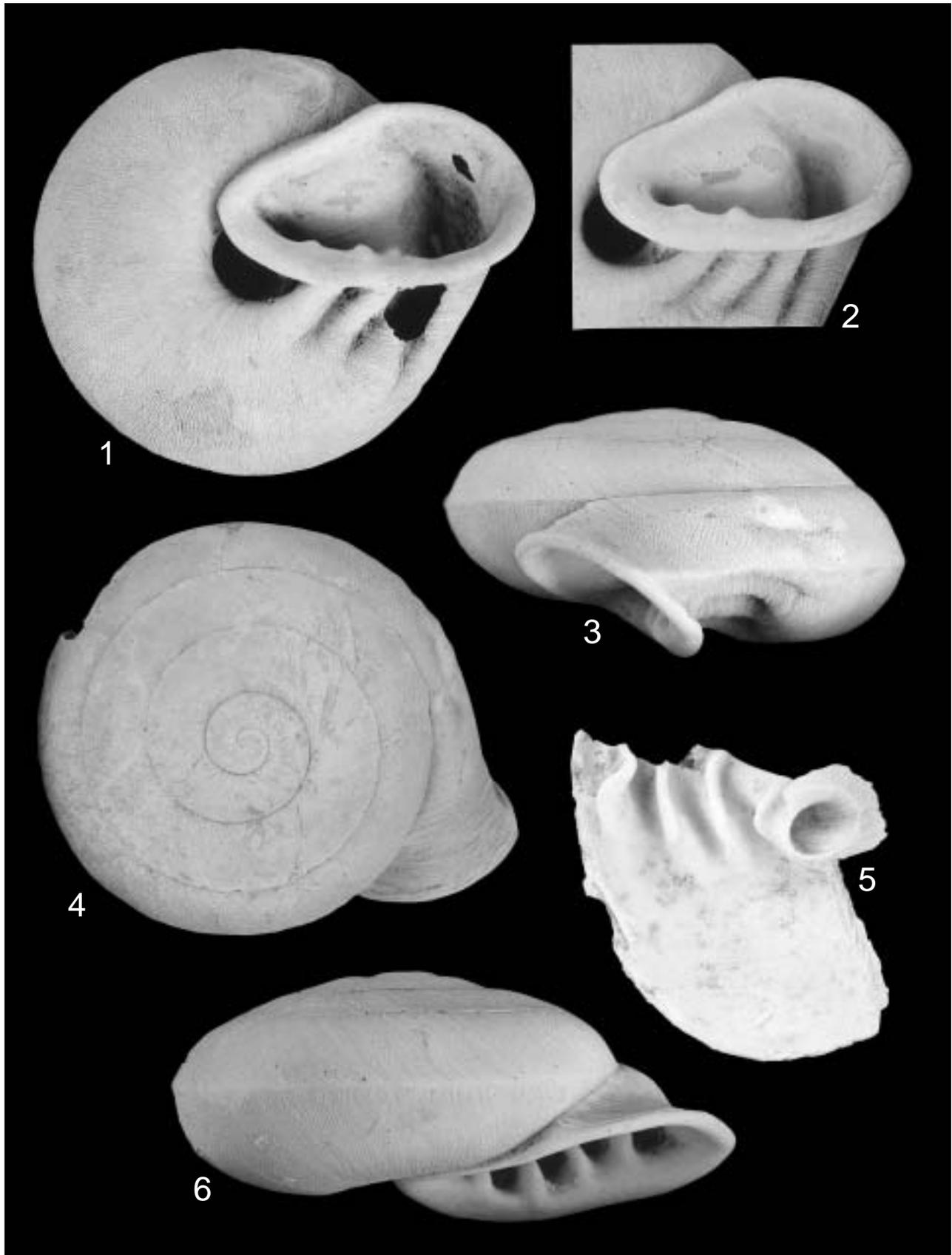


### Plate 13

Recent (Fig. 1) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1–6. *Pleurodonte candescens* (C. B. Adams). 1, RGM 188 754, umbilical view,  $\times 3.2$ . 2–4, 6, RGM 188 755. 2, umbilical view,  $\times 3.3$ . 3, lateral view,  $\times 4$ . 4, apical view,  $\times 3.4$ . 6, apertural view,  $\times 3.8$ . 5, RGM 188 756, broken aperture to show lamellae,  $\times 3.8$ .

All specimens coated with ammonium chloride sublimate.

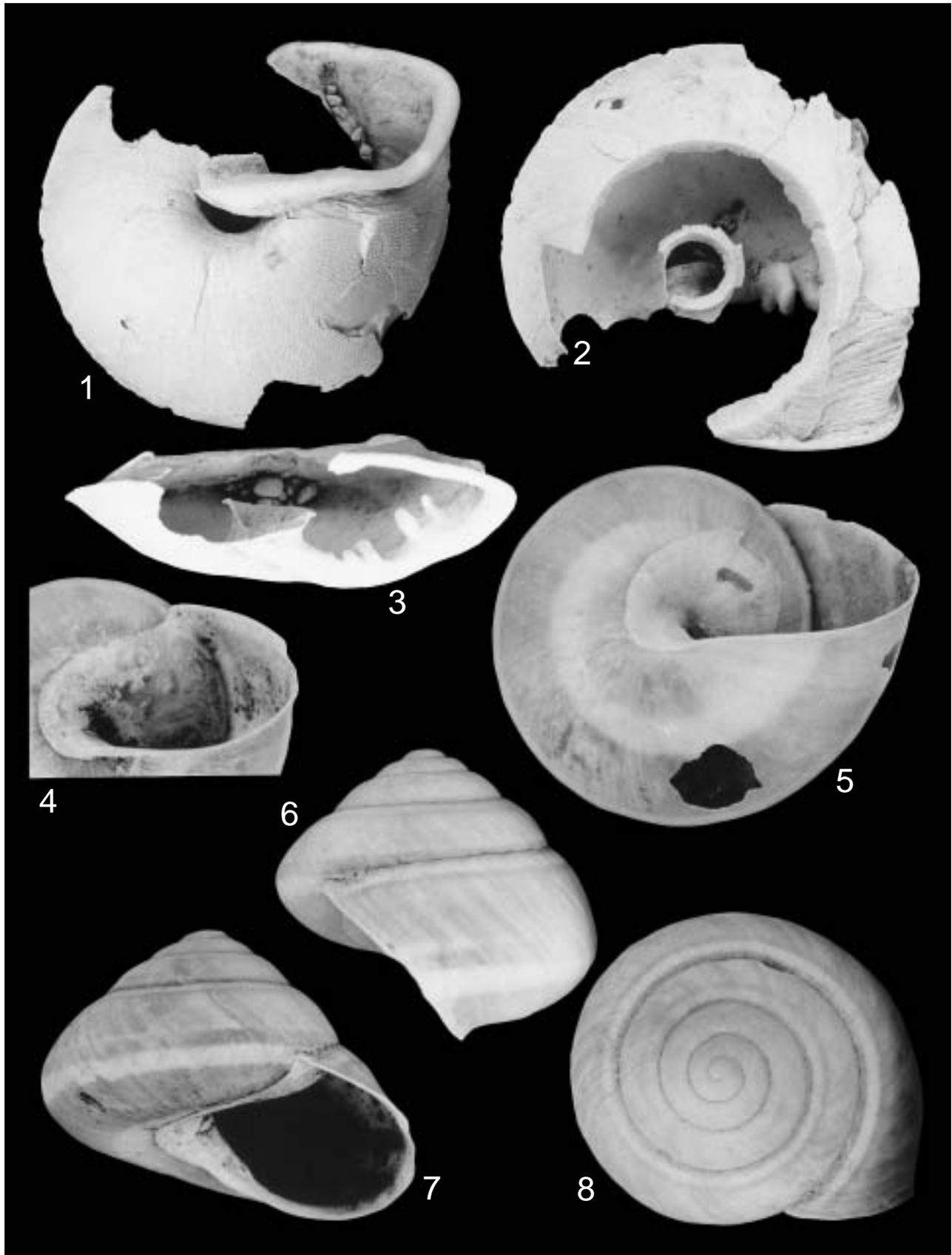


## Plate 14

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1–3. *Pleurodonte catadupae* (Baker), RGM 188 757. 1, umbilical view,  $\times 2.8$ . 2, apical view,  $\times 2.8$ . 3, apertural view,  $\times 2.9$ .  
Figs. 4–8. *Dialeuca conspersula* (Pfeiffer). 4, 6–8, RGM 188 758. 4, detail of aperture in umbilical view. 6, lateral view. 7, apertural view. 8, apical view. 5, RGM 188 759, umbilical view.

All specimens coated with ammonium chloride sublimate and approximately  $\times 4$  unless stated otherwise.

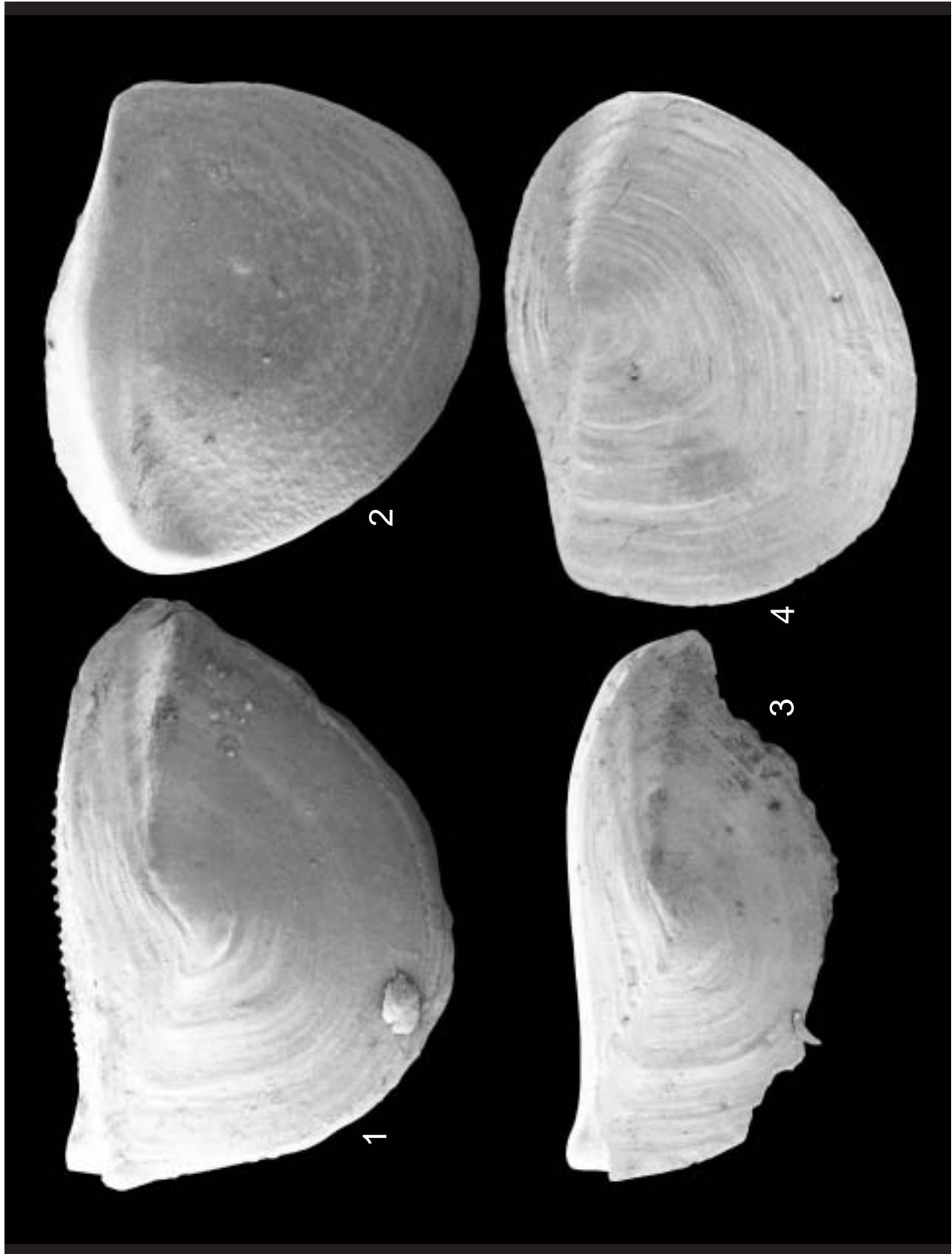


## Plate 15

Late Pleistocene helicimid opercula from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Fig. 1. *Alcacia* (?*Hjalmarsona*) *solitaria* (C. B. Adams). External surface, × 26.  
Figs. 2, 4. *Helicina neritella* (Lamarck). 2. internal surface. 4, external surface. Both, × 20.  
Fig. 3. *Alcacia brownii* (Gray). External surface, × 16.

All SE micrographs.



**Plate 16**

Late Pleistocene stoastomatid opercula from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 3. *Fadyenia leana* (C. B. Adams). 1, internal surface. 2, external surface. Both,  $\times 112$ .

Figs. 2, 4. *Fadyenia jayana* (C. B. Adams). 3, internal surface,  $\times 128$ . 4, external surface,  $\times 104$ .

All SE micrographs.



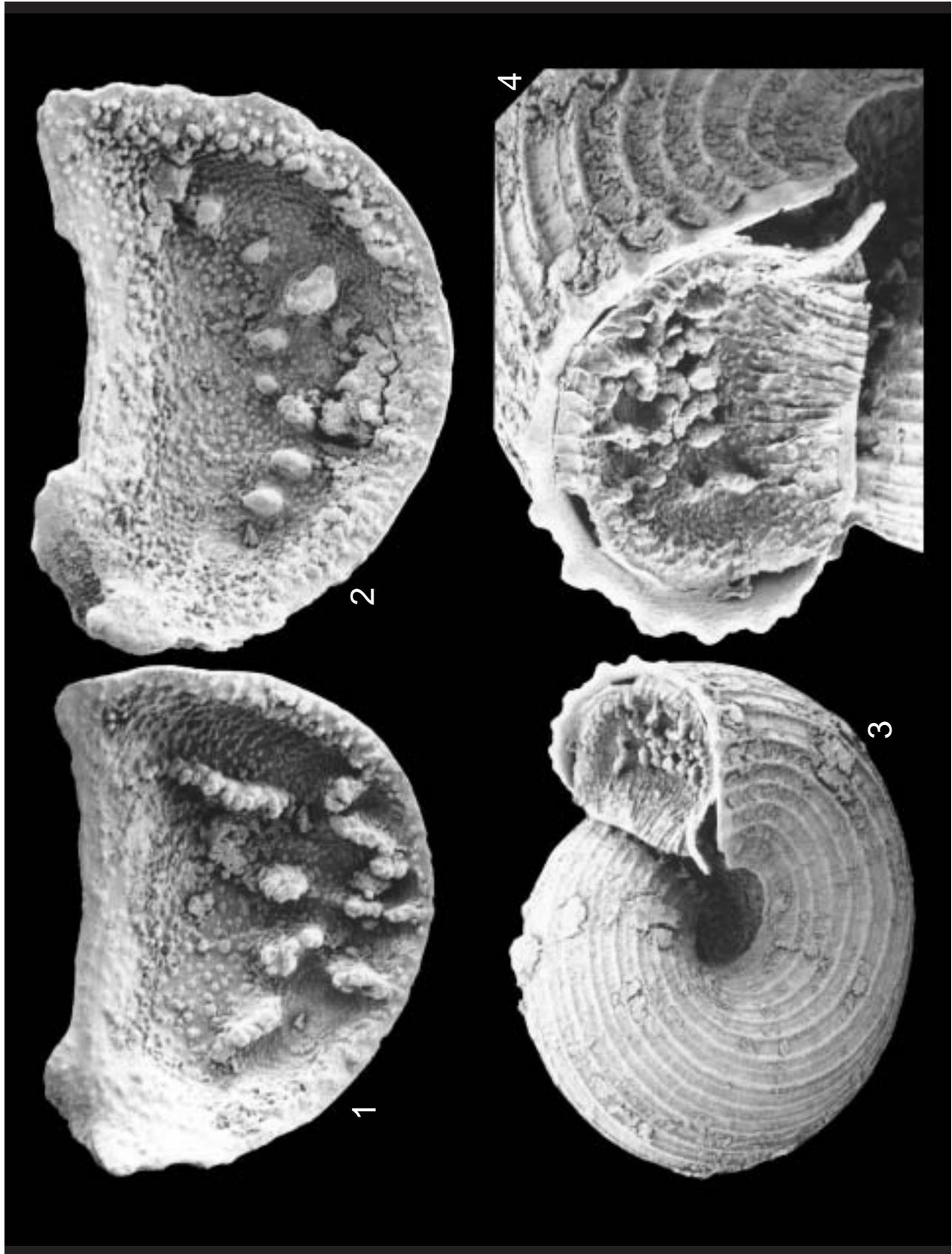
**Plate 17**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Fadyenia jayana* (C. B. Adams). 1, 2, external surfaces of isolated opercula. 1,  $\times 128$ . 2,  $\times 104$ .

Figs. 3, 4. *Fadyenia lindsleyana* (C. B. Adams). 3, oblique umbilical view of shell with operculum in place,  $\times 40$ . 4, detail of operculum of preceding example,  $\times 100$ .

All SE micrographs.



**Plate 18**

Recent (Figs. 1, 3) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-4. *Fadyenia blandiana* (C. B. Adams). 1, umbilical view,  $\times 60$ . 2, umbilical view of shell with operculum in place,  $\times 64$ . 3, apical view,  $\times 64$ . 4, details of operculum,  $\times 160$ .

All SE micrographs.

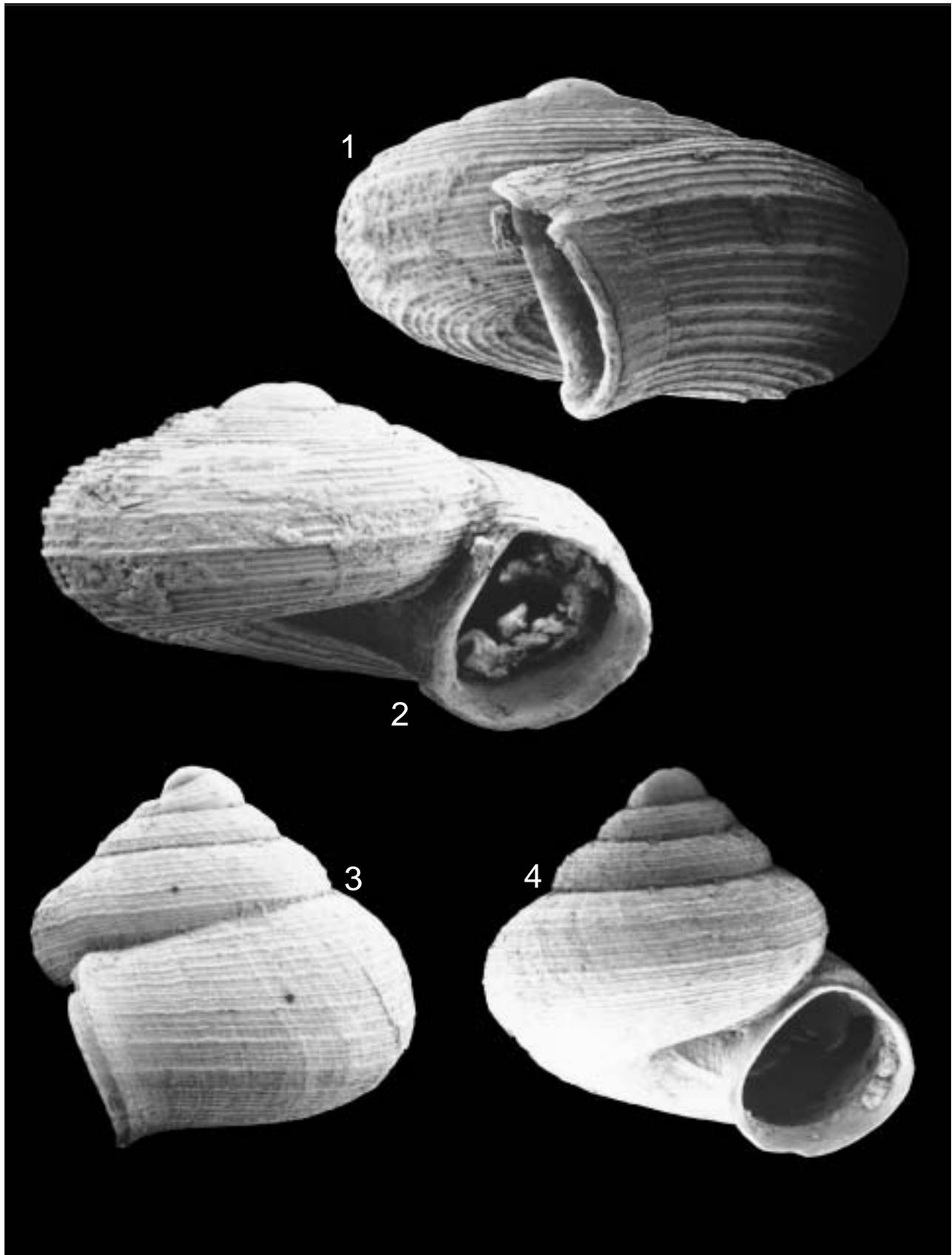


**Plate 19**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Fadyenia blandiana* (C. B. Adams). 1, lateral view,  $\times 80$ . 2, apertural view,  $\times 72$ .  
Figs. 3, 4. *Fadyenia leana* (C. B. Adams). 3, lateral view. 4, apertural view. Both,  $\times 40$ .

All SE micrographs.

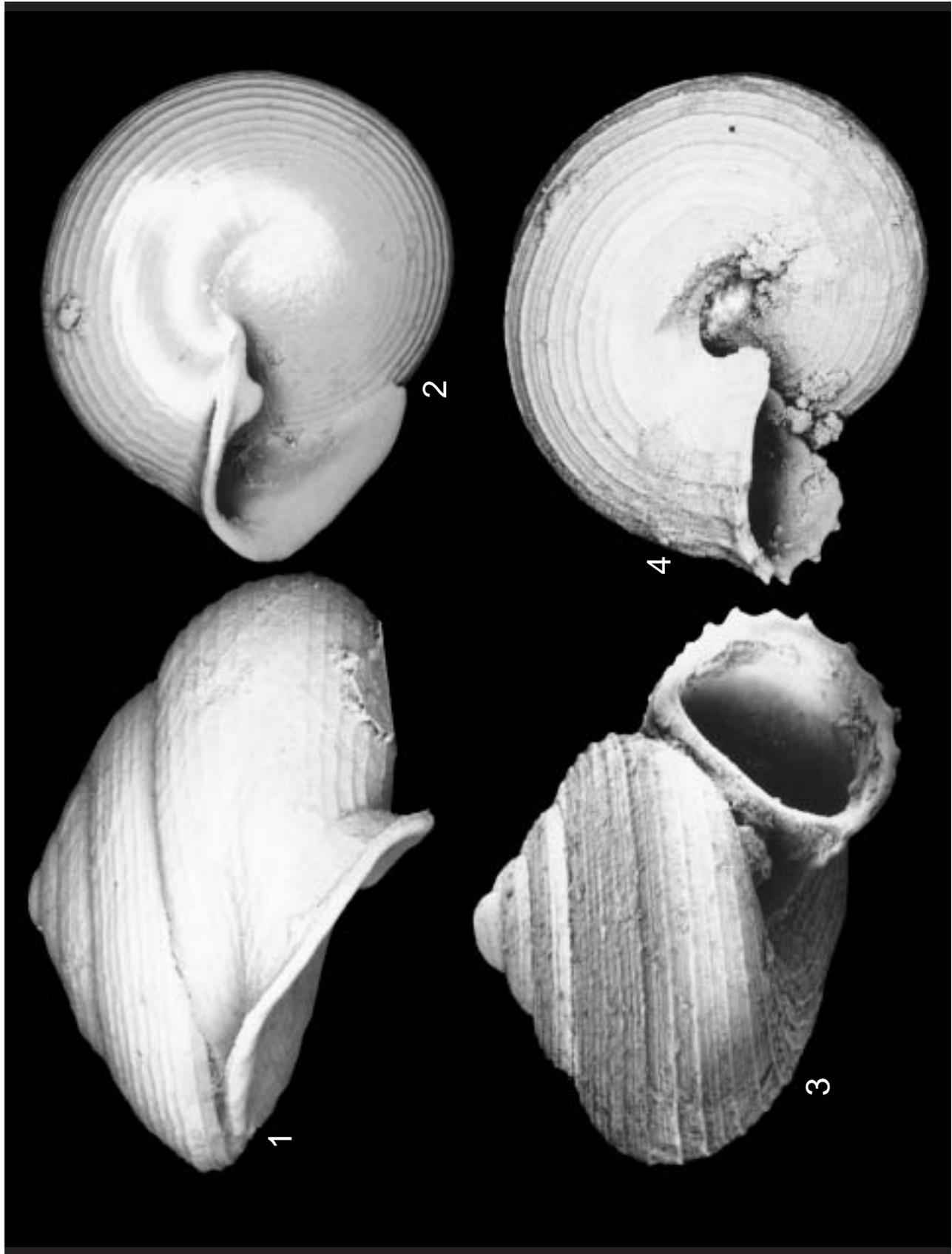


**Plate 20**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Lucidella (Perenna) lineata* (C. B. Adams). 1, lateral view,  $\times 40$ . 2, umbilical view,  $\times 26$ .  
Figs. 3, 4. *Fadyenia jayana* (C. B. Adams). 3, apertural view,  $\times 52$ . 4, umbilical view,  $\times 48$ .

All SE micrographs.



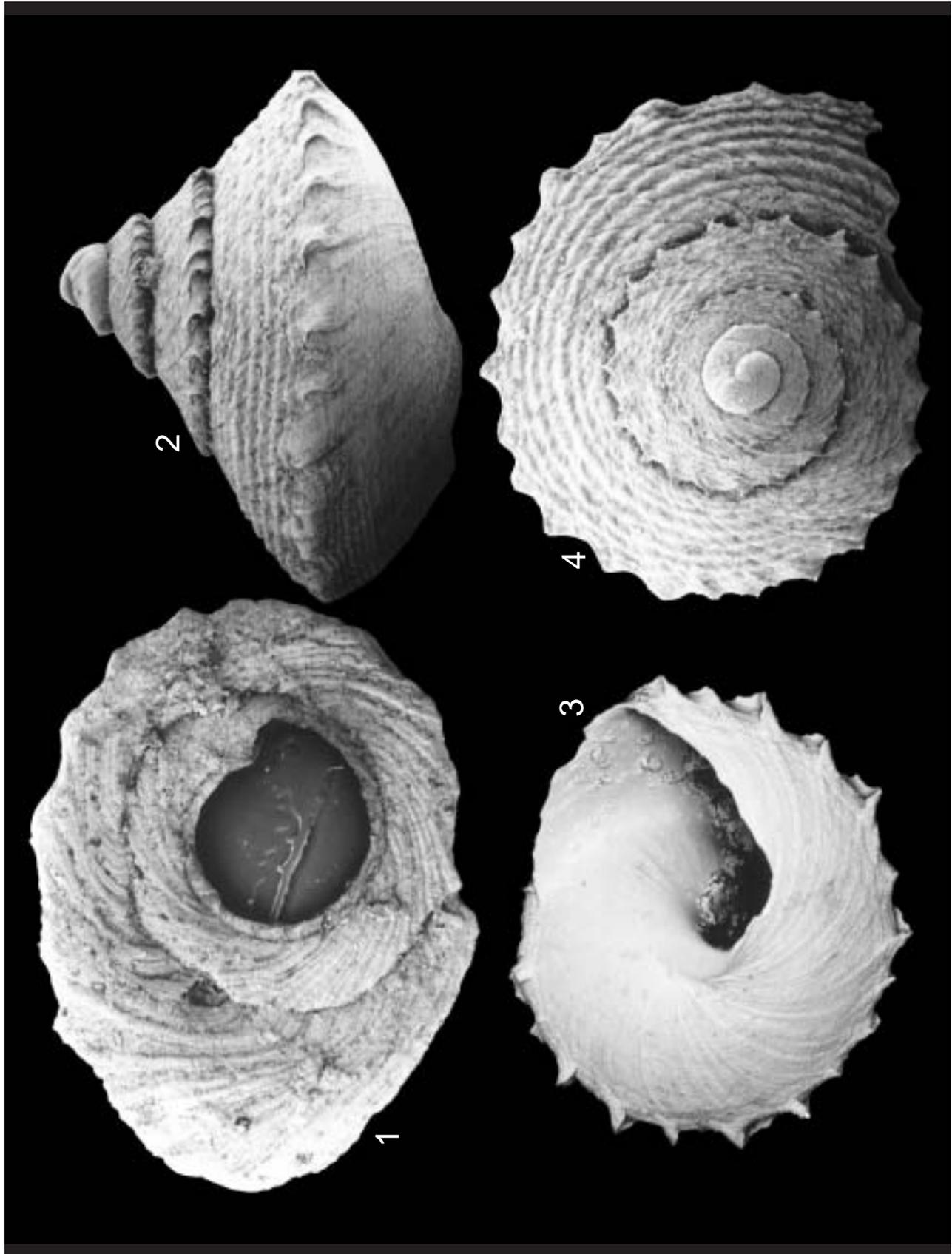
**Plate 21**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Fig. 1. Operculum of *Colobostylus (Tudorops) yallahensis* (C. B. Adams). External surface,  $\times 20$ .

Figs. 2–4. *Eurochatella pulchella* (Gray) juvenile. 2, posterior lateral view,  $\times 20$ . 3, umbilical view,  $\times 34$ . 4, apical view,  $\times 20$ .

All SE micrographs.

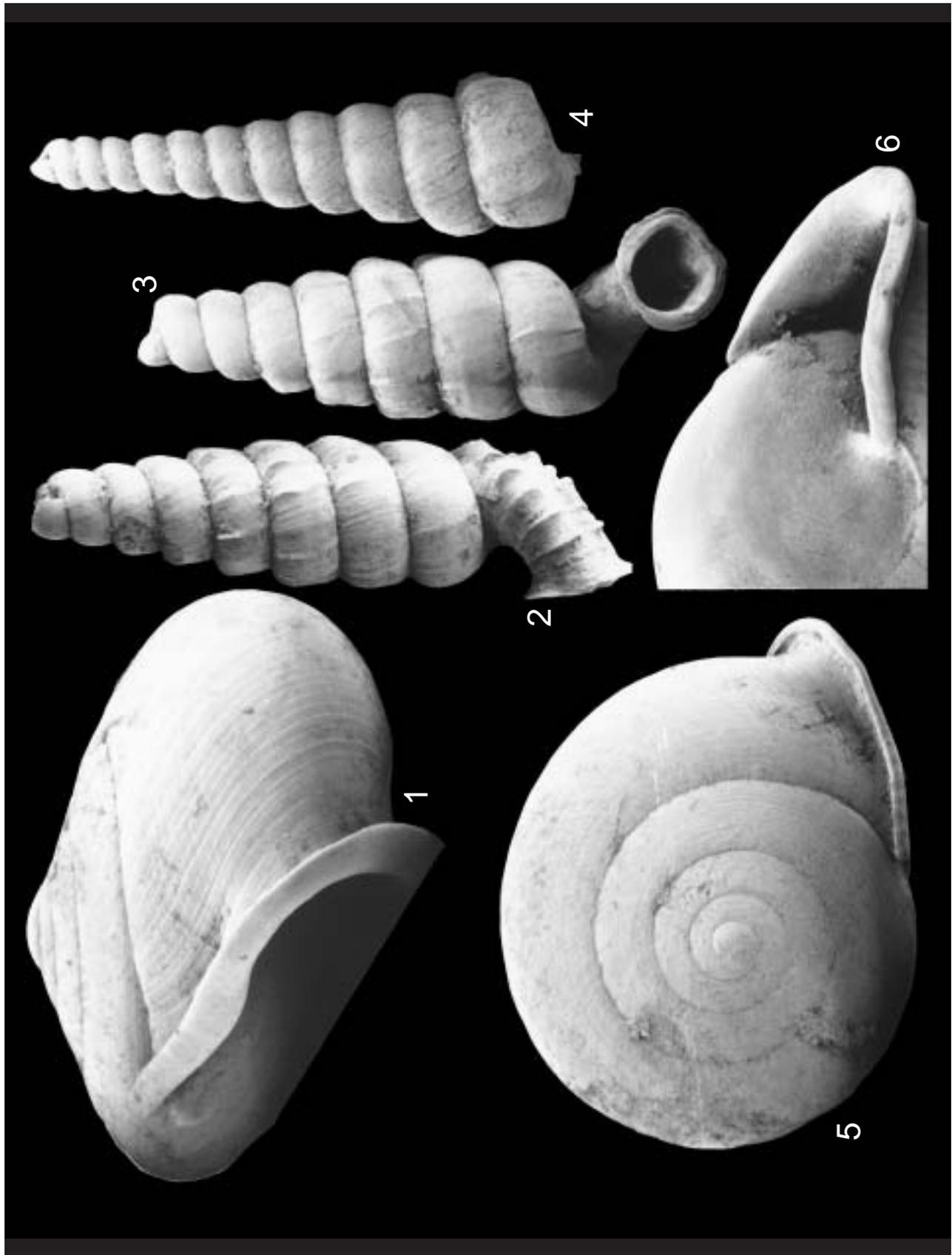


**Plate 22**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 5, 6. *Lucidella (Poenia) depressa* (Gray). 1, lateral view,  $\times 24$ . 5, apical view,  $\times 17$ . 6, detail of aperture in umbilical view,  $\times 20$ .  
Figs. 2-4. *Geoscala costulata* (C. B. Adams). 2, 3, adult shell. 2, lateral view  $\times 15$ . 3, apertural view,  $\times 16$ . 4, juvenile shell in posterior lateral view,  $\times 18$ .

All SE micrographs.



### Plate 23

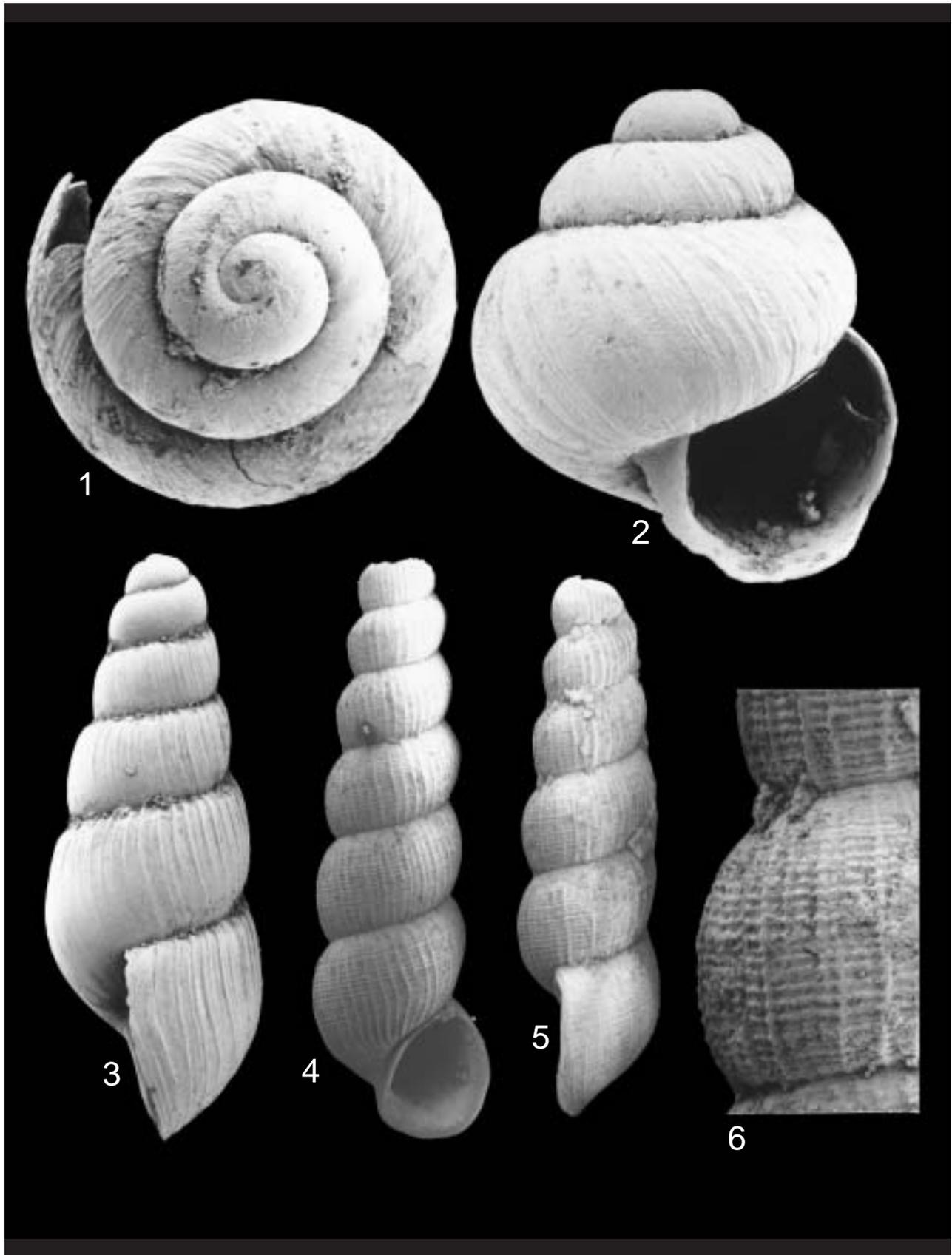
Recent (Fig. 3) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Ptychopatala* sp. a. 1, apical view,  $\times 60$ , 2, apertural view,  $\times 64$ .

Fig. 3. *Allopeas micra* (d'Orbigny). Lateral view,  $\times 20$ .

Figs. 4, 6. *Geomelania (Merrilliana) parvula* Pilsbry and Brown. 4, apertural view,  $\times 18$ . 5, lateral view,  $\times 20$ . 6, detail of ornament on penultimate whorl,  $\times 64$ .

All SE micrographs.

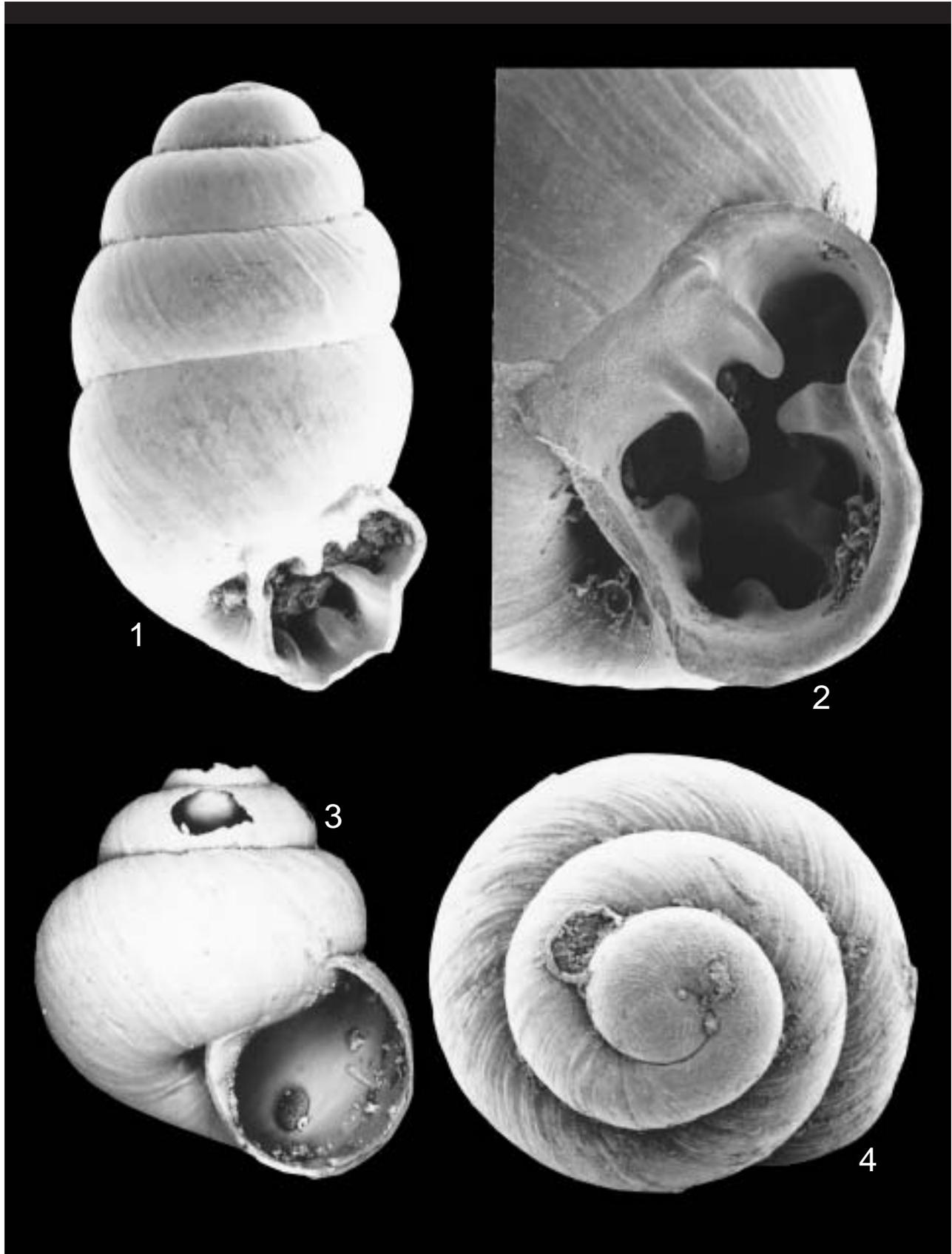


**Plate 24**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Vertigo milium* (Gould). 1, apertural view,  $\times 80$ . 2, detail of aperture,  $\times 160$ .  
Figs. 3, 4. *Ptychopatala macneilli* (Clapp). 3, apertural view,  $\times 64$ . 4, apical view,  $\times 80$ .

All SE micrographs.



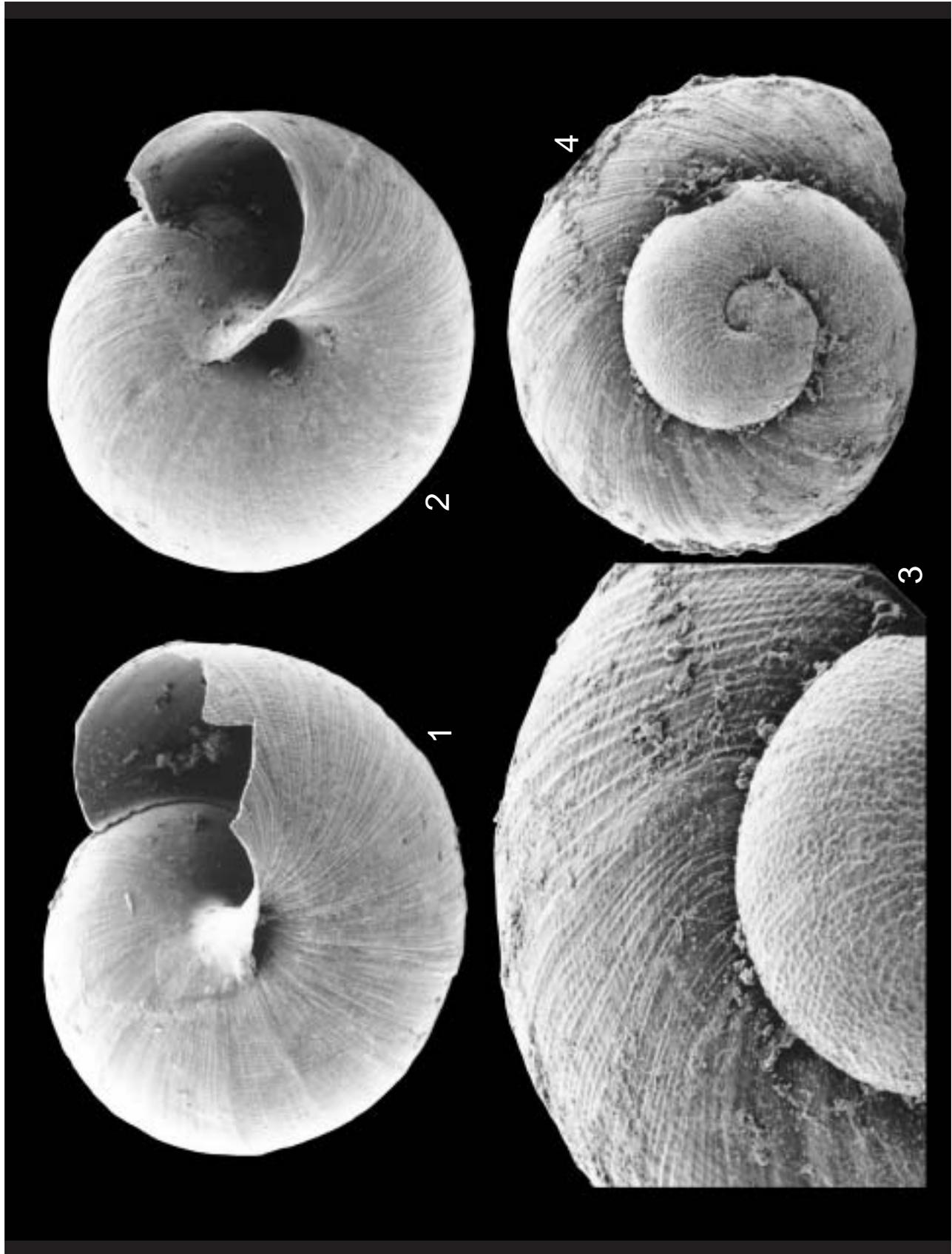
**Plate 25**

Recent and Late Pleistocene (Fig. 2) gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 3, 4. *Ptychopatala dioscoricola* (C. B. Adams). 1, umbilical view,  $\times 72$ . 2, detail of surface ornament (note the spiral striae),  $\times 160$ .  
4, apical view,  $\times 80$ .

Fig. 2. *Ptychopatala* sp. b. Umbilical view,  $\times 68$ .

All SE micrographs.

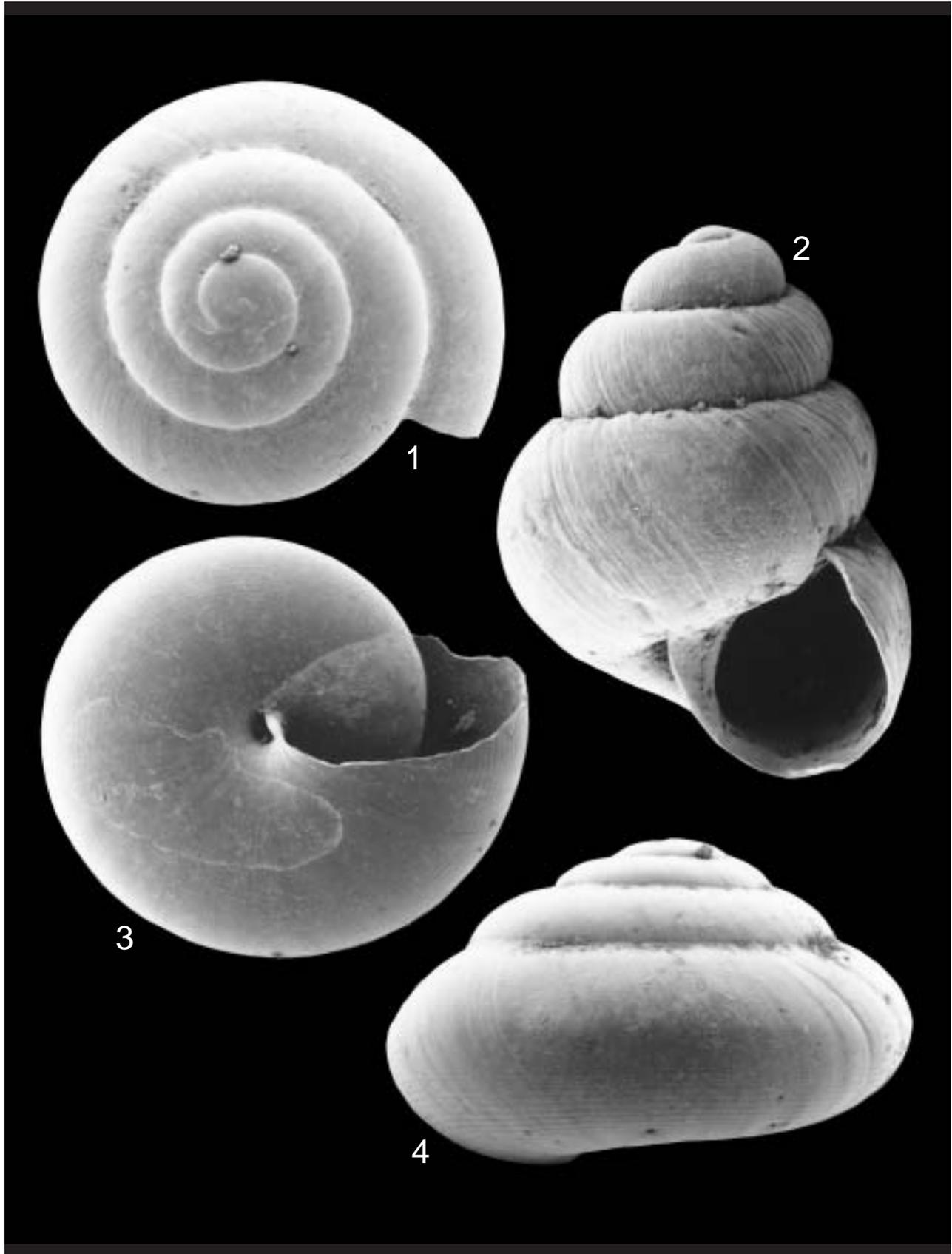


**Plate 26**

Recent and Late Pleistocene (Fig. 2) gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 3, 4. *Guppya gundlachi* (Pfeiffer). 1, apical view,  $\times 36$ . 3, umbilical view,  $\times 40$ . 4, posterior lateral view,  $\times 40$ .  
Fig. 2. *Ptychopatula* sp. b. Apertural view,  $\times 68$ .

All SE micrographs.

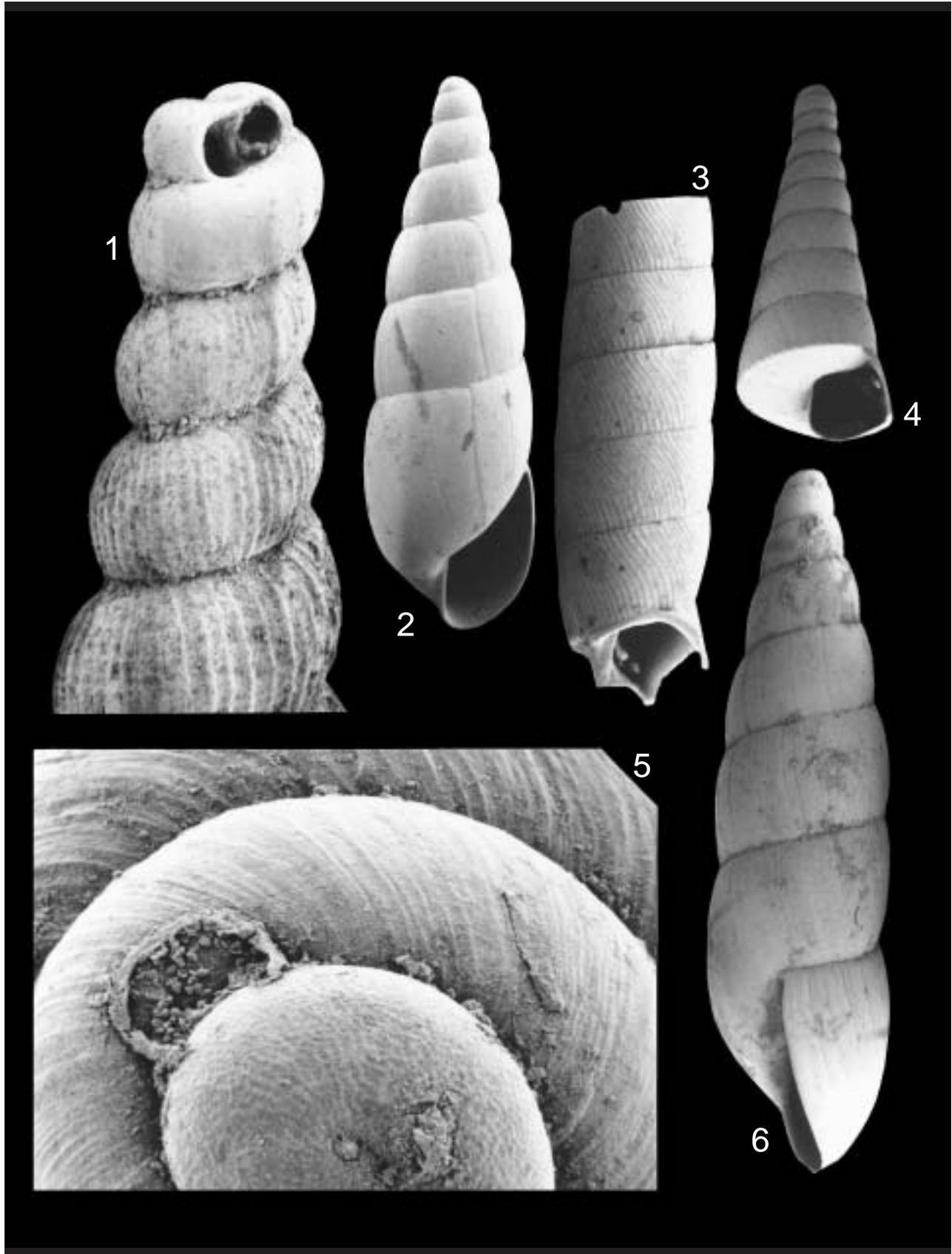


## Plate 27

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Fig. 1            *Geomelania (Merrilliana) parvula* Pilsbry and Brown, Juvenile, detail of apical whorls, × 64.  
Figs. 2, 6.      *Sigmataxis procerus* (C. B. Adams). 2, apertural view. 6, lateral view. Both, × 10.  
Fig. 3.          *Spirostemma tenellum* (C. B. Adams). Lower whorls of damaged shell, × 10.  
Fig. 4.          *Anoma fuscolabris* (Chitty). Juvenile shell in apertural view, × 10.  
Fig. 5.          *Ptychopatula macneilli* (Clapp). Details of surface ornament, × 160.

All SE micrographs.



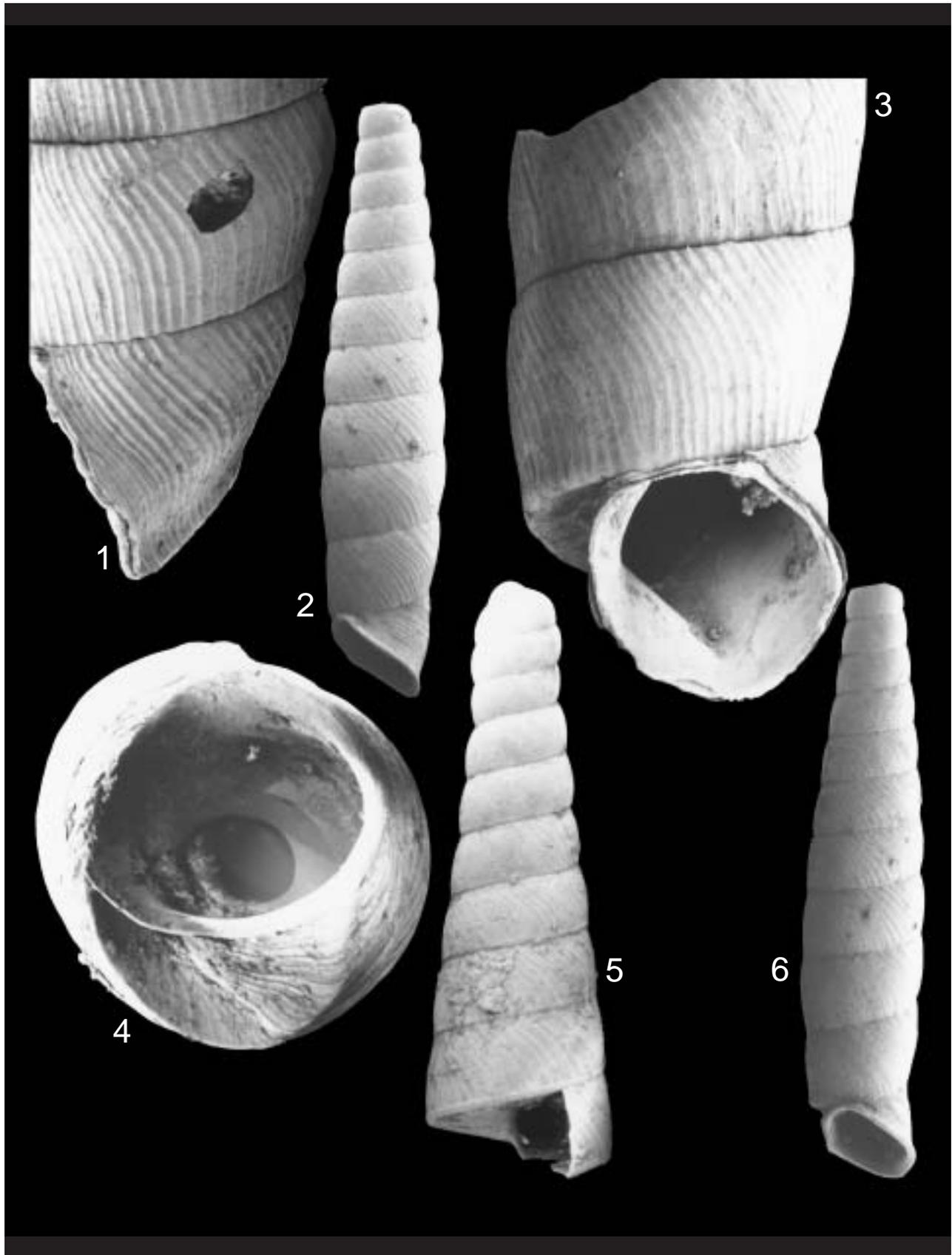
**Plate 28**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 3. *Spirostemma* cf. *S. dunkeri* (Pfeiffer). 1, lateral view. 3, apertural view of fragmentary shell. Both,  $\times 20$ .

Figs. 2, 4–6. *Spirostemma tenellum* (C. B. Adams). 2, oblique lateral view. 6, oblique apertural view. Both,  $\times 13$ . 4, detail of false umbilicus,  $\times 40$ . 5, apical whorls of juvenile,  $\times 24$ .

All SE micrographs.



## Plate 29

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

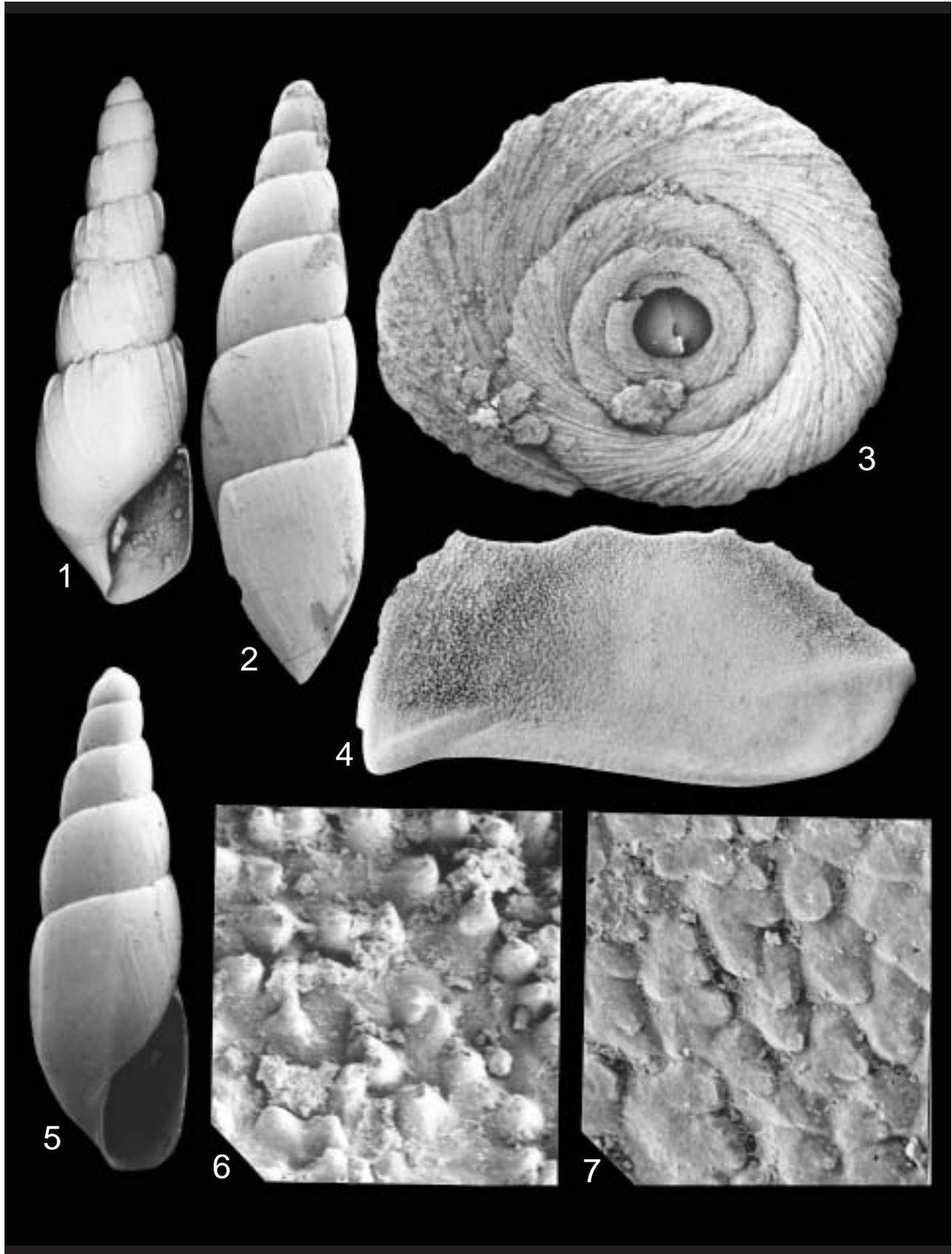
Fig. 1. *Costavarix gossei* (Pfeiffer). Apertural view,  $\times 16$ .

Figs. 2, 5. *Sigmataxis* sp. a. 2, lateral view. 5 apertural view. Both,  $\times 12$ .

Fig. 3. External surface of operculum of *Colobostylus (Colobostylus) thysanoraphe* (Sowerby),  $\times 20$ .

Figs. 4, 6, 7. Internal surface of operculum of *Alcadia brownii* (Gray). 4, general view,  $\times 16$ . 6, detail of pointed tubercles,  $\times 320$ . 7, detail of flattened tubercles,  $\times 320$ .

All SE micrographs.

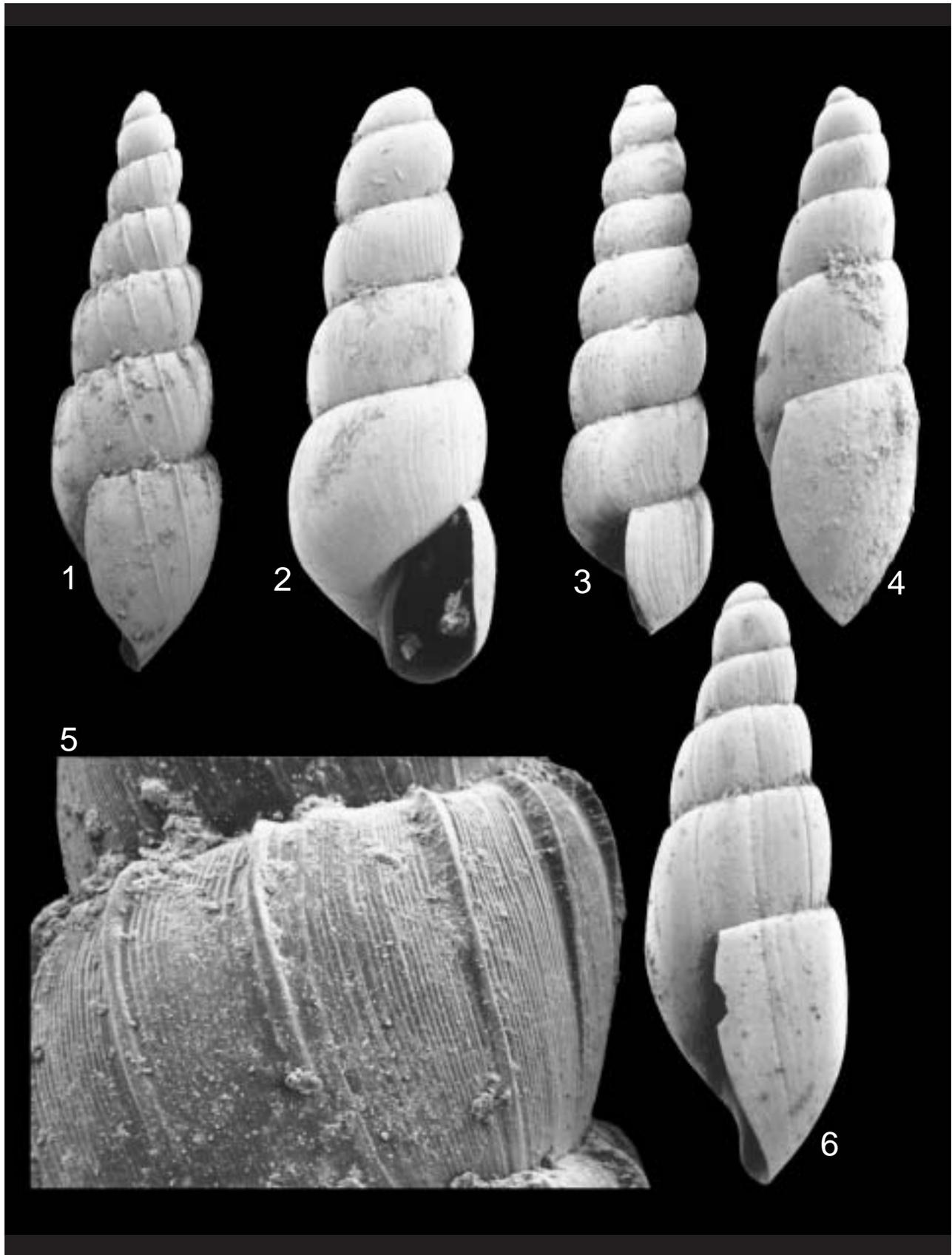


### Plate 30

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Figs. 1, 5. *Costavarix costulatus* (C. B. Adams). 1, lateral view  $\times 16$ . 2, detail of ornament on 5th whorl,  $\times 80$ .  
Figs. 2, 3. *Spiraxis (Repressaxis) terebella* (C. B. Adams). 2, apertural view of juvenile shell,  $\times 30$ . 3, lateral view of adult shell,  $\times 18$ .  
Fig. 4. *Sigmataxis* cf. *S. pauperculus* (C. B. Adams). Lateral view of juvenile,  $\times 20$ .  
Fig. 6. *Sigmataxis* sp. a. Lateral view of shell,  $\times 20$ .

All SE micrographs.



### Plate 31

Recent (Fig. 6) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Fig. 1. *Costavarix gossei* (Pfeiffer). Detail of surface ornament, × 160.

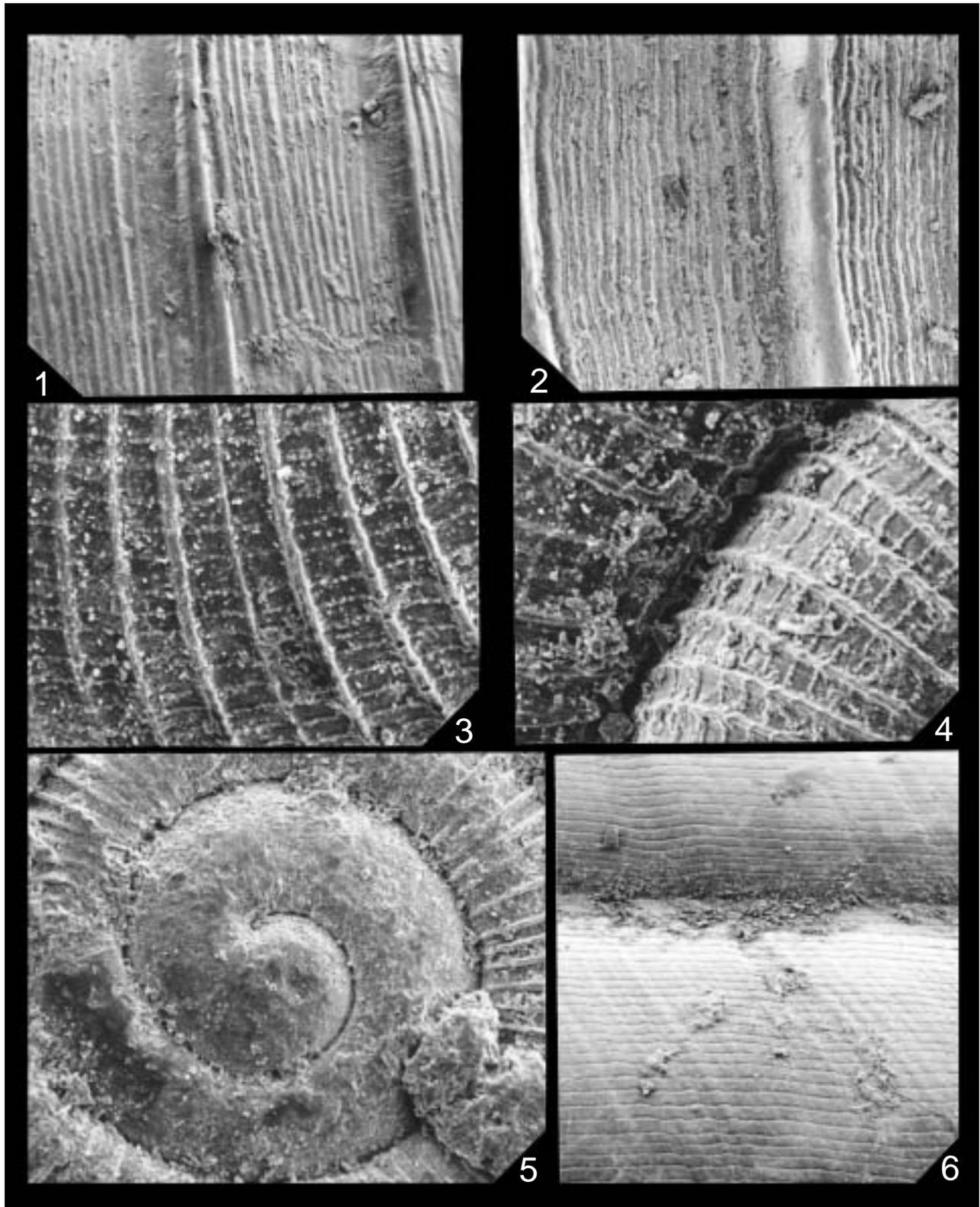
Fig. 2. *Costavarix costulatus* (C. B. Adams). Detail of surface ornament, × 160.

Figs. 3, 4. *Radiodiscus* sp. a. 3, detail of ornament on ventral surface. 4, detail of ornament on 3rd and 4th whorls of dorsal surface. Both, × 320.

Fig. 5. *Radiodiscus?* sp. b. Detail of protoconch, × 160.

Fig. 6. *Guppya gundlachi* (Pfeiffer). Detail of surface ornament, × 160.

All SE micrographs.



**Plate 32**

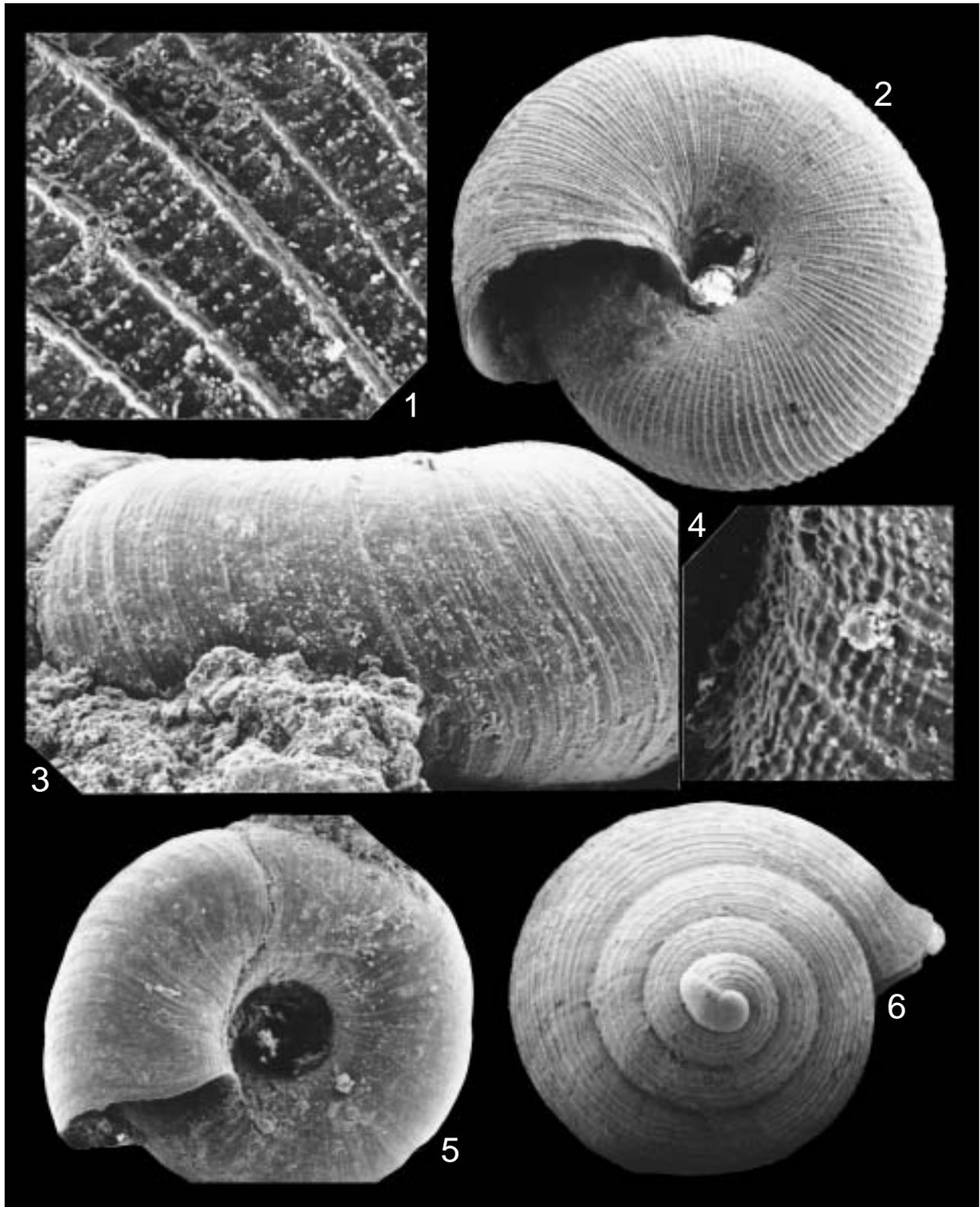
Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Radiodiscus* sp. a. 1, detail of surface ornament on ventral surface,  $\times 480$ . 2, umbilical view,  $\times 60$ .

Figs. 3–5. *Punctum (Punctum)* sp. a. 3, detail of periphery of whorls,  $\times 160$ . 4, detail of ornament adjacent to the umbilicus,  $\times 640$ . 5, umbilical view,  $\times 80$ .

Fig. 6. *Fadyenia leana* (C. B. Adams). Apical view,  $\times 40$ .

All SE micrographs.

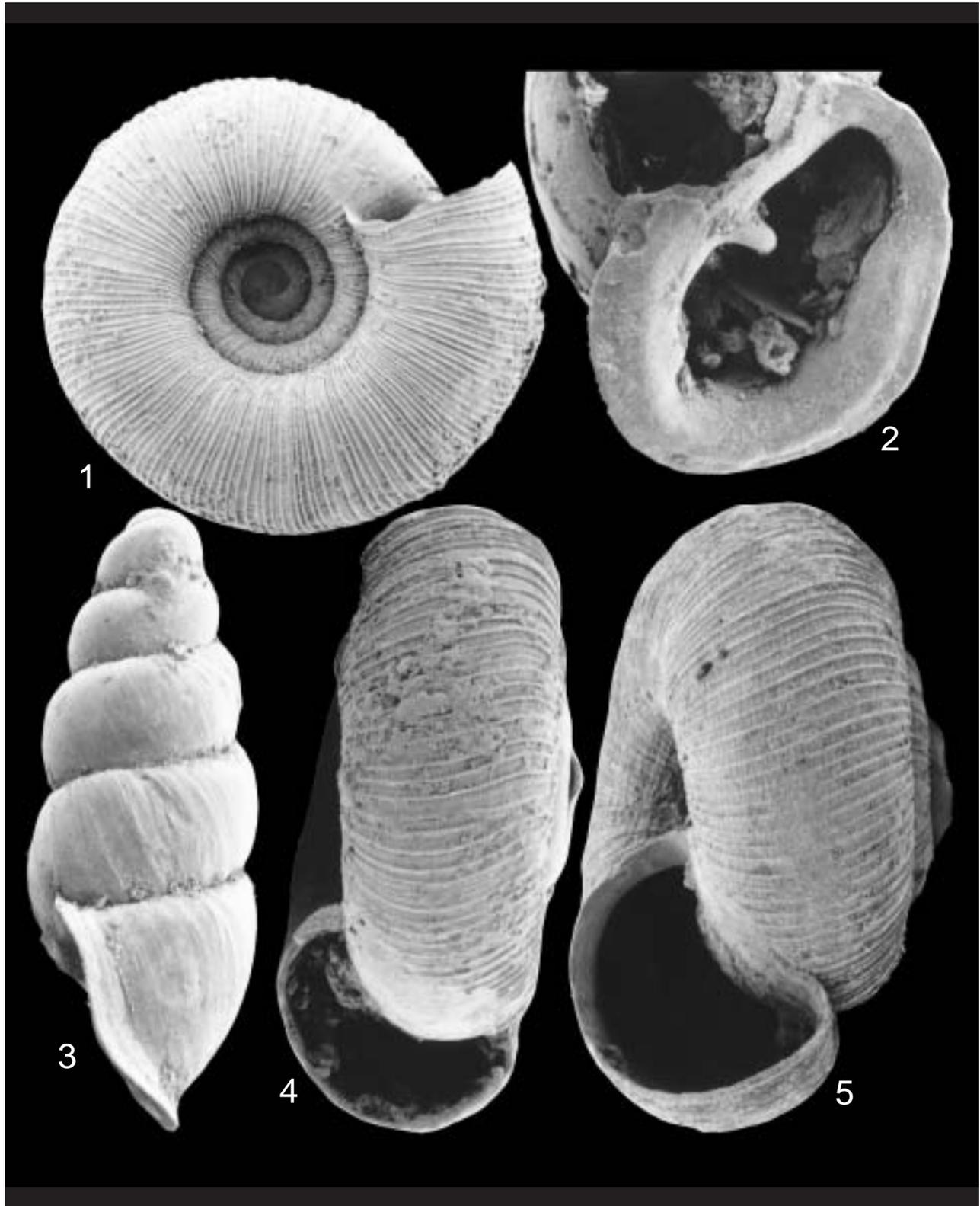


### Plate 33

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

- Figs. 1, 4. *Radiodiscus?* sp. b. 1, umbilical view,  $\times 48$ . 4, apertural view,  $\times 64$ .  
Figs. 2, 3. *Carychium jardineanum* (Chitty). 2, aperture and internal lamella,  $\times 56$ . 3, lateral view,  $\times 104$ .  
Fig. 5. *Radiodiscus* sp. a. Apertural view,  $\times 72$ .

All SE micrographs.



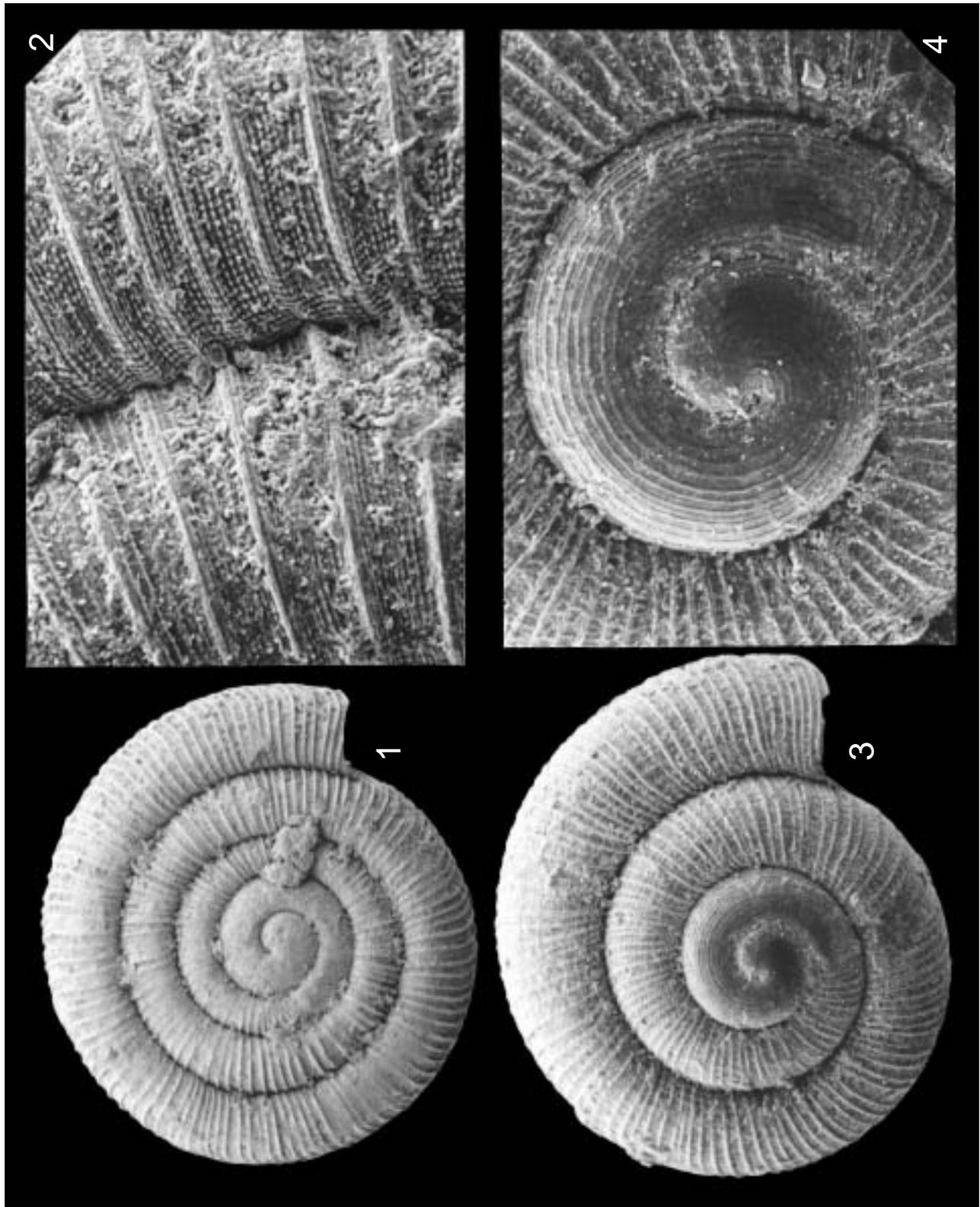
### Plate 34

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Radiodiscus?* sp. b. 1, apical view,  $\times 52$ . 2, detail of surface ornament,  $\times 320$ .

Figs. 3, 4. *Radiodiscus* sp. a. 3, apical view,  $\times 64$ . 4, detail of protoconch, note spiral lineations characteristic of *Radiodiscus*,  $\times 160$ .

All SE micrographs.

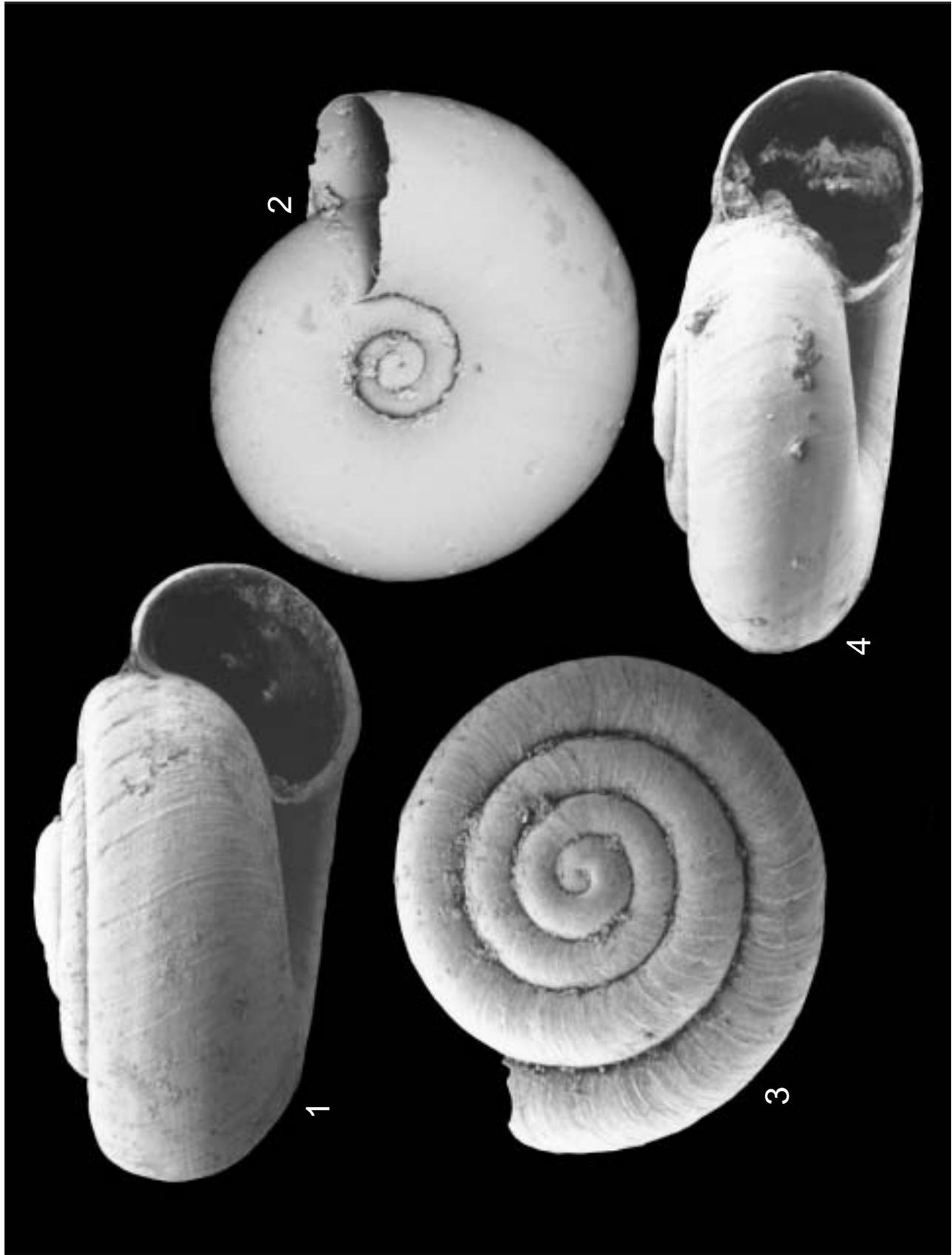


**Plate 35**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 3. *Punctum (Toltecia) vitreum* H. B. Baker. 1, apertural view,  $\times 40$ . 3, apical view,  $\times 32$ .  
Figs. 2, 4. *Happiella brevis* (C. B. Adams). 2, umbilical view,  $\times 40$ . 4, apertural view,  $\times 48$ .

All SE micrographs.



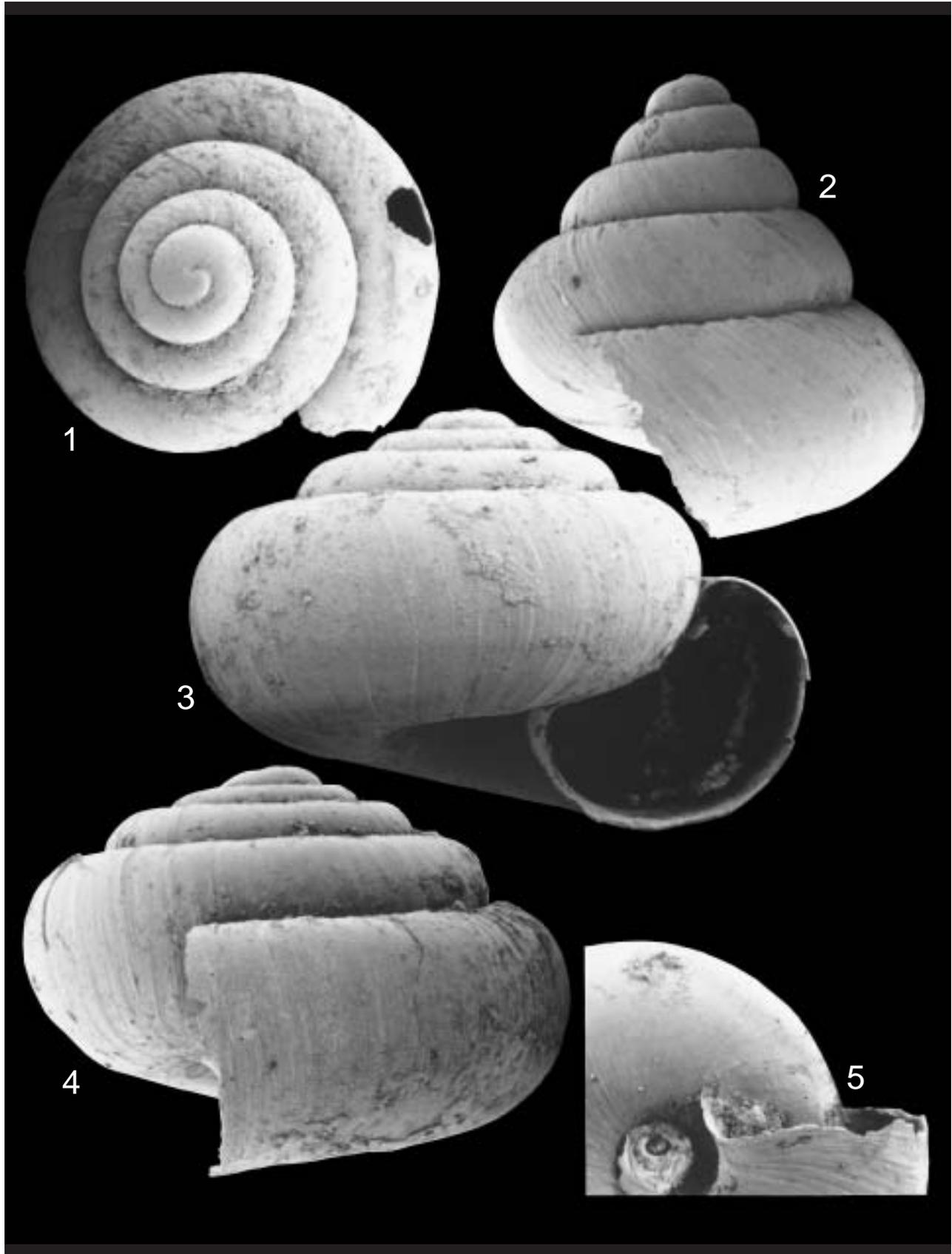
**Plate 36**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 2. *Aeretrochus mc nabiana* (Chitty). 1, apical view,  $\times 22$ . 2, lateral view,  $\times 18$ .

Figs. 3–5. *Microsagda angustispira* (C. B. Adams). 3, apertural view,  $\times 30$ . 4, lateral view,  $\times 30$ . 5, umbilical view,  $\times 24$ .

All SE micrographs.



**Plate 37**

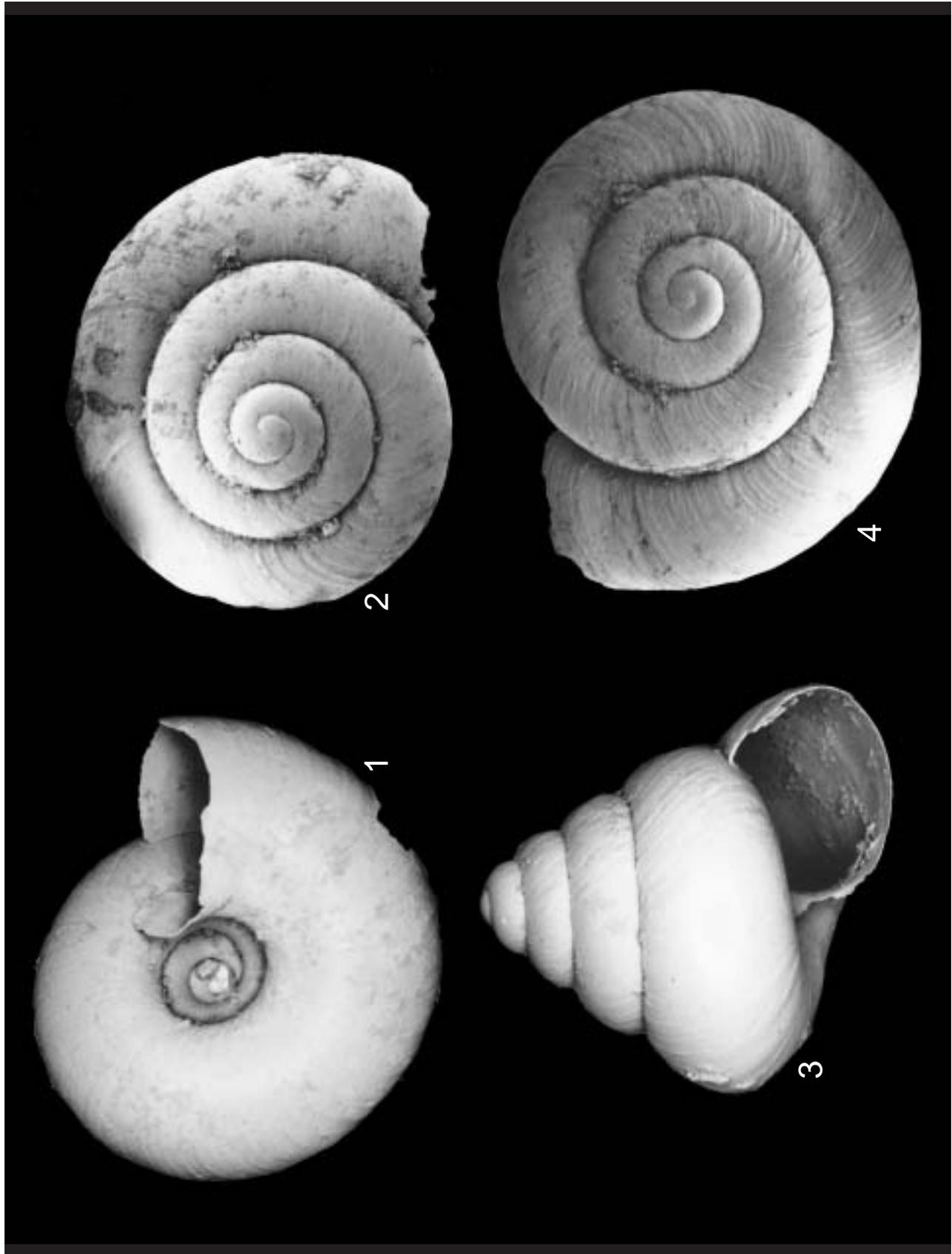
Recent (Fig. 2) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 4. *Aeretrochus perdepressa* (C. B. Adams). 1, umbilical view. 4, apical view. Both,  $\times 16$ .

Fig. 2. *Aeretrochus* sp. a. Apical view,  $\times 16$ .

Fig. 3. *Aeretrochus mc nabiana* (Chitty). Apertural view,  $\times 18$ .

All SE micrographs.

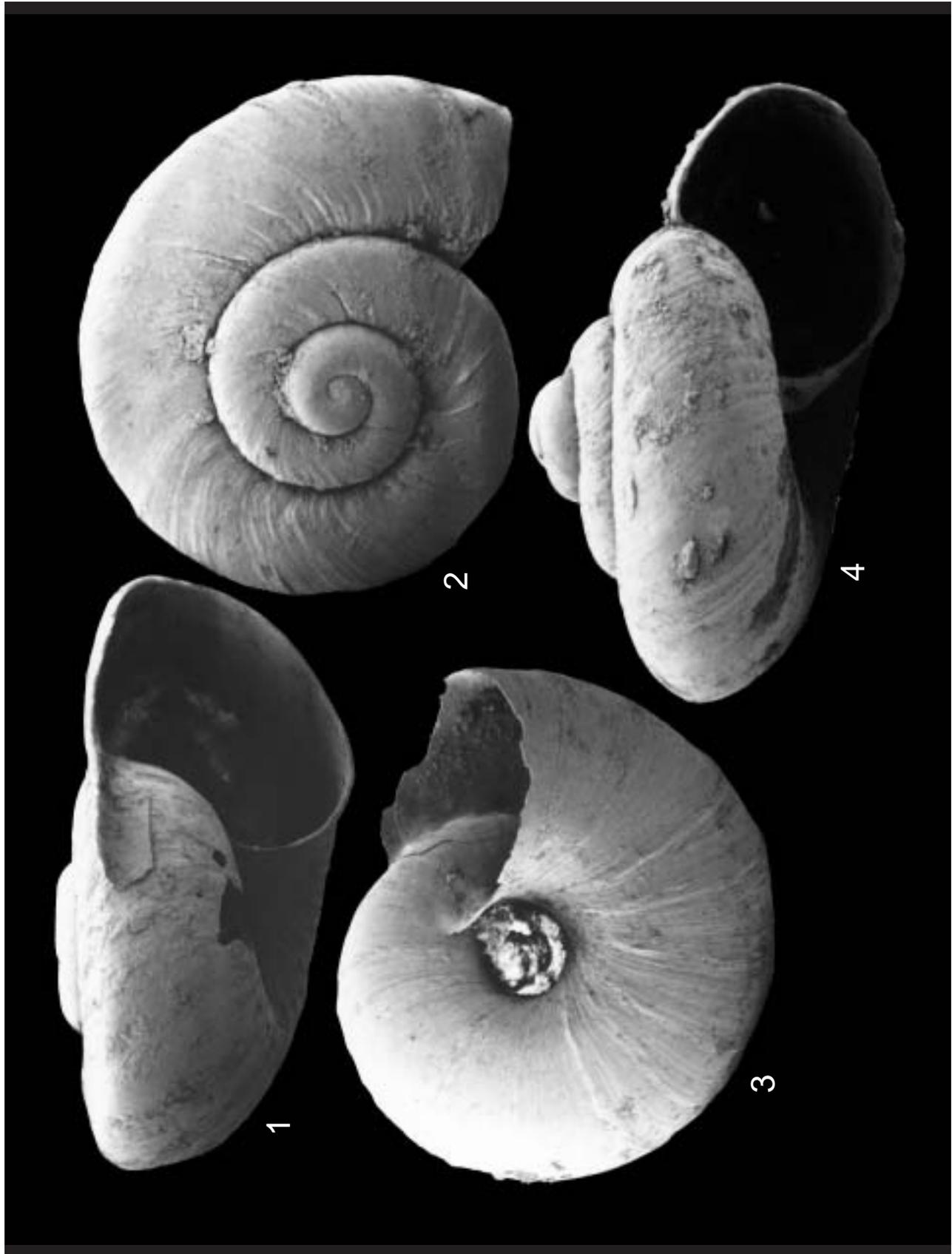


**Plate 38**

Recent (Fig. 4) and Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1-3. *Comeosagda ptychodes* (Pfeiffer). 1, apertural view,  $\times 28$ . 2, apical view,  $\times 20$ . 3, umbilical view,  $\times 17$ .  
Fig. 4. *Aeretrochus* sp. a. Apertural view,  $\times 24$ .

All SE micrographs.



**Plate 39**

Late Pleistocene gastropods from the Red Hills Road Cave, parish of St. Andrew, Jamaica.

Figs. 1, 4. *Proserpinula margaritella* Pilsbry and Brown. 1, apical view  $\times 20$ . 4, umbilical view,  $\times 28$ .  
Figs. 2, 3. *Proserpinula discoidea* (C. B. Adams). 2, umbilical view,  $\times 18$ . 3, apical view,  $\times 32$ .

All SE micrographs.

