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Review and prospectus of the Late Pleistocene fauna of the Red Hills Road Cave, Jamaica.

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Abstract: The Red Hills Road Cave (or fissure) in the parish of St Andrew, Jamaica, is an insignificant remnant of a karstic feature that was largely quarried away during road building before the mid-1980s. However, it is the most important site for Late Pleistocene terrestrial palaeontology on the island; 80+ species have been recognized, although some await formal description. The site is about 30,000 years old (oxygen isotope stage 3), but may span at least 15,000 years. The invertebrate fauna includes both land snails and arthropods, largely or entirely derived from the surrounding area; none are obligate cave dwellers. The 62 species of land snails are the most diverse of any Jamaican cave, but, unlike other sites, do not indicate local environmental stability during the Late Pleistocene; only about half the snail taxa found in the cave still occur in the local area. The arthropods include the only fossil millipedes, isopods and insects (fly puparia, beetle elytra) in the Jamaican fossil record, in addition to a land crab. The vertebrate fauna remains under-studied, but includes a rodent, three species of bat and a flightless ibis, in addition to undifferentiated bird, reptile and amphibian remains.

Keywords: oxygen isotope stage 3, taphonomy, palaeoecology, vertebrates, land snails, arthropods

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> *"The site was discovered in 1988 and immediately recognised as an unusually rich source of Late Quaternary gastropods and vertebrate bone ..."* (McFarlane and Blake, 2005, p.399).

Jamaica is one of the larger Antillean islands and has been exposed sub-aerially for about the last 10 million years (Edward Robinson, 1994, p.122). The island's geological record, which dates back only to the mid-Cretaceous, is dominated by limestones, which account for more than two-thirds of the surface outcrop (Fig.1). Most widespread are the Eocene and younger limestones, namely the Yellow Limestone Group (Eocene), White Limestone Group (Eocene to Miocene) and limestone formations of the Coastal Group (Miocene to Pleistocene). These limestones are riddled with features typical of caves and karst in the humid tropics (Fincham, 1997; Miller, 2004).

The Red Hills Road Cave or fissure is a very incomplete, somewhat less than impressive, but highly fossiliferous, karstic feature dissolved into the mid Tertiary White Limestone Group (Figs 2, 3). Among the many truly spectacular caves in Jamaica (Fincham, 1997), the remains of the Red Hill Road Cave are insignificant, but its value is scientific, not speleological. It was discovered in 1988 by two students, Ms Anita Godwin (now Dr Anita Warrington) of the University of Liverpool and Ms Marlene Britton of the University of the West Indies, Mona. A remnant of the cave is all that is left after road construction sometime earlier (Fig.3). What remains suggests that it was either a bottle-shaped cave (Donovan and Veltkamp, 1994) or a fissure (McFarlane and Blake, 2005), which acted as a trap for the accumulation of vertebrates, land snails and soil arthropods during the Late Pleistocene. The fossil fauna is unusually diverse and is still being analyzed.

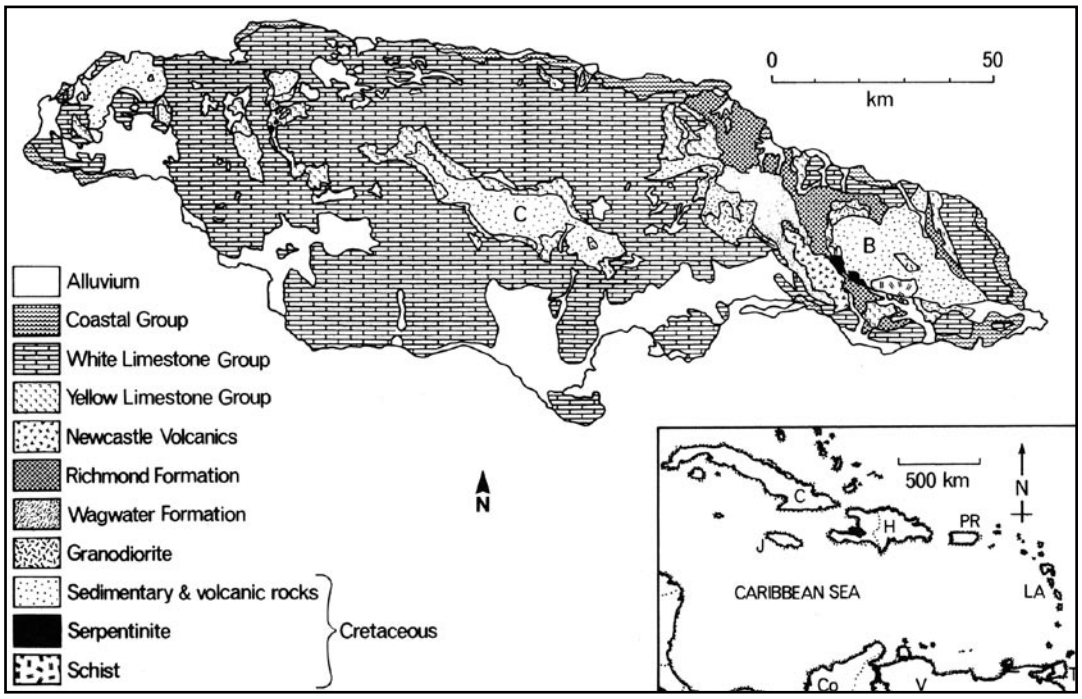

Figure 1: *Simplified geological map of Jamaica, showing the principal stratigraphical units (after Donovan, 1993, fig. 1; based on Geological Survey Department, 1959).*
Key:
B = Blue Mountain inlier;
C = Central inlier.
Ages of principal Cenozoic units:
granodiorite = Late Cretaceous to Paleocene;
Wagwater Formation and Newcastle Volcanics = Paleocene;
Richmond Formation = Paleocene to Early Eocene;
Yellow Limestone Group = Early to Mid Eocene;
White Limestone Group = Mid Eocene to Late Miocene;
Coastal Group = Late Miocene to Quaternary;
alluvium = Quaternary.
Inset: location of Jamaica.
Key (clockwise from Jamaica):
J = Jamaica;
C = Cuba;
H = Hispaniola (Haiti and Dominican Republic);
PR = Puerto Rico;
LA=Lesser Antilles;
T=Trinidad;
V=Venezuela;
Co=Colombia.

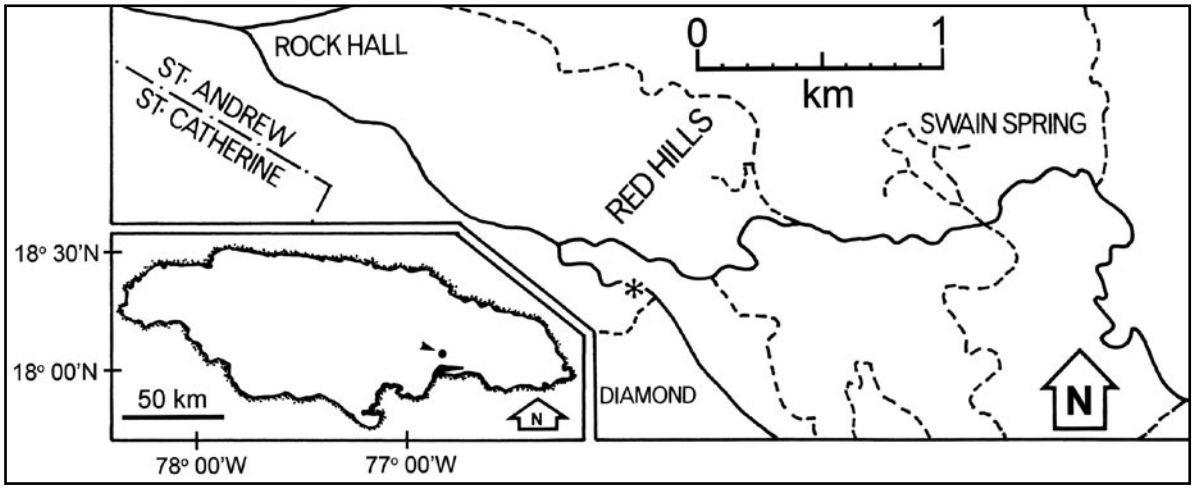

Figure 2: *Locality map to show the position of the Late Pleistocene Red Hills Road Cave (∗) on the south side of the Red Hills Road near Diamond, in the parish of St Andrew, Jamaica (improved after Donovan and Veltkamp, 1994, fig.1).*

Main roads (continuous lines), minor roads (broken lines) and the boundary between the parishes of St Catherine and St Andrew, are shown.

The Inset map shows the approximate position of the main map (arrowed) within the island of Jamaica

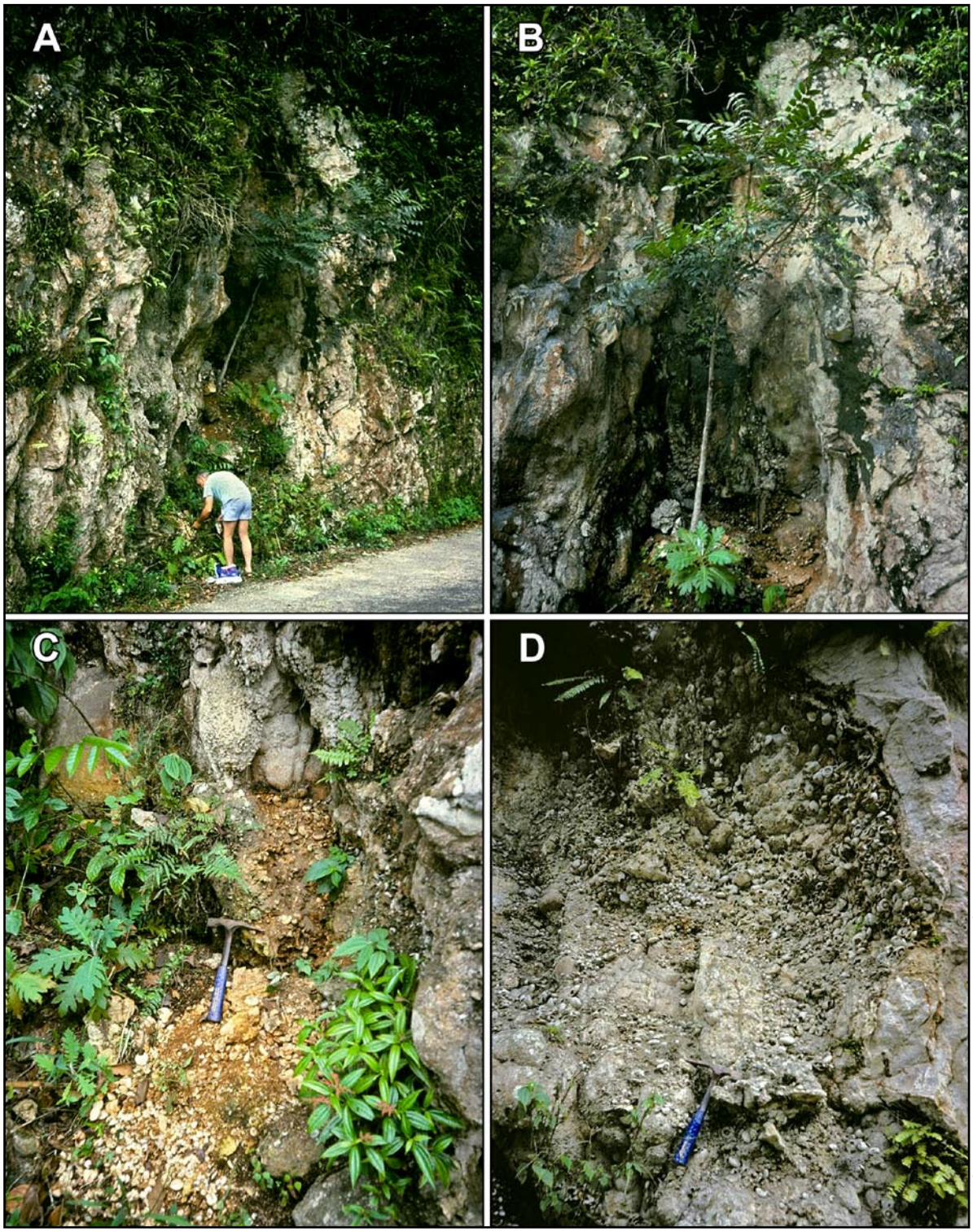

Figure 3: *Images of the Red Hills Road Cave.*

(A) General view of cave (centre), with Chris Paul providing a scale. The remaining shallow section of the cave is shaped like the side of a bottle. A small tree grows on the remnants of the sedimentary infill.

(B) Detail of the upper part of the cave, narrowing upwards. Note the dense vegetation on the surface of the limestone at the top of the image.

(C) Sedimentary infill; it is unknown how far this extends below the surface of the road. The red matrix is derived from the local terra rossa*. White clasts include, mainly, limestone fragments and Pleistocene land snails, but also bones and rarer arthropods.*

(D) The upper part of the cave showing the lining of dripstone. The bubble-like appearance is due to numerous shells of the large land snail Pleurodonte *(Figs 6A–6E) being cemented in place, indicating that the Red Hill Road Cave was formerly filled with sediment at least to this level. Images taken during the early or mid 1990s.*

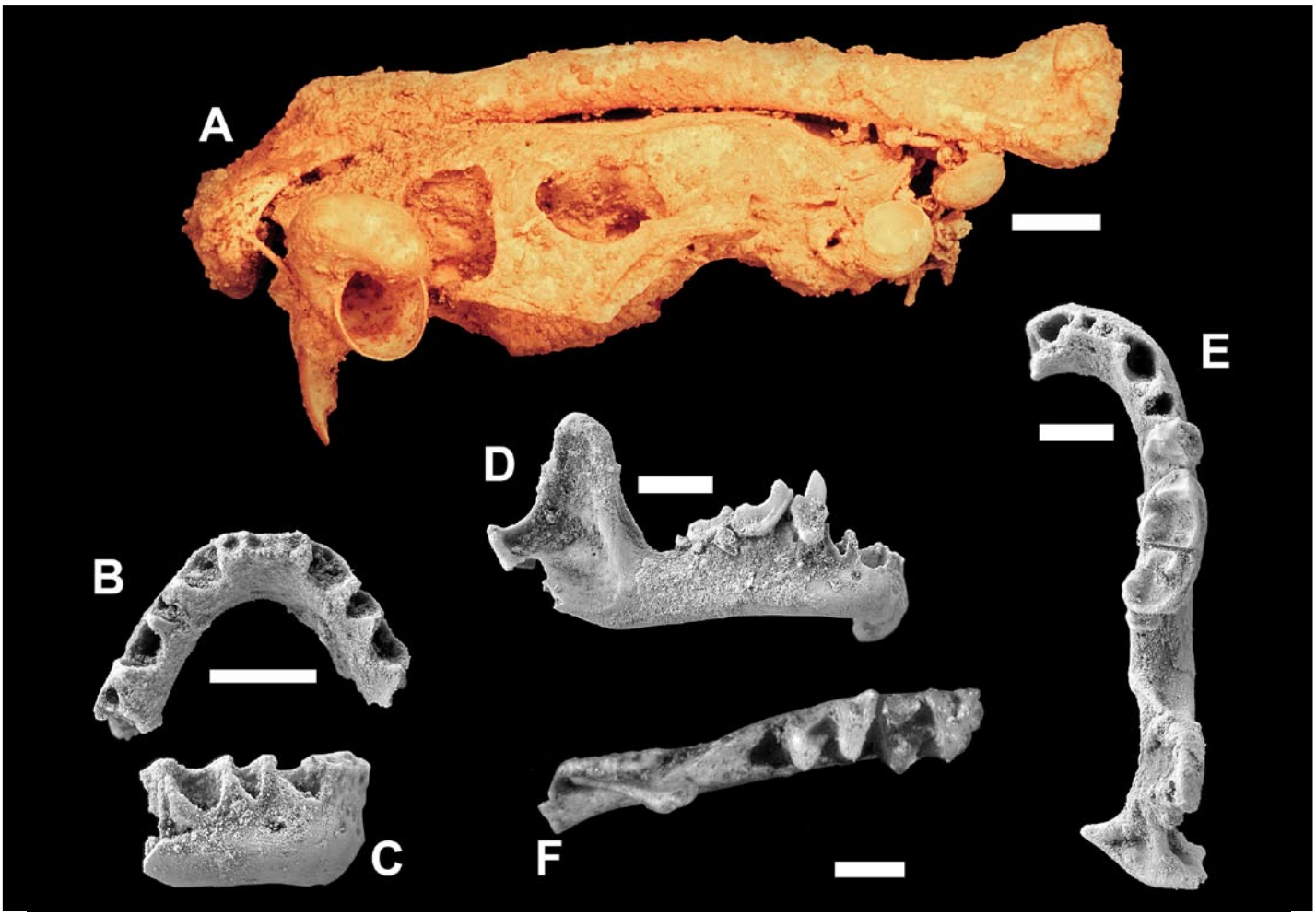

Figure 4: *Some Late Pleistocene vertebrates of the Red Hill Road Cave. Scale bars represent 2mm unless stated otherwise.*

(A) The skull of the rodent **Geocapromys brownii** *(Fischer) cemented to the right humerus of the flightless ibis* **Xenicibis xympithecus** *Olson and Steadman (compare with Morgan, 1993, fig.2C; after Donovan and Paul, 2011, fig.11) and land snails. Specimen in Geology Museum, University of the West Indies. Scale bar represents 10mm. (B, C)* **Chiropteran** *sp. indet., RGM 632 058, anterior of jaw in occlusal (B) and right lateral (labial) views (after Ouwendijk et al., in press, fig.2A, B). (D, E)* **Stenoderma rufum** *Desmerest, RGM 632 059, right mandible, in right lateral (labial) (D) and occlusal views (after Ouwendijk et al., in press, fig.2D, C). (F)* **Tadarida** *sp. cf.* **T. brasiliensis** *I. Geoffroy St-Hilaire, RGM 632 064, broken right mandible, occlusal view (after Ouwendijk et al., in press, fig. 3A). Scale bar represents 1mm.*

For several reasons the Red Hill Road Cave is the most important cave site for Pleistocene palaeontology in Jamaica. It is the only cave on the island to yield diverse terrestrial arthropods – the only other fossil deposits in the region to produce such a fauna are the Miocene amber-rich beds of the Dominican Republic (see, for example, Chiang Wu, 1996; Ross, 1998). The land snails of the Red Hill Road Cave are the most diverse known from the island and show a palaeogeographical pattern unsuspected from other cave sites. And the vertebrates, although incompletely studied at present, offer the potential to be at least as diverse as those in other Jamaican caves (compare with Morgan, 1993). This Paper summarizes the current knowledge of the palaeontology of the Red Hill Road Cave and identifies what still awaits attention.

History of research

As noted above, the Red Hill Road Cave was discovered in 1988 by two students. This was part of a survey by Godwin for new sites for Pleistocene land snails as part of her research on their shell chemistry, the results of which regrettably remain unpublished (Godwin, 1990). The cave was first investigated by the Geological Society of Jamaica in February 1989 (Donovan and Gordon, 1989), and it has been visited subsequently by, among others, student groups from the University of the West Indies, Mona, and Jamaican field meetings of the Geologists' Association (Donovan *et al*., 1995; Eric Robinson, 1996, p.148) and an extramural group from the Natural History Museum, London. All of these excursions led to new specimens being collected, mainly by Donovan and Jamaican colleagues. In the mid-1990s, as sediment continued to be lost by (mainly) natural processes, a large bulk sample was deposited in the Geology Museum of the University of the West Indies, Mona (Donovan, 1997). This was the sediment residue after crania and mandibles of *Geocapromys brownii* (Fischer, 1830), and large bones of the extinct ibis *Xenicibis xympithecus* Olson and Steadman, 1977, were collected by Ross MacPhee, Don McFarlane and others.

The first assessment of the vertebrate fauna of the cave was by Savage (1990), who had received a sample of the bones from Donovan. Perhaps surprisingly, it is the vertebrates that remain under-studied (see below) and it is only elements amongst the mammals that have received adequate description (McFarlane and Blake, 2005; Ouwendijk *et al*., *in press*).

Macro-invertebrates have fared rather better. Donovan and Veltkamp (1994) identified three species of fossil millipedes and used their preservation for an analysis of the Pleistocene taphonomy of the cave. Recent studies have expanded on this arthropod fauna, which includes members of three classes (Donovan, 2008; Collins *et al*., 2009; Baalbergen and Donovan, *in press*). The large and diverse fauna of land snails was described in the monograph by Paul and Donovan (2006), who later published the only previous (semi-popular) review of the fauna (Donovan and Paul, 2011).

Locality and age

The site is on the south side of the Red Hills Road (Fig.2; Jamaica 1:50,000 new series sheet 13, 'The Blue Mountains', NGR 643 572), in the parish of St Andrew, Jamaica, about 3.3km 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; Fig.3 herein). 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 (Fig.3C). The last is probably derived largely from the *terra rossa* soils that are prevalent in this area, hence the name Red Hills. Where lithified (e.g. Fig.4A), 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), which might have been near-completely filled (Fig.3D) before excavation. It is unknown how far the infilled cave extends below road level.

The site is Late Pleistocene, about 30,000 years old. The first indication of probable age was given by the presence of Pleistocene vertebrates, because such occurrences in Jamaica are almost invariably younger than 100,000 years (MacPhee *et al*., 1989). Preliminary, uncalibrated dating by amino acid racemization of the land snail *Pleurodonte* by the late Glenn Goodfriend (*in* Paul and Donovan, 2006, p.110) suggested an age between 20,000 and 40,000 years (20,000–30,000 years according to McFarlane and Blake, 2005, p. 403). Uncorrected radiocarbon dates from the same snail genus suggested an age of 31,960 ± 1,220 years (McFarlane and Blake, 2005, p.403); it was suggested that the 'limestone effect' was probably less than 1,000 years. Fluorine ages from long bones of *Geocapromys* vary between 25,600 ± 2,300 and 40,700 ± 3,200 years, possibly indicating the minimum age range of the cave fill (McFarlane and Blake, 2005, pp.402–403). That is, the sedimentary fill of the Red Hill Road Cave was deposited (at least mainly) during oxygen isotope stage 3 (Van Meerbeeck *et al*., 2009).

The Late Pleistocene fauna

All figured specimens are deposited in the Naturalis Biodiversity Center, Leiden, the Netherlands (RGM) unless stated otherwise.

Vertebrates (Fig.4)

An anomaly of the research programme on the Red Hill Road Cave fauna is the slow progress in describing and identifying the varied vertebrate elements beyond, in most cases, open nomenclature. Savage (1990, p.33) noted that *"... vertebrates are all preserved as disarticulated bones. Some of the bones are very fresh and others are coated in dripstone ... The amphibians comprise only a few very small bones and no recognizable skull or dental material. The reptiles are small lizards and there is one mandibular ramus amongst the isolated bones. Birds are represented by several medium and small sized species; tarso-metatarsals are the most readily recognized limb bones."* Undoubtedly, it is the fragmentary nature of the remains of diverse small vertebrates, mixed together like a Pleistocene 'Irish stew', that has discouraged their systematic study.

Studies of amphibians and reptiles of the Red Hill Road Cave have not moved forward since 1990, though lizard mandibles are among the most recognizable of vertebrate remains. Birds have fared only slightly better. It has been documented that limb bones of the extinct ibis, *Xenicibis xympithecus* Olson and Steadman, occurs in the Red Hill Road Cave (McFarlane and Blake, 2005, p.399; Donovan and Paul, 2011, p.178, fig. 11; Longrich and Olson, 2011; Fig.4A herein) and the beak of a passerine awaits description (Donovan and co-workers, research in progress). This Paper confirms that tarso-metatarsals are common bird bones, as are claws, but they remain unidentified.

Only the mammals of the Red Hill Road Cave vertebrates have been described in detail. Savage (1990, pp.33–34, fig.1) recognized the Jamaican hutia, *Geocapromys brownii* (Fischer) (Fig.4A), which is still extant (Anderson *et al*., 1983), and reviewed its affinities, morphology of the molars/premolars, and distribution in the Pleistocene and Recent. McFarlane and Blake (2005) determined a survivorship curve for *G. brownii* from Red Hill Road Cave using a sample of 105 hemi-mandibles, which confirmed that a broad range of ages at death was represented, with the highest mortality (= most specimens) during their first six months. This was regarded as *"... typical of rodents in which newly-weaned young disperse from natal refugia into an environment that exposes them to predation"* (McFarlane and Blake, 2005, p.403) and finally disproved speculations that the accumulation of bones was the result of disaggregation of owl pellets.

Fossil bats are moderately well known from the Pleistocene of Jamaica; Morgan (1993) listed 12 species, to which McFarlane *et al*. (2002, table 1) added the Jamaican fruit bat, *Artibeus jamaicensis* Leach, 1821. Currently there are 21 extant species (Morgan, 1993, p.419; McFarlane, 1997, p.58). Bat remains are extremely rare in the Red Hill Road Cave, but it has yielded three species (Ouwendijk *et al*., *in press*; Figs 4B–4F herein). *Stenoderma rufum* Desmarest, 1820, the red fruit bat, is the most common taxon in the cave and is still extant in the more eastern Greater Antilles, but has been extirpated in Jamaica. *Tadarida* sp. cf. *T. brasiliensis* I. Geoffroy St-Hillaire, 1824, the Brazilian free-tailed bat, represents a taxon still widespread in the Greater Antilles, including Jamaica. Chiropteran spp. indet. are known from incomplete mandibles that are morphologically distinct from the other two species in the cave. The only other possible mammalian fossil is a single molar with marsupial affinities, an unexpected find (compare with MacPhee *et al*., 1983, p. 834), but this identification is preliminary and further specimens are need for confirmation (Van den Hoek Ostende and Donovan, research in progress).

Land snails (Fig.5)

The Pleistocene fossil fauna of terrestrial gastropods from Red Hill Road Cave is the richest yet reported from Jamaican caves with 62 species (Paul and Donovan, 2006, table 1). Goodfriend (1986) 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 (Paul, unpublished data) did not exceed 30 species. The fossil fauna is also significantly more diverse than the Recent fauna in the area (Paul and Donovan, 2006, table 2), although the latter might have suffered from recent forest clearance.

One possible reason for the richness is that the Red Hill Road Cave fauna accumulated over a very long time period. This supposition is supported by the fluorine age data obtained from long bones of *Geocapromys* (see above), which vary between about 25,000 and 40,000 years (McFarlane and Blake, 2005, pp.402–403). For a discussion of the distribution of the land snails of the Jamaican Pleistocene, see Donovan and Paul (*in press*).

Jamaica has a highly diverse fauna of extant terrestrial gastropods with over 500 nominal species (Groh and Parkinson, 1987; Rosenberg and Drumm, 2004; Rosenberg and Muratov, 2006), making it a biodiversity 'hot spot' for this group. 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, 1986, 1989; Goodfriend and Mitterer, 1988, 1993) 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 or, in some cases, as a result of forest clearance by humans within historical times (Paul and Donovan, 2006, table 3). Other differences between fossil and modern faunas mainly included the introduction, probably by humans within historical times, of a number of taxa with widespread distributions in the tropics (Rosenberg and Muratov, 2006, table 2).

The Red Hill Road Cave has a particularly low proportion of fossil species known still to live in the immediate vicinity of the cave. Comparison of the fossil and Recent faunas at Red Hill Road Cave (Paul and Donovan, 2006, table 1) gives a pattern of occurrence in which 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. Of a total of 80 species recognized, only 30 (37.5 %) are common to both the fossil and Recent faunas (Paul and Donovan, 2006, table 2). This suggests that significant migration and extirpation of snails has occurred in the Red Hills area, and that the geographical distributions of local endemic snails are not as stable as had previously been assumed. Distribution data for Jamaican local endemic snails are generally poor because virtually no locality data were recorded when species were first described in (mainly) the 19th Century. However, it is possible to state where nearest known localities are for several of the fossil species. For example, the nearest locality for *Colobostylus* (*Tudorops*) *yallahensis* (C. B. Adams, 1851a) (Fig.5L) and *Geoscala costulata* (C. B. Adams, 1849b) (Figs 5O, 5P) is Mount Diablo, approximately 30km to the northwest (BMNH collection and Paul, 1982, respectively), and *Pleurodonte subacuta* (Pfeiffer, 1868) (Fig.5E) also occurs in the higher hills around Moneague and Mount Diablo to the northwest of the Red Hill Road Cave.

These and other 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 (Paul and Donovan, 2006, table 4). Goodfriend and Mitterer (1988) discussed size differences between Pleistocene and Recent examples of the land snails *Pleurodonte lucerna* (Müller, 1774) and *Alcadia major* (Gray, 1824), 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

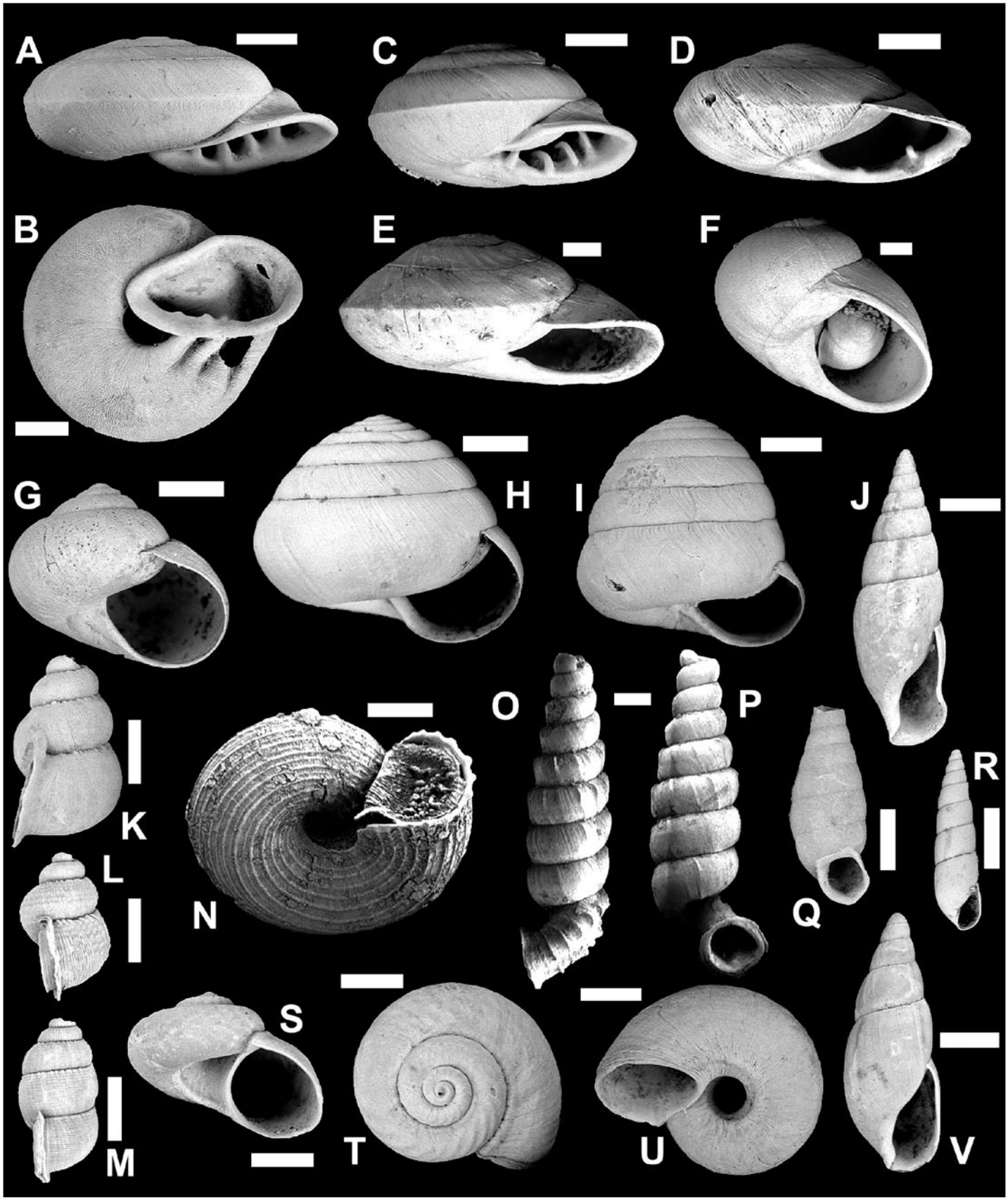

Figure 5: *Some Late Pleistocene land snails of the Red Hill Road Cave. All figures after Paul and Donovan (2006).*

Scale bars represent 10mm unless stated otherwise.

(A, B) **Pleurodonte candescens** *(C B Adams, 1850). (A) RGM 188 755. (B) RGM 188 754, umbilical view. (C)* **Pleurodonte sinuata** *(Müller, 1774), RGM 188 752. (D)* **Pleurodonte sublucerna** *(Pilsbry, 1889), RGM 188 748. (E)* **Pleurodonte subacuta** *(Pfeiffer, 1868), RGM 188 743. (F)* **Eurycratera jamaicensis** *(Gmelin* in *Linné, 1791), RGM188 741. (G)* **Zaphysema tenerrimum** *(C B Adams, 1845), RGM 188 738. (H)* **Sagda cookiana** *(Gmelin* in *Linné, 1791), RGM 188 736. (I)* **Sagda spei** *Pilsbry and Brown, 1910, RGM 188 731. (J)* **Varicella (Varicellaria) griffithi** *(C B Adams, 1845), RGM 188 727. (K)* **Colobostylus (Colobostylus) thysanoraphe** *(G B Sowerby II, 1843), RGM 188 718, lateral view. (L)* **Colobostylus (Tudorops) yallahsensis** *(C B Adams, 1851a), RGM 188 716, lateral view. (M)* **Adamsiella (Adamsiella) grayana** *(Pfeiffer, 1846), RGM 188 7234, lateral view. (N)* **Fadyenia lindsleyana** *(C B Adams, 1849a), specimen lost, oblique umbilical view of shell with operculum in place. Scale bar represents 1 mm. (O, P)* **Geoscala costulata** *(C B Adams, 1849b), specimen lost, lateral (O) and apertural views. Scale bar represents 1mm. (Q)* **Anoma fuscoplabris** *(Chitty, 1853), RGM 188 724. (R)* **Sigmataxis procerus** *(C B Adams, 1845), RGM 188 726. (S–U)* **Poteria (Bartschivindex) varians** *(C B Adams, 1851b). (S) RGM 188 711, apertural view. (T, U) RGM 188 710, apical (T) and umbilical views. (V)* **Euvaricella venusta** *(Pfeiffer, 1841), RGM 188 729.*

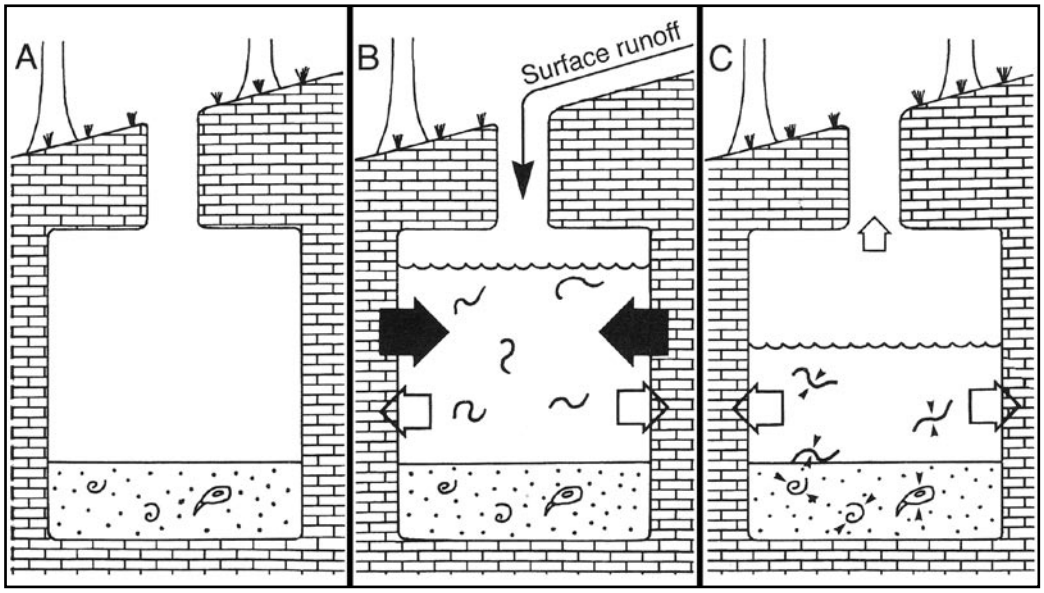

Figure 6: *Postulated depositional sequence for calcitic preservation of millipedes and isopods in the Red Hill Road Cave (after Donovan and Veltkamp, 1994, fig.7).*

(A) Dry/damp conditions. The cave acts as a bottle trap for any organisms that fall into the opening in the roof, but accumulation of infill is slow. Such conditions would have prevailed except during severe weather conditions. That the cave may have been damp is suggested by the occurrence of ostracods.

(B) Hurricane/tropical storm conditions. The cave fills with water from surface runoff and from the karstic aquifer (large black arrows; smaller open arrows indicate outflow into karst). Millipedes and other organisms washed in and drown.

(C) After the storm. Water level drops by evaporation (small arrow) and karstic runoff. Calcareous skeletons in, on and floating above the sediment (mainly gastropods, vertebrates and certain arthropods) act as substrates for calcite precipitation (small black arrows). Uncalcified organisms and soft tissues rot away.

during the Late Pleistocene and wetter conditions during the Holocene. The evidence from the Red Hill Road Cave 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* (Gmelin *in* Linné, 1791), 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 and arboreal species. Another puzzling aspect of the snail fauna is the complete absence of *Urocoptis* Beck, 1837, and *Apoma* Pilsbry, 1903. They are ground-dwelling species confined to limestone habits. They are found virtually everywhere that the White Limestone Group is exposed.

Arthropods

The fauna of macroscopic fossil arthropods of the Red Hill Road Cave consists of 13 or more taxa, including millipedes (at least four species), isopods (four species), decapods (one species) and insects (four species) (Baalbergen and Donovan, *in press*). Most of these taxa are classified in open nomenclature, which is in part a function of the common preservation of these fossils with a sugary coat of calcite on the external surface, concealing fine detail (Donovan and Veltkamp, 1994). Preservation has favoured those taxa with at least a small proportion of calcite in their exoskeleton in life, which facilitated inorganic encrustation with calcite post-mortem (Fig.6). The ostracods are the only arthropods from the Red Hill Road Cave that await description.

Diplopoda (Figs 7A–7F)

In addition to the taxa identified by Donovan and Veltkamp (1994) – that is, *Rhinocricus* sp. or spp., *Chondrotropis* sp. and *Caraibodesmus verrucosus* (Pocock, 1894) (Figs 7C–7F) – one further millipede species from the Red Hill Road Cave has been described by Baalbergen and Donovan (*in press*), namely *Cyclodesmus* sp. cf. *C. porcellanus* Pocock, 1894, which had (and has) the ability to roll into a ball (Figs 7A, 7B). *Rhinocricus* spp. live in the upper part of the leaf litter and are of the 'bulldozer/rammer' ecomorphological type (Hopkin and Read, 1992, p.38). *Chondrotropis* sp., *Caraibodesmus verucosus* and *Cyclodesmus porcellanus* are polydesmids. Commonly, members of this order live in darker places, such the deeper layers of the soil. This suggests that, during tropical storms, a large amount of the adjacent soil was washed into the Red Hill Road Cave, including the deep layers.

Crustacea – Isopoda (Figs 7G–7O)

The many isopods that have been discovered within the sediment of the Red Hill Road Cave have been classified as four species (Baalbergen and Donovan, *in press*) (Figs 7G–7O). Most of the specimens belong to *Philoscia* sp. 2, a flattened and narrow bodied isopod; *Philoscia* sp. 1 has a more widened and flattened body. The other two species are pill bugs and have the ability to roll into a ball (*Venezillo boonae* Van Name, 1936, and *Pseudarmadillo* sp.). Members of *Philoscia sensu lato*, *Pseudarmadillo* and *Venezillo boonae* are all extant in Jamaica. The palaeoecology of the Red Hill Road Cave isopods is broadly similar to that of the millipedes, that is, they lived in the leaf litter.

Crustacea – Decapoda (Figs 7P, 7Q)

All crab claws from the Red Hill Road Cave most probably belong to *Sesarma* sp. cf. *S. cookei* Hartnoll, 1971 (Baalbergen and Donovan, *in press*) (Figs 7P, 7Q). *Sesarma cookei* is an extant, terrestrial crab species and occurs on Jamaican mountain slopes between 300 and 900m in elevation in completely dry rock rubble habitats (Abele and Means, 1977). The available crab fossils are no indication that there has been any aquatic life in the Red Hills Road Cave. Land crabs are the only arthropod group to have been recognized in other Pleistocene cave faunas in Jamaica (Donovan and Dixon, 1998; Collins *et al*., 2009).

Insecta (Figs 7R, 7S)

Remains of some Pleistocene insects have been discovered, namely fossil fly puparia (Figs 7R, 7S) and beetle(?) elytra, although the available specimens are less well preserved and rarer than the isopods, millipedes and land crabs (Baalbergen and Donovan, *in press*). Calliphoridae/Sarcophagidae larvae parasitize other animals, such as vertebrates (Calliphoridae) or insect nests (Sarcophagidae). Probably, the Sciomyzidae larva has parasitized molluscs, which are common and diverse within the cave sediment.

Discussion

The Red Hill Road Cave is only a minor dissolution feature in the highly karstified landscape of Jamaica, but it has yielded the most diverse fauna of Late Pleistocene terrestrial fossils known from the island. No other site has yielded as many as 50 species of land snails, yet the Red Hill Road Cave has produced 62, many in great abundance. To this is added 13 species of arthropods in three classes (Diplopoda, Crustacea and Insecta). All of the fossil macroinvertebrates from this site have been described (Paul and Donovan, 2006; Baalbergen and Donovan, *in press*). It is only the vertebrates that lag behind, although the principal mammal groups (Chiroptera, Rodentia) have now been documented (McFarlane and Blake, 2005; Ouwendijk *et al*., *in press*).

Despite the faunal richness of the site, significant questions in systematic palaeontology, palaeoecology and taphonomy remain to be asked. There is no indication that any of the fossil macroinvertebrates from Red Hill Road Cave were obligate cave dwellers. They provide information about the surrounding Late Pleistocene environment rather than that in the cave. Microscopic ostracods, the only undescribed arthropod group, are important environmental indicators (e.g., Holmes, 1998) and they might have lived in the cave; they require study. Birds and lizards are the commonest of the undescribed vertebrate fossils, and require more focussed study to differentiate the full diversity of their remains. Some remains, such as bird beaks and claws, and lizard jaws, are readily differentiated, and these need more accurate determination. At least some of them might have used the cave as a domicile.

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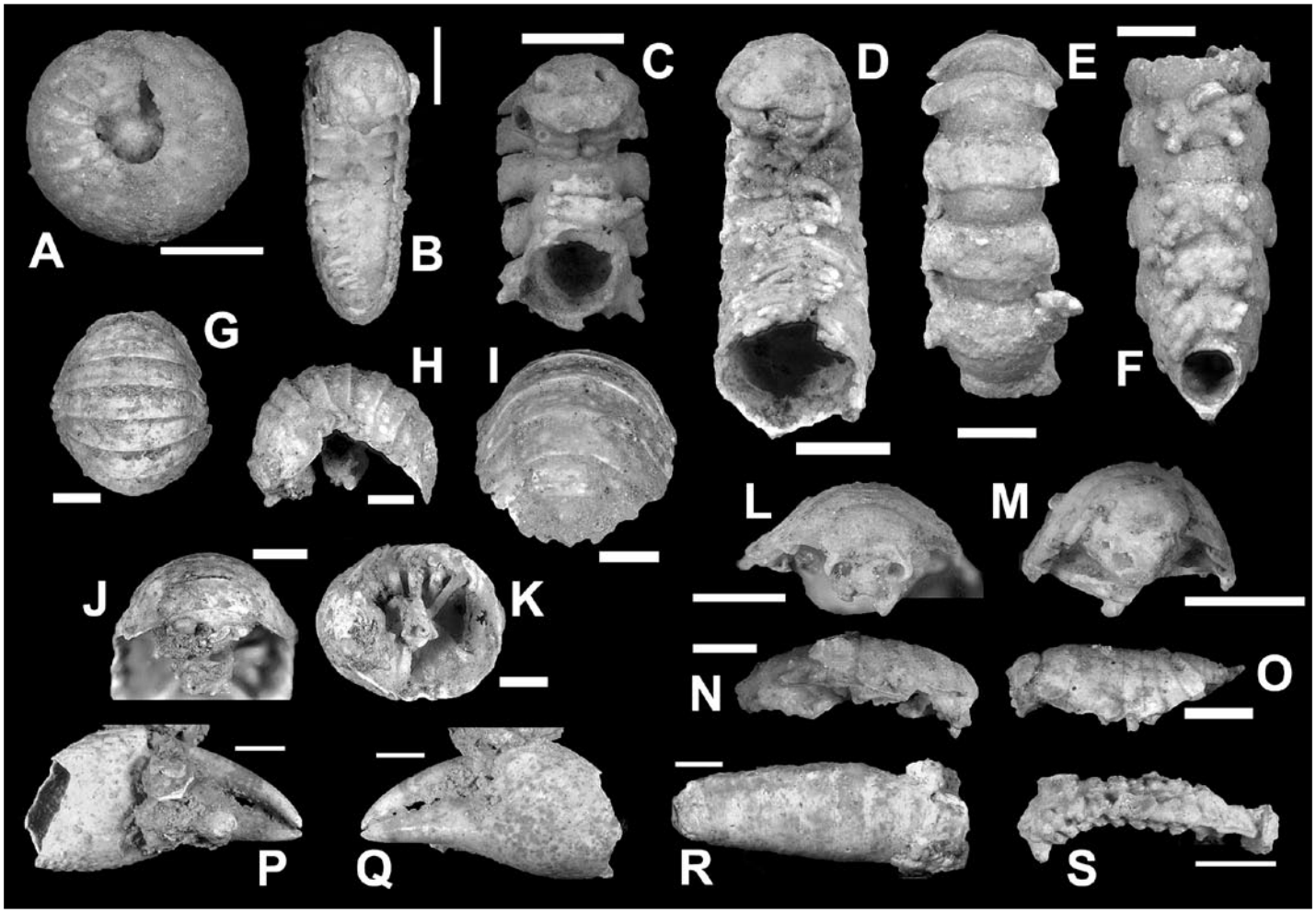

Figure 7: *Some Late Pleistocene arthropods of the Red Hill Road Cave. All figures after Baalbergen and Donovan (in press).*

Scale bars represent 2mm (A–F, P, Q, S) or 1mm (G–O, R).

(A–F) Millipedes. (A, B) **Cyclodesmus** *sp. cf.* **C. porcellanus** *Pocock. (A) RGM 789 611, lateral view of enrolled specimen. (B) RGM 789 610, ventral view showing basal attachments of legs. (C)* **Caraibodesmus verrucosus** *(Pocock), RGM 789 607, ventral view of the anterior segments, showing the head, and basal attachments of legs and antennae. (D)* **Rhinocricus** *sp., RGM 789 601, ventral view of anterior showing the head, antennae and legs. (E, F) Aff.* **Chondrotropsis** *sp. (E) RGM 789 604, dorsal view of anterior segments. (F) RGM 789 605, ventral view of posterior segments showing basal attachments of legs.*
(G–K) Isopod (pill bug) **Venezillo boonae** *Van Name, RGM 789 615, in dorsal (G), lateral (H), abdominal (I), frontal (= head) (J) and ventral views.*
(L–O) Philosciid isopods. (L, N) **Philoscia** *sp. 1, RGM 789 617, in frontal (= head) (L) and lateral views. (M, O)* **Philoscia** *sp. 2, RGM 789 619, in frontal (M) and lateral views.*
(P, Q) Decapod crustacean (land crab) **Sesarma** *sp. cf.* **S. cookei** *Hartnoll (specimen lost), articulated left chela (claw), views of inner (P) and outer surfaces.*
(R) Dipteran puparium, calliphorid or sarcophagid sp. indet., RGM 789 628, lateral view. (S) Dipteran puparium, sciomyzid sp. indet., RGM 789 630, lateral view.

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