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The late Pleistocene hutias (*Geocapromys brownii*) of Red Hills Fissure, Jamaica

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Red Hills Fissure (RHF) is an in-filled, karstic solutional feature exposed by a roadcut in southern Jamaica. The site was discovered in 1988 and immediately recognized as an unusually rich source of late Quaternary gastropods and vertebrate bone dating from the late Pleistocene. Recent work on RHF has focused on the abundant remains of the endemic, mid-sized rodent *Geocapromys brownii*. Morphological data on a collection of hemi-mandibles has facilitated the construction of a life table for the species in the late Pleistocene: the first for any West Indian Pleistocene vertebrate. Studies of fluorine uptake in the fossil bone have also defined the time-span of the RHF deposit, approximately 25–40 kyr BP.

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1. INTRODUCTION

The Jamaican hutia, *Geocapromys brownii*, is a medium sized ($\sim$1000–2000 g; Anderson *et al*. 1983) rodent and one of the few endemic West Indian mammals to have survived into the 21st century. *Geocapromys* has extant sister species on East Plana Cay, Bahamas (*G. ingrahami*), and extinct congeners on Little Swan Island (*G. thoractus*; Morgan 1989), Cayman Brac (*G. sp*.; Morgan 1993) and Cuba (three nominal species, Anderson *et al.* 1983). The species is now scarce and protected in Jamaica, but was formerly widespread and apparently very numerous. Extant populations are known from a wide range of ecotypes, from the arid thorn scrub of the Hellshire Hills to the montane rainforest of the John Crow mountains. Large numbers of hutia bones occur in dry caves throughout Jamaica, with at least 20 documented cave localities (Morgan 1993; McFarlane *et al*. 2002). Anderson *et al.* (1983) reported a further nine amerinidan sites where *Geocapromys* occurs as a zooarchaeological component. Nevertheless, fossil populations have been little studied.

In 1988, University of Liverpool and University of the West Indies geologists excavated a karst fissure exposed in the wall of a roadcut in the Red Hills, north of Kingston. The fissure is approximately 8 m in vertical extent, with a maximum width of 3 m. The fissure contained large numbers of well-preserved bones of *Geocapromys* (Figure 1), together with birds (including the enigmatic flightless ibis *Xenibis*), many species of terrestrial gastropods (Paul and Donovan, research in progress) and exquisitely preserved millipedes (Savage 1990; Donovan and Veltkamp 1994). Red Hills Fissure (RHF) vertebrate bone does not yield macromolecular collagen residues when dissolved in dilute HCl, and is therefore not amenable to direct radiocarbon dating. A specimen of the terrestrial gastropod *Pluerodonte* was recovered from the fissure and radiocarbon dated by the senior author in 1995 (shell carbonate date), yielding an age of 31 960 ± 1220 years BP (Beta Analytic, No. 83969). This specimen was

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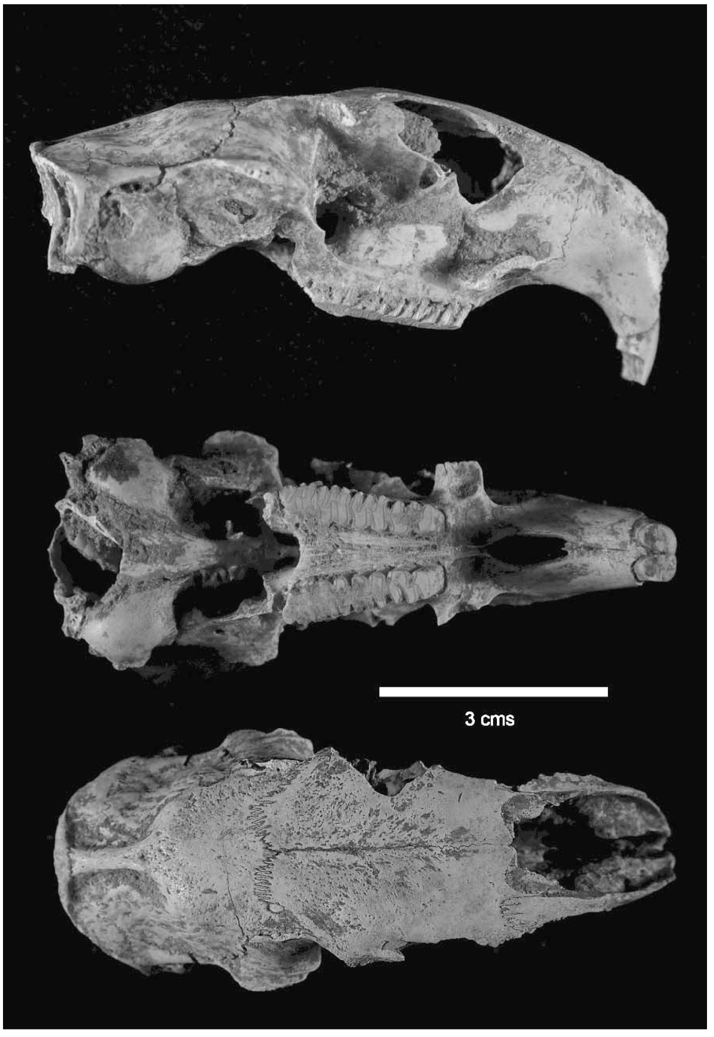

Figure 1. Skull of *Geocapromys brownii* from Red Hills Fissure (LACM 96629).

recovered from mixed out-washings of the fissure, so that its original stratigraphic position is unknown. The dead-carbon effect in Jamaican *Pluerodonte* collected from limestone habitat has previously been investigated and quantified (Goodfriend and Stipp 1983), is expected to be less than 1 standard deviation of the radiocarbon date and is therefore ignored here.

On the assumption that RHF was open and collecting vertebrate remains for a significant interval of time, attempts were made to recollect at the site in 2003 and recover material from both the upper and lower portions of the fissure. This work had only limited success, as very little vertebrate bone was found remaining *in situ*.

As an alternative to direct radiocarbon dating of large numbers of stratigraphically mixed *Geocapromys* bones from slumped deposits below the fissure, we have employed fluorine relative dating (FRD) as an adjunct to selective radiocarbon dating. Recent advances in FRD (Schurr 1989) have demonstrated that FRD has the potential to discriminate relative age differences in bone deposits at low cost and high temporal resolution ($\sim$50 yrs for mid-Holocene archaeological bone).

Very little life history information is available for any of the diverse assemblage of extinct West Indian mammals. However, because *Geocapromys* has survived into modern times, some ecological information is available.

Recent work by Wilkins (2001) on live-caught *Geocapromys brownii* has established a 'von Betalanffy growth curve' based on the mandibular toothrow length, of the form

$$L_t = L_0[1 - e^{-K(t-t_0)}]$$

where L_t is the toothrow length at time t, K is a growth rate constant equal to 1.50 and $t_0 = 0.4664$.

Since *Geocapromys* mandibles are well represented in Red Hills Fissure, and toothrow length can be determined accurately, age at death for the thanatocoenose can be established and used to construct a static life table using standard ecological methods.

2. METHODS

Mandibular toothrow length (P4–M3, or their alveoli) was measured for 105 hemi-mandibles of *Geocapromys brownii* recovered from RHF, and the specimens assigned to one of nine six-monthly age cohorts according to Wilkin's equation. A static life table was compiled by standard methods (see e.g. Krebs 1998) and used to derive age-specific survivorship.

Sub-samples of 10 mg were cut from 13 individual *Geocapromys* femora and assayed for fluorine content by ion-selective electrode (Schurr 1989). Additionally, two gastropods in association with fluorine-assayed *Geocapromys* bone were collected from known stratigraphic positions within RHF, cleaned of extraneous matrix, and submitted for AMS ^{14}C (carbonate) dating at the Gliwice Radiocarbon Laboratory, Poland.

These samples were used to construct a fluorine–age linear uptake model. Since both radiocarbon age and fluorine measurements incorporate significant measurement error, we used a Monte Carlo procedure to generate a dataset of age–fluorine data pairs ($N = 100$) from the Gaussian distributions of both the radiocarbon dates and fluorine values. On the assumption that fluorine uptake is linearly correlated with age over the relevant time interval, we then obtained a linear regression equation for this dataset and used it to predict age (and standard deviation of the age predication) for all fluorine-assayed specimens.

Specimens are accessioned into the collections of the Natural History Museum, Los Angeles County (LACM).

3. RESULTS

Geocapromys survivorship at Red Hills Fissure (Figure 2) is typical of that seen in many small mammals. Life expectancy for animals in lowest in their first 6 months of life, at 1.36 years, peaking in the 2.5–3.0 year cohort at 5.25 years. Maximum predicted life span is approximately 8 years.

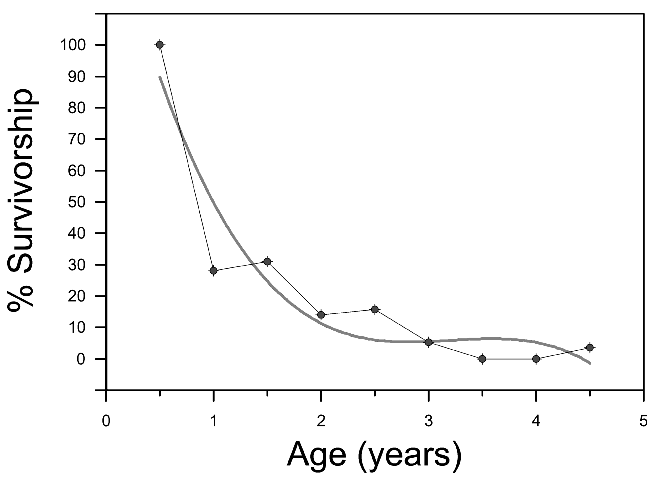

Figure 2. Survivorship curve for late Pleistocene *Geocapromys brownii* collected from Red Hills Fissure, Jamaica.

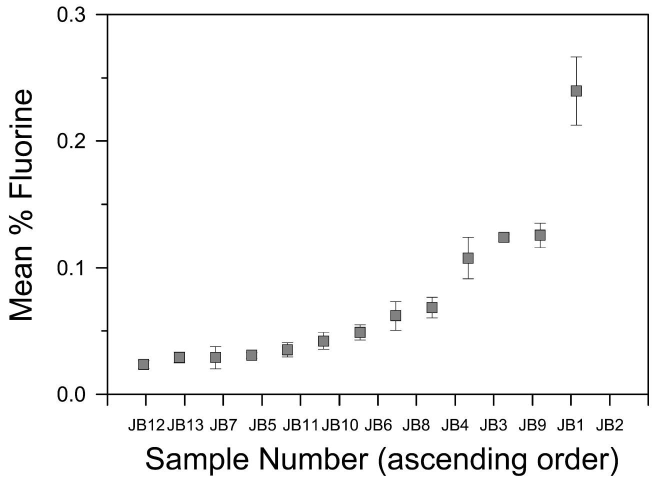

Figure 3. Fluorine content (percentage by dry bone mass) of 13 samples of *Geocapromys brownii* bone from Red Hills Fissure, Jamaica.

AMS ^{14}C ages based on land snail shell carbonate, without correction for the 'limestone effect', were 21 140 ± 110 rcybp for a specimen collected *in situ* at the 302 cm level in RHF and 29 560 ± 300 rcybp for a specimen collected from matrix slumped to the base of the fissure (original stratigraphic position unknown). The limestone effect is expected to make the true age of these specimens younger than the apparent ^{14}C age by less than 1000 years (Goodfriend and Stipp 1983) and is ignored hereafter.

Fluorine analysis reveals that there are statistically significant differences in percentage fluorine content of *Geocapromys* bone from RHF (one-way ANOVA, $F = 61.97$, $P = 5.96 \times 10^{-22}$; Figure 3). On the assumption that fluorine content is primarily a function of age at this site, we interpret the variation in fluorine content as indicative of significant age differences in the specimens. The predicted 'fluorine ages' range from 25.6 ± 2.3 kyr to 40.7 ± 3.2 kyr (Figure 4).

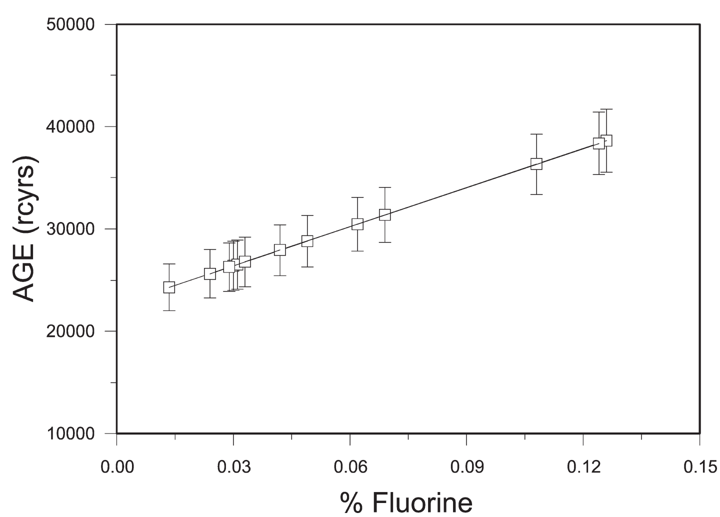

Figure 4. Predicted age (with 1 sigma confidence limits) of 13 specimens of *Geocapromys brownii* from Red Hills Fissure, Jamaica.

4. DISCUSSION

4.1. Origin of the thanatocoenose

Red Hills Fissure is a remnant of a former karst void exposed by road-cutting (Donovan and Gordon 1989). Most of the original cavity has been removed, making it impossible to judge the geometry of the original cave/fissure. Vertebrate fossil deposits accumulate in caves and fissures as predator (owl) deposits, as accumulations beneath natural trap/pitfalls, as flood deposits and as the remains of animal dens (Kos 2003a, 2003b). The RHF deposit is not dominated by microvertebrates as is typical of owl deposits in Antillean caves (cf. McFarlane and Garrett 1989), nor does it give evidence of any sorting by water. We reject the animal den hypothesis because of the high diversity of species (mammals, birds, reptiles and invertebrates) present. Moreover, the observation that some of the *Geocapromys* material was preserved in partial articulation argues strongly that the animals were not denning in the site, in which cases trampling and disassociation of the specimens are normal. We therefore conclude that RHF was an open fissure or cave that functioned as a rather non-selective natural trap for terrestrial fauna.

4.2. The survivorship curve

Death assemblages accumulating in natural traps exhibit catastrophic age-frequency profiles, with all age classes represented (Klein and Cruz-Uribe 1984), as is clearly the case at RHF. The most notable feature of the survivorship curve is the high mortality of young animals, which experienced a 72% mortality in the first 6 months of life. This pattern is typical of rodents in which newly-weaned young disperse from natal refugia into an environment that exposes them to predation. Late Pleistocene Jamaican predators would have included a caracara (McFarlane *et al.* 2002), a burrowing owl (Morgan 1993) and the extant Barn Owl.

4.3. Age relationships

The age of the RHF fauna has proven difficult to establish, because the vertebrate bone has been entirely leached of macro-molecular organics suitable for radiocarbon dating. Moreover, the majority of fossil material has been collected from slumped and mixed debris at the foot of the fissure, and the original relative stratigraphic position of the specimens is therefore unknown. Examination of the fissure in the summer of 2003 revealed very little material remaining *in situ*. The late Glenn Goodfriend attempted an uncalibrated amino-acid racemization date on RHF *Pluerodonte* shells, estimating racemization rate on the basis of his considerable experience at other Jamaican sites. He estimated an age of '20 000–30 000 years BP' (G. Goodfriend, personal communication, 1994) on material of unknown stratigraphic provenance within the site. The subsequent radiocarbon date on *Pluerodonte* shell carbonate (neglecting the 'limestone effect', which is probably less than 1000 yrs; Goodfriend and Stipp 1983) yielded 31.96 ± 1.22 ka on the same material, and confirmed that at least some of the RHF deposit dates from Oxygen Isotope Stage 3.

Analysis of the fluorine content of 13 *Geocapromys* long bones from RHF demonstrates significant differences in age, assuming a linear fluorine–age uptake model. Predicted 'fluorine ages' span some 15 kyr of the late Pleistocene, mid- to terminal Isotope Stage 3. The youngest gastropod shell ^{14}C age, allowing for limestone effects, suggests that the youngest material in RHF accumulated around the Last Glacial Maximum, $\sim$18 kyr BP. kyr BP. The impled accumulation (fissure infilling) rate of $\sim$0.5 m per millenium is in accord with anecdotal observations in other Jamaican karst sites.

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