Late Holocene extinction of Puerto Rican native land mammals

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Electronic Appendix A: Palaeontological Fieldwork

Nineteen days were spent in the field between 11 January and 4 February 2005, during which a total of 26 caves were sampled for subfossils. Most of these sites were located in the northern karst belt immediately south of Barahona village in Morovis Principality, a region also favoured by earlier palaeontologists (Anthony 1918; Choate & Birney 1968; Pregill 1981; McFarlane 1999a), with two additional sites located respectively in the southern limestone belt and the southern coastal plain. Sampling involved dry-screening with 2 mm screens and subsequent residue sorting, except where indicated below. Nineteen caves were found to contain subfossil remains of extinct mammals, and are listed and discussed briefly below.

1. **Cueva del Perro** (topographic coordinates 2030686 N, 769482 E; Universal Transverse Mercator Grid, corrected to Puerto Rico datum).

This site had previously been excavated by J. W. Bee (Choate & Birney 1968), field parties from the Smithsonian Institution (Pregill 1981), and McFarlane (1999a). Fieldwork at the site involved removal of loose superficial sediment, and sampling 2 cm depth intervals across the compacted sediment of Layer A (wet-screening with 2 mm screens), in a 40×40 cm quadrat situated 270 cm from the northeast cave wall at the edge of Bee's excavation pit. Vertebrate bones and charcoal were collected from the residue of each sampling interval.

2. **Cave 72** (2030271 N, 768897 E)

A previously unstudied cave with DNR number '72' marked on the wall close to the entrance. Considerable sediment remained close to the cave walls, but was relatively moist. Subfossils were often encrusted and present on or near the sediment surface, suggesting that the site was unlikely to yield radiometrically recent specimens.

3. **Nesophontes Cave** (2030320 N, 0769577 E)

Previously sampled by field parties from the Smithsonian Institution (Pregill 1981), who reported that the slope immediately inside the southern entrance contained an extremely rich concentration of bones. In the three decades since the Smithsonian visits, much of the slope deposit appears to have eroded away, with subfossil material being considerably less abundant than anticipated, although an associated but very incomplete skeleton of *Acratocnus* was recovered from the site.

4. **Nesophontes II Cave**

A small (<10 m) raised, closed passageway immediately adjacent to and above the southern entrance of Nesophontes Cave contained an extremely rich owl accumulation, with the densest concentration of bones located 20-24 cm below

sediment surface along the eastern wall. This accumulation was completely collected, and found to contain extensive material of *Nesophontes*, as well as sparse *Heteropsomys* and considerable bird and lizard material.

5. **Nesophontes Minor**

A small shelter located immediately below the northern entrance of Nesophontes Cave, which contained a small amount of *Acratocnus* material.

6. **Cueva Clara** (2030126 N, 769400 E)

Apparently previously sampled by Anthony, Bee and McFarlane, although different researchers do not agree whether the former localities identified by this name represent the same site (Pregill 1981; McFarlane 1999a). Remaining sediment along the cave walls near the entrance has become partially calcified, consisting of lumpy concretions which are difficult to sample, although the upper calcified layers yielded a possible proximal ulna of *Rattus*, suggesting that rapid calcification has occurred relatively recently. A small chamber further inside the cave contains a rich assemblage of bird bones with some *Nesophontes*.

7. **Cueva de la Vaca** (2030161 N, 769331 E)

Previously sampled by McFarlane (1999a). Excavation of the top 20 cm of sediment adjacent to McFarlane's pit yielded a rich accumulation of rodents, including an incomplete femur larger than that of *Elasmodontomys*, representing a new extinct rodent genus. Although McFarlane reported the presence of *Nesophontes* at this site, the genus is apparently absent from the top 20 cm, suggesting a taphonomic bias to the assemblage that warrants further study.

8. **Cueva de la Vaquita** (2030310 N, 769322 E)

A previously unstudied small (c. 15×20 m) cave situated less than 100 m down the same valley as Cueva de la Vaca. No subfossil material was obtained from the main chamber, but some apparently old samples were obtained from below a travertine sill in the back chamber.

9. **Snake Cave**

A previously unexcavated small (c. 8×10 m) cave situated close to the head of the small valley and in the same valley wall as Cueva de la Vaca, containing a taphonomically similar rich rodent assemblage which also warrants further investigation.

10. **Cueva Cucaracha**

A previously unstudied cave with two entrances between Cueva de la Vaca and Snake Cave, containing a range of subfossil taxa.

11. **Cueva Niña**

A previously unexcavated small (c. 1.5 m^2 dry sediment) cave, situated in the same small valley directly opposite Cueva de la Vaca, and containing a range of different native and introduced mammal taxa close to the sediment surface.

12. **Sinkhole Cave** (2030272 N, 769495 E)

A previously unstudied cave at the head of the valley containing Cueva de la Vaca, with two large sinkholes in the roof below which *Elasmodontomys* toothplates were uncovered from the top 3 cm of sediment.

13. **Creek Cave** (2030437 N, 769497 E)

A previously unexcavated small (c. 5 m deep) cave, containing small amounts of subfossil material.

14. **Inside Out Cave** (2030490 N, 769694 E)

An extended c. 16 m long overhang alongside a trackway, extending into a shallow cave at its northern end. Sediment-covered travertine ledges just above current ground level at the southern end of the overhang yielded well-preserved *Nesophontes* crania, and a small cavity in the wall ('Phil's Hole') adjacent to these contained moist, humic-rich soil filled with broken glass, pig bones and recent-looking *Isolobodon* and *Cyclura* material, as well as older-looking *Elasmodontomys* bones (a pelvic fragment and a patella). However, the presence of crab remains in Phil's Hole indicates that bioturbation is likely to have occurred.

15. **Cueva Arcilla** (2029934 N, 768931 E)

A heavily mined cave containing little intact sediment or subfossil material. Although known to members of the Fundación de Investigaciones Espeleológicas del Karso Puertorriqueño by the name 'Arcilla', it does not match the description of Cueva Arcilla given by Pregill (1981).

16. **Barahona IV** (2030925 N, 768026 E)

A tunnel-shaped cave with two large entrances, previously sampled extensively by the Smithsonian Expedition (Pregill 1981). Large spoil piles from these former excavations are present in the cave, and little original sediment remains except in the narrow passageway between the two entrances, from which some subfossil material was retrieved.

17. **CM Cave** (2030990 N, 768213 E)

A through tunnel behind a banana plantation close to Barahona IV, with *Isolobodon* remains within 5 cm of the sediment surface.

18. **Monte Grande *aka* Trina Cave** (200024 N, 700369 E)

A large cave situated on a steep rocky slope near Trina Creek in the southern limestone belt near San German. A cave faunule containing *Rattus*, *Isolobodon*, and extinct native mammals was described from this site by Reynolds et al. (1953), but today no sediment remains in the entrance chamber from which it is likely that this material was originally collected. Considerably further inside the cave, a chamber accessible via a steep climb contained a pocket of sediment with *Rattus* and *Nesophontes* present together in the top 5 cm.

19. **Guánica Bat Cave** (1987110 N, 727740 E)

A large cave situated in subtropical dry forest close to the south coast. Although it was described by Pregill (1981) as the only significant site discovered by the Smithsonian Expedition outside the Barahona area, very little subfossil material was found in the cave during our fieldwork.

	Cueva del Perro	Cave 72	Nesophontes Cave	Nesophontes II	Nesophontes Minor	Cueva Clara	Cueva de la Vaca	Cueva de la Vaquita	Snake Cave	Cueva Cucaracha	Cueva Niña	Sinkhole Cave	Creek Cave	Inside Out Cave	Cueva Arcilla	Barahona IV	CM Cave	Monte Grande	Guánica Bat Cave
Acratocnus odontrigonus		×	×		×		×	×		×	×			×		×			
Elasmodontomys obliquus	×	×	×				×	×	×	×		×		×	×	×			
Heteropsomys insulans	×	×		×			×		×	×									
Isolobodon portoricensis							×				×		×	×			×		×
Nesophontes edithae	×		×	×		×				×				×		×		×	
Rattus rattus	×	×		×		×	×		×		×	×		×				×	
Tainotherium valei							×												

Table S1. Subfossil mammal material collected from 19 non-archaeological Puerto Rican cave sites in 2005.

Electronic Appendix B: Radiometric Dating

Radiometric Dating Methods

Bone samples were prepared for AMS ^{14}C dating at the Oxford Radiocarbon Accelerator Unit (ORAU) using routine collagen extraction procedures (Bronk Ramsey et al. 2000). An additional ultrafiltration pre-treatment step was used to further purify the bone gelatin and retain only the >30kD molecular weight fraction for radiocarbon assay (see Bronk Ramsey et al. 2004; Higham et al. 2006). Lyophilised gelatin samples were combusted using a Roboprep CHN sample converter unit and mass spectrometrically analysed using a Europa Scientific 20-20 mass spectrometer, operating in continuous flow mode. Graphite was prepared using routine methods (Bronk Ramsey & Hedges 1999). Bone collagen preservation was evaluated primarily using the carbon to nitrogen atomic ratio (C:N) and the % weight collagen extracted from the bone. The bones dated at ORAU were within the acceptable C:N range of 2.9 to 3.5. All dated samples exceeded 1% wt. collagen, which is the minimum acceptable threshold.

Conventions used for Radiometric Ages

In this paper, radiocarbon ages are reported as conventional ages ‘BP’ (Before Present, or 1950 AD) as recommended by international conventions (see Stuiver & Polach 1977), whilst calibrated, or calendar ages are reported as ‘cal BP’ or ‘cal AD/BC’. Calibrated ages were obtained using the INTCAL04 dataset of Reimer et al. (2004).

Electronic Appendix C: Body Mass Estimates for West Indian Insectivores and Echimyids

Species	M1 length	M1 width	Body mass (g)	n	m1 length	m1 width	Body mass (g)	n	Body mass (g), direct measurement	n
Nesophontes edithae (Puerto Rico)	3.55	3.83	207.8	2	3.15	2.10	124.6	6	–	–
N. hypomicrus (Hispaniola)	1.99	1.93	23.8	4	1.89	1.19	21.0	23	–	–
N. micrus (Cuba)	2.33	2.42	46.1	11	2.24	1.55	42.6	13	–	–
N. paramicrus (Hispaniola)	2.51	2.28	47.4	10	2.33	1.40	39.0	15	–	–
N. zamicrus (Hispaniola)	1.55	1.52	10.4	3	1.13	1.37	10.6	13	–	–
N. sp. (Cayman Brac)	2.04	2.17	30.5	10	1.99	1.29	26.2	20	–	–
Solenodon arredondoi (Cuba)	4.50	7.50	989.8	1	–	–	–	–	–	–
S. cubanus (Cuba)*	–	–	–	–	–	–	–	–	769.0	2
S. marcanoi (Hispaniola)	–	–	–	–	3.37	2.90	229.8	1	–	–
S. paradoxus (Hispaniola)*	–	–	–	–	–	–	–	–	805.5	39

Table S2. Body mass estimates for different extinct and extant West Indian insectivores. Asterisks indicate species that are still extant. *Nesophontes* and extinct *Solenodon* species body masses estimated using upper and lower first molar dimensions, based on insectivore regression equations in Bloch et al. (1998). Cuban *Nesophontes* taxonomy follows Condis Fernandez et al. (2005). *N. edithae* appears to display significant temporal changes in body size (McFarlane 1999b), so the body mass estimate for this species is based only on stratigraphically young specimens interpreted as probably of Holocene age. Most estimates based on direct measurements by the lead author of subfossil material from: American Museum of Natural History (*N. micrus, N. submicrus, N. zamicrus*), Museum of Comparative Zoology, Harvard University (*N. hypomicrus, N. zamicrus, S. marcanoi*), United States National Museum (*N. hypomicrus, N. paramicrus, N. zamicrus*), University of Florida Museum of Natural History (Cayman Brac *Nesophontes* sp.), and lead author's

personal collection (*N. edithae*). Other *Solenodon* molar measurements from Ottenwalder (2001). Direct body mass measurements of *Solenodon cubanus* and *S. paradoxus* from Ottenwalder (1991).

Species	Femoral anteroposterior width	Body mass (g), OLS	Body mass (g), RMA	n
Boromys offella (Cuba)	3.28	418.5	410.2	2
Boromys torrei (Cuba)	2.45	202.3	195.6	20
Brotomys voratus (Hispaniola)	4.07	723.9	717.3	32
Heteropsomys insulans (Puerto Rico)	6.23	2138.7	2165.0	8

Table S3. Body mass estimates for different West Indian echimyid species using anteroposterior femoral diameter at 65% distance from distal articular surface, based on ordinary least squares (OLS) and reduced major axis (RMA) regression equations in Biknevicius et al. (1993). Measured material from: American Museum of Natural History (*Boromys offella*, *B. torrei*; uncatalogued postcrania from H. E. Anthony's 1917 Daiquiri collection (Anthony 1919), assessed by lead author to represent these species on the basis of stratigraphically associated craniodental material), The Natural History Museum, London (*H. insulans*), and United States National Museum (*Brotomys voratus*). No postcrania are known for *Brotomys contractus* (Hispaniola).

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