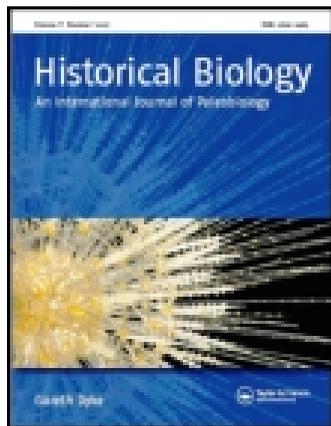


This article was downloaded by: [Natural History Museum]

On: 31 October 2014, At: 09:40

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Historical Biology: An International Journal of Paleobiology

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/ghbi20>

In the footsteps of the bone collectors: nineteenth-century cave exploration on Rodrigues Island, Indian Ocean

J. P. Hume^a, L. Steel^b, A. A. André^c & A. Meunier^c

^a Bird Group, Department of Life Sciences, Natural History Museum, Akeman St, Tring Herts HP23 6AP, UK

^b Department of Earth Sciences, Natural History Museum, Cromwell Rd, London SW7 5BD, UK

^c François Leguat Museum, Anse Quitor, Rodrigues

Published online: 06 Mar 2014.

To cite this article: J. P. Hume, L. Steel, A. A. André & A. Meunier (2015) In the footsteps of the bone collectors: nineteenth-century cave exploration on Rodrigues Island, Indian Ocean, *Historical Biology: An International Journal of Paleobiology*, 27:2, 265-286, DOI: [10.1080/08912963.2014.886203](https://doi.org/10.1080/08912963.2014.886203)

To link to this article: <http://dx.doi.org/10.1080/08912963.2014.886203>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

In the footsteps of the bone collectors: nineteenth-century cave exploration on Rodrigues Island, Indian Ocean

J. P. Hume^{a*}, L. Steel^b, A. A. André^c and A. Meunier^c

^a*Bird Group, Department of Life Sciences, Natural History Museum, Akeman St, Tring Herts HP23 6AP, UK;* ^b*Department of Earth Sciences, Natural History Museum, Cromwell Rd, London SW7 5BD, UK;* ^c*François Leguat Museum, Anse Quitor, Rodrigues*

(Received 21 December 2013; accepted 19 January 2014; first published online 6 March 2014)

For all of the nineteenth-century bone collectors working on Rodrigues, their main objective was to search the caves for specimens of the Solitaire *Pezophaps solitaria*, the sister taxon of the Dodo *Raphus cucullatus* of neighbouring Mauritius. Rodrigues Island has an extensive calcarenite plain in the southwest of the island, which contains numerous caves. A number of expeditions explored the area and excavated the caves, especially during the 1860s and 1870s, resulting in the discovery of thousands of subfossil bones. Some details of these activities were published, and some of the expedition explorers left manuscript reports, all of which provide clues as to where they were excavating. Here, we present the results of a modern attempt to reconstruct the movements of these expeditions and to discover which of the numerous caves were visited and excavated.

Keywords: Solitaire *Pezophaps solitaria*; Dodo *Raphus cucullatus*; Edward Newton; George Jenner; Henry H. Slater; William Caldwell

Introduction

The Mascarene Islands of Mauritius, Réunion and Rodrigues are situated in the southwestern Indian Ocean; all are volcanic in origin and have never been connected to each other or any other landmass. Rodrigues (19.72°S, 63.42°E) (Figure 1) is the smallest and most remote of the islands, being 17.7 km long and 8.45 km wide, with a surface area of 104 km², and is situated approximately 574 km to the east of Mauritius (Cheke and Hume 2008). Rodrigues is a basaltic island, but has a small covering of calcarenite (lithified calcareous sand dunes) (Middleton and Burney 2013) generally called the Plaine Corail, covering an area of approximately 3 km² in the southwestern corner of the island (Saddul 2002) (Figure 2a and b). Middleton (1998) divides the Plaine into three subdivisions, Plaine Corail (west of Rivière Anse Quitor), Plaine Caverne (directly east of Rivière Anse Quitor) and Corail-Petite Butte (east of Plaine Caverne), which have their own groups of caves. In this paper and for simplicity, we use the name Plaine Corail for the entire calcarenite plain. The Plaine Corail is noted for the development of caves and other karst features that have been formed by the dissolution of the limestone. There are at least 30 known caves, ranging from small overhangs that extend for only a few metres, to larger cave systems that extend for up to 700 + m (Middleton and Burney 2013). Their depth is constrained by the thickness of the calcarenite, which rarely exceeds 20 m. The aeolian deposition of the calcarenite has been dated at 80,000 YBP (Montaggioni 1973), but it is probably much older (Middleton and

Burney 2013). At the very least, a date of 9540–9460 cal. YBP obtained from a sediment core at the base of Canyon Tiyel (Burney et al. *in press*) indicates that mature cave systems existed well before. A number of these caves have skylights (roof openings) or steeply inclined entrances, which have acted as natural traps for live animals and water-transported bones, and continue to do so (personal observation). Sedimentation rates appear to have been quite slow (Hume 2013; Burney et al. *in press*) and preservation of bones can be exceptionally good. The sediments within the caves can be extremely rich in subfossil remains.

The palaeontological history of Rodrigues began with the discovery in 1786 of bones of the Rodrigues Giant Tortoise *Cylindraspis* sp. and the Solitaire *Pezophaps solitaria* (Strickland 1853), the latter being the sister taxon of the Dodo *Raphus cucullatus* of neighbouring Mauritius; both species were extinct flightless columbids (pigeons and doves), and called ‘didines’ at the time. Further collecting took place over the next century (Table 1), but it was not until the 1860s and early 1870s that large-scale excavations took place, organised by the colonial secretary Edward Newton and the police magistrate, George Jenner. In 1874, there was a multidisciplinary expedition by the Royal Society of London to study the Transit of Venus and to record the natural history of Rodrigues (see Cheke and Hume 2008). The naturalist Reverend Henry H. Slater was responsible for the study and excavation of the caves (Slater 1879a, 1879b). The following year, William Caldwell, who had been sent to Rodrigues to investigate

*Corresponding author. Email: j.hume@nhm.ac.uk



Figure 1. (Colour online) Aerial image of Rodrigues showing the probable route (white) taken by the bone collectors to reach the Plaine Corail. The black line denotes the approximate area of the limestone. Site 1: the landing place at Anse Patate used by Edward Newton and others visiting Cavernes Patate and Safran. Site 2: the landing place at Anse Quitor used by all of the bone collectors to visit Grande Caverne and other caves in the vicinity of Canyon Tiyel. Image downloaded from Google Earth.

charges of fraud against Jenner's successor, explored the caves for 3 months and collected many bones (Caldwell 1875). Two further collections were made by the Rodriguan ships' pilot, William Vandorous, and then by the police magistrate, Joseph Clanfergael O'Halloran (North-Coombes 1971), but there are no records as to where they excavated.

For all of these collectors, their main interest was to search the caves for specimens of the solitaire. They were also interested in collecting didine gizzard (bezoar) stones (Newton 1878), and to ascertain why the remains of solitaires had accumulated in the caves. Early travellers to Rodrigues had previously described the endemic fauna and flora in detail (Leguat 1708; Tafforet c. 1726), but their accounts were generally concerned with the larger and more edible species such as the solitaire and endemic giant tortoises *Cylindraspis* sp. Due to various anthropogenic factors, most species became extinct so rapidly that they were never scientifically described at the time. It is mainly due to the preservation of subfossil material in cave deposits that we are aware of the endemic terrestrial gastropods (Griffiths and Florens 2006), and the smaller vertebrates such as geckos (Arnold 2000) and passerine birds (Hume 2013).

The aim of this paper was to review the activities of the collectors involved in cave exploration on Rodrigues and highlight the discoveries of each of these expeditions. The cave locations mentioned in the manuscripts, notes and diaries are vague and often difficult to interpret, especially as place names, if they existed at all, have changed considerably (Table 2). Almost all nineteenth-century

collections held in museums have no context or precise provenance, beyond 'Cavern, Rodrigues'. We use our knowledge of the Plaine Corail and its caves, in conjunction with historical literature, in an attempt to reconstruct the movements of these nineteenth-century bone collectors.

Methods

All caves were measured using a 50-m tape to the nearest centimetre. Cave entrances were recorded by GPS (error ± 1.5 –2 m). Hard copies of the manuscript notes by Jenner (1871) and Slater (c.1875a, c.1875b), cave maps by Brial (1996) and Middleton (1998, 2008), and printouts from Google Earth were used in the field.

Institutional abbreviations

FLMR, François Leguat Museum, Rodrigues; GLAHM, Hunterian Museum, Glasgow; MI, Mauritius Institute, Mauritius; MNHN, Muséum National d'Histoire Naturelle, Paris; NHMUK, Natural History Museum, London; RSAS, Royal Society of Arts and Sciences, Mauritius; UMZC, University Museum of Zoology, Cambridge.

Pioneer bone collectors 1786–860

The first subfossil bones on Rodrigues were found in a cave by Captain de Labistour in 1786 (Desjardins 1831 [1972]; North-Coombes 1994; Cheke and Hume 2008). They

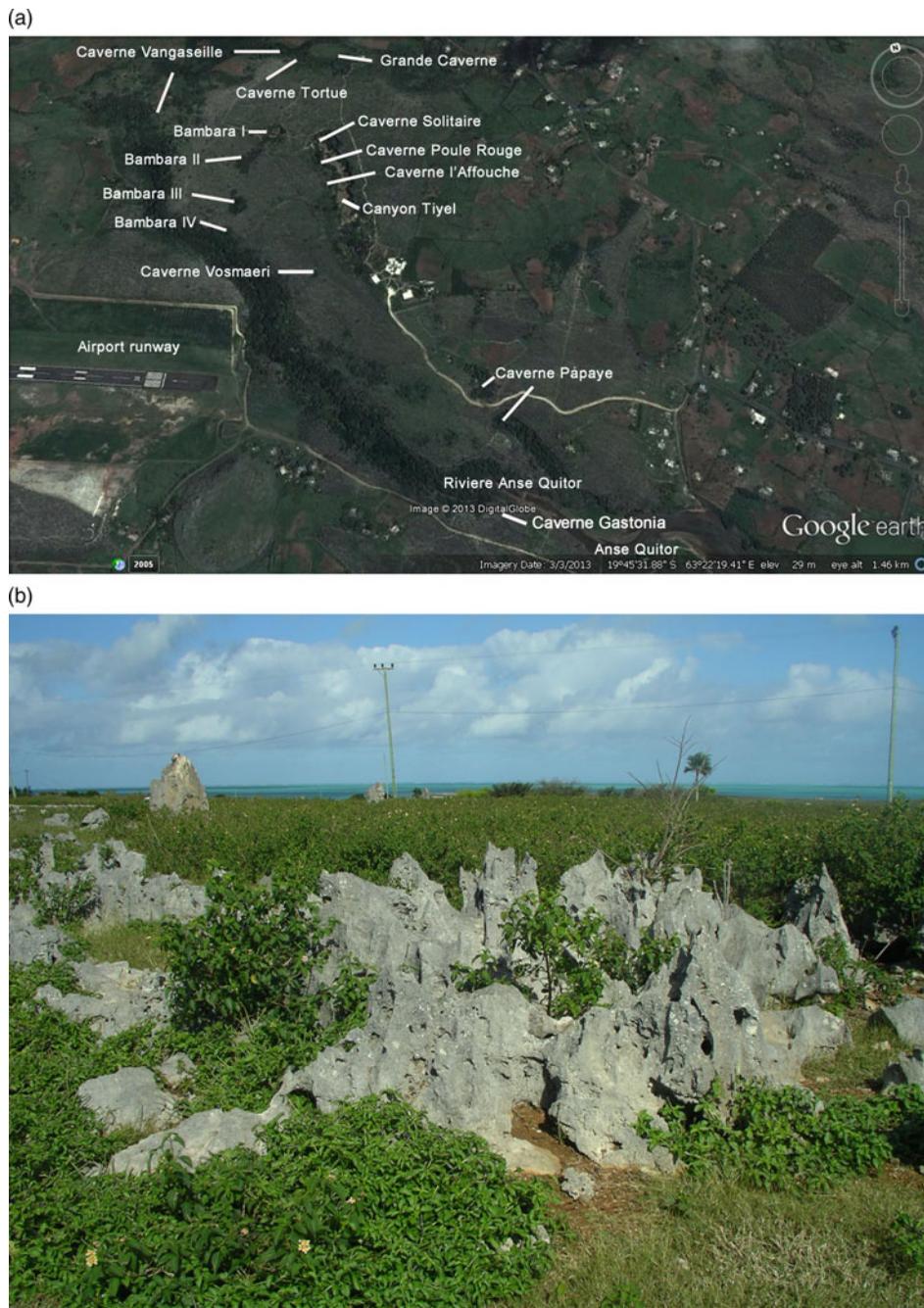


Figure 2. (Colour online) (a) Annotated detail of the Plaine Corail cave area, where almost all of the fossil material was collected, and the caves mentioned in the text. Image downloaded from Google Earth. (b) A view of the Plaine Corail looking south from the access road to the François Leguat Giant Tortoise and Cave Reserve. Electricity Pole Cave is close to the wooden pylon in the centre of the image.

comprised six solitaire bones, five of which were received by the French comparative anatomist, Georges Cuvier in 1830 (see below), the sixth remaining in Mauritius until 1849 (Strickland 1849), and a single tortoise bone (Günther 1879). *En route* to the caves, Labistour also collected a Rodrigues giant tortoise (Appendix 1 in the Supplementary data). This was the only time a giant tortoise was recorded alive on the Plaine Corail and one of the last to be taken; two

individuals seen in a valley around 1795 was the final record (Cheke and Hume 2008, p. 115). Labistour described two large caves (Grand Caverne and Caverne Patate) in his manuscript notes (Appendix 1 in the Supplementary data), but did not mention in which of these caves he found the specimens (see North-Coombes 1971, 1994). However, it is more likely that he collected his specimens in Grande Caverne. During Labistour's visit, the entrance was

Table 1. List of the nineteenth-century solitaire *P. solitaria* bone collections made on Rodrigues, in chronological order, with present location of specimens where known.

Collector	Year	Location history (number of specimens)
Labistour	1786	Originally deposited in the collection of the Société d'Histoire Naturelle, Mauritius; now in MNHN, Paris (five bones). Originally deposited in the collection of the Société d'Histoire Naturelle, Mauritius; now in UMZC, Cambridge (one bone). Total six bones.
F. Dawkins	1832	Originally deposited in the collection of the Société d'Histoire Naturelle, Mauritius; now in UMZC, Cambridge (one bone).
H. Eudes	1832	Deposited in Andersonian Museum, Glasgow by Telfair. Current whereabouts unknown (six bones). NHMUK has casts of these bones. Deposited in the Zoological Society of London collections by Telfair; now in NHMUK (five bones). Total 11 bones.
Unknown	Before 1860 (sent to Owen in England by Bouton in 1860)	Originally deposited in the collections of the RSAS, Mauritius. Current whereabouts unknown, but possibly MI (three bones).
E. Newton/F. Barclay	1864	UMZC, Cambridge (three bones).
G. Jenner	1865	UMZC, Cambridge (85 bones).
G. Jenner and T. Morris	1866	UMZC, Cambridge (2000 + bones, including two associated skeletons).
G. Jenner	1871	UMZC, Cambridge (approx. 1000 bones).
H.H. Slater	1874	Originally deposited in the collections of the Royal Society of London; now in NHMUK (2000 + bones, including two associated skeletons). Originally deposited in the collections of the Royal Society of London; now in RCSHM (two associated skeletons).
I.B. Balfour	1874	GLAHM, Glasgow (21 bones).
W.J. Caldwell and T. Morris	1875	Originally deposited in the collections of the RSAS, Mauritius (two associated skeletons). Current whereabouts unknown, but possibly MI.
W. Vandorous	1875 or later	Size and location of collection unknown.
J.C. O'Halloran	1881 or later	Originally deposited in the collections of the RSAS, Mauritius ('box of bones'). Current whereabouts unknown, but possibly MI.

'unencumbered', but the surveyor C.T. Hoart in 1825 (in North-Coombes 1971) reported that rock fall had occurred in the entrance. Labistour may have been accompanied by one Monsieur de Forvalle, who, along with a guide, appears to have previously visited the caves; therefore, it is not clear who actually picked up the bones (North-Coombes 1994). Strickland (1849, 1853) stated that as they were all uniformly encrusted in a 'stalagmitic covering', and there was no duplication of any bones, they must have been collected from the same cave and all belonged to the same individual. Labistour's son-in-law, Monsieur Roquefeuille, gave the bones to Julien Desjardins, one of the founders of the Société d'Histoire Naturelle (later the Royal Society of Arts and Sciences, Mauritius or RSAS), who in 1830 passed them to Cuvier (Desjardins 1831 [see Ly-Tio-Fane 1972]; Strickland and Melville 1848; Bartlett 1851). Cuvier erroneously reported them as having been found under a lava flow on Mauritius and belonging to the dodo (Cuvier 1830; see Desjardins 1831 [1972, p. 46]), which caused much confusion over the next few decades (Strickland and Melville 1848).

Colonel Francis Dawkins, military secretary to the first governor of Mauritius, Robert T. Farquhar, was prompted by Farquhar and Charles Telfair, a military surgeon, naturalist and a founder of the Société d'Histoire

Naturelle, to search Rodrigues for evidence of solitaires (Telfair 1833; North-Coombes 1991). Because of the pre-eminence of Cuvier, and especially that he was then patron of the Société d'Histoire Naturelle, no Mauritian naturalist dared challenge his judgement (North-Coombes 1991). Telfair was keen to resolve this issue and to obtain solitaire bones from the caves. Strickland (1853, p. 188) implied that Telfair had obtained some bones in 1831, but in fact Telfair had only just started to inquire about getting specimens in that year (Cheke and Hume 2008). Dawkins arrived on H.M. Corvette *Talbot* in August 1832 (North-Coombes 1991), when he 'visited the caverns in which bones have been dug up' (Telfair 1833, p. 31). This was presumably where Labistour had previously excavated, which we believe was in Grande Caverne and possibly Caverne Patate. Some accounts state that Dawkins was unsuccessful (North-Coombes 1991), or found only fragments (Telfair 1833), but in fact he collected a perfect solitaire tarsometatarsus (Strickland 1849) (Table 1); the cave sediment was 6–8 ft deep (Telfair 1833).

Dawkins was assisted by Honoré Eudes, a senior resident of Rodrigues, who continued searching the caves presumably after Dawkins had left (Eudes 1832; Cheke and Hume 2008). Eudes excavated at the entrance of 'the large cavern' where he found bones on the surface and to a

Table 2. Etymology of place names and cave names mentioned in the text.

Present name	Alternative name	Etymology
Plaine Corail		French term for 'Coral Plain', which is a misnomer, as the aeolian calcarenite is not formed from coral reefs.
Caverne Patate		Named after the fishing village, Patates.
Rivière Anse Quitar	Rivière Quitarde	It appears that the word 'Quitar' is a deformation of 'Butor' (Heron). The Green-backed Heron <i>Butorides striatus</i> is frequently seen in this river valley and estuary.
Caverne Safran		Named after a French variety of potato, <i>Solanum tuberosum</i> , or an old French term 'safran' which means the plant, saffron <i>Crocus sativus</i> . Alternatively, 'safran' meaning 'boat rudder' could be referable to a feature in the cave.
Canyon Tiyel	Caverne Mahot/ Caverne Tilleul	The name Mahot (Ma-oo) applied to the critically endangered <i>Hibiscus liliiflorus</i> , which once grew in the canyon. The name 'Tiyel' is derived from the family name, Tilleul, a farmer who once lived in the canyon, and has been so named since the 1940s.
Caverne Vangasaille		Vangasaille is a Creole term for a particular hard-skinned citrus fruit. The latter grow in abundance in Canyon Tiyel today. The name applied to the region north of the present-day cave reserve, including the area of Grande Caverne and Caverne Tortue.
Grande Caverne	Caverne Tamarin	Grande Caverne means 'Great Cave' in reference to it being one of the largest in the region. It was also called Caverne Tamarin due to one immense Tamarind tree <i>Tamarindus indica</i> growing near the entrance.
Caverne Tortue		Named in reference to the large number of endemic tortoise <i>Cylindraspis</i> sp. bones found within the cave.
Caverne Bambara		The origin of this name is unclear, as it has no known meaning.
Caverne Mapou		Named after the Mapou tree <i>Myrcine</i> sp.
Caverne Six Sting		This cave was named by Aurele André as 'Six Sting', as upon its discovery, Arnaud Meunier, Julian Hume and caver Steve Bourne, were stung twice each by the introduced Yellow Paper Wasp <i>Polistes olivaceous</i> or 'Mus Zon'
Caverne Vosmaeri		Named by Julian Hume after the Rodrigues Saddleback Tortoise <i>Cylindraspis vosmaeri</i> , as upon discovery of the cave a single, complete cranium of this species was found on the floor of the cave near the entrance.
Caverne Solitaire		Named by Arnaud Meunier because of the abundance of solitaire bones found within the cave.
Caverne l'Affouche		Named after the fig <i>Ficus reflexa</i> , or 'l'Affouche' because of the large root system of this tree growing into the cave entrance.
Caverne Poule Rouge		Named by Richard Payendee after the Poule Rouge or Mauritian Red Rail <i>Aphanapteryx bonasia</i> .
Caverne Dora		Named by Arnaud Meunier, after Cyclone Dora in 2007 cleared the vegetation from the cave entrance, allowing the cave to be discovered.
Caverne de la Vierge	Cave aux Crabes	From the French 'Cave of the Virgin' because of the abundance of immaculate white formations. The French 'Cave of Crabs' is named after the abundance of land crabs.
Caverne Papaye		Named after the large number of Papaya <i>Carica papaya</i> trees growing around the cave entrance.
Electricity Pole Cave		Named by Lorna Steel, as the cave entrance is situated directly underneath one of the wooden poles supporting the electricity cables that run beside the access road to the François Leguat Giant Tortoise and Cave Reserve.
Caverne Gastonia		Named by Richard Payendee after Bois Blanc <i>Gastonia rodriguesiana</i> , as a single tree of this endemic species grows near the entrance of the cave.
Petit Lac	Etang Davy	French term for 'small lake', as this marsh periodically contains water. The French 'Lake Davy' was named by Pierre Brial in reference to a Rodriguan forest guard named Davy Jones Lamvohee, who co-discovered the site.
Caverne de l'Etrave		Named after the stem (forward most extension of a boat's keel), which may be in reference to a feature in the cave.

Note: This is not a complete list of all of the caves of Rodrigues.

depth of 3 ft (Telfair 1833). We believe that this cave was Grande Caverne. Eudes collected 11 solitaire bones and some tortoise remains and sent them to Telfair prior to November 1832 (Telfair 1833; Strickland and Melville 1848). Telfair presented six of the bones collected by Eudes to the Andersonian Museum in Glasgow, and five to the Zoological Society of London (Telfair 1833; Bartlett

1851; Strickland 1853; Newton 1896). It is commonly stated that Telfair received 12 bones from Eudes (Strickland 1853, p. 188), but in fact one of these was the tarsometatarsus obtained by Dawkins. This bone, along with the sixth Labistour specimen, remained on Mauritius in the Société d'Histoire Naturelle collection until 1849, when Wenceslas Bojer, a third founder of the Society, sent

Strickland both bones (Strickland 1849) (Table 1). We believe that these two bones were the ones referred to in the minutes of the RSAS meeting held on 8 April 1847, where it was agreed that

the specimen [sic] of fossil bones, in the Society's possession, which are believed to be referable to extinct birds, be sent to Mr. Strickland, and directions were given to the curator of the museum to prepare and deliver them to Mr. Cuninghame, for transmission. (Bouton 1848b, p. xv)

George C. Cuninghame, a senior official on Mauritius, was on leave in England when Strickland (1844) made a request for information concerning fossil remains on all three Mascarene Islands. In October 1845, Cuninghame asked Captain Kelly of H.M.S. *Conway* and Mr Halkett, aide-de-camp to the governor, who were then travelling to Rodrigues, to conduct a search (Bouton 1848a, p. 91; North-Coombes 1971, p. 262). Kelly was unable to locate Dawkin's and Eude's excavation sites, but did manage to explore two caves. However, he did not retrieve any bones (Strickland and Melville 1848, p. 52).

Due in part to Cuvier's earlier blunder, it was thought that the solitaire was either a fictitious bird or founded on an imperfect description of the dodo (Strickland 1844). Strickland remarked that every effort should be made on Rodrigues to obtain more bones and that anyone visiting the island should search in caves, in alluvia of streams, and even in ancient rubbish tips associated with towns and villages. He also remarked that all solitaire bones should be carefully examined to confirm their distinctness from the dodo. The solitaire bones were later described and figured in the first monograph on the dodo and solitaire (Strickland and Melville 1848, pp. 46, 54, Pls. 13–15), where the bird was placed in the monotypic genus, *Pezophaps*.

Strickland and Melville's monograph raised scientific awareness of the possibility that dodo bones might be preserved on Mauritius in certain depositional environments such as caves and marshes. However, it was not until 1865 that a bone-rich deposit was discovered at a marsh called the Mare aux Songes by Harry Higginson, a railway engineer, and George Clark, a local school teacher (Hume et al. 2009). Clark contacted the colonial secretary on Mauritius, Edward Newton, whose brother Alfred was a zoologist at the University of Cambridge, UK. Also aware of the discoveries was the comparative anatomist Richard Owen, of the British Museum, London. Academic rivalry over this important site soon developed between these two parties (see Hume et al. 2009) and, through underhand means, Owen received the first shipment of dodo bones. This ensured that he published the first scientific description of the dodo skeleton (Owen 1866), much to the annoyance of the Newton brothers.

As a result of Owen's actions over the dodo, funds from the British Association for the Advancement of Science (BAAS) that had been awarded to the Newtons for

excavations on Mauritius were used to pay for excavations on Rodrigues instead (Hume et al. 2009). Edward Newton had briefly visited some caves in 1864 (E. Newton 1865), but the trip was curtailed, so the local police magistrate George Jenner collected a small series of bird and tortoise bones for him in 1865 (A. Newton 1865b). Jenner had been unable to hire local men to undertake a large-scale excavation, so BAAS funds paid for Mauritian and Malagasy labourers to assist him in 1866 and 1871, before he left Rodrigues permanently later that year (North-Coombes 1971). Jenner's 1865 and 1866 excavations resulted in a monograph on the solitaire, in which most of the cranial and post-cranial skeleton was described (Newton and Newton 1868, 1869).

Another small shipment comprising a solitaire tibiotarsus, the shaft of a tarsometatarsus and some fragments of the shaft of a femur was sent to Richard Owen in 1860 by Louis Bouton, then secretary of the RSAS Mauritius (Bouton 1861). These bones were found by Bouton in the RSAS collections among subfossil material from Flacq on the east coast of Mauritius, and Bouton sought Owen's opinion on their identity (Morris, in Owen 1872b, p. 519). There is a possibility that these bones were in fact dodo, but it is more likely that they were solitaire bones from Rodrigues and had been accidentally placed among the Mauritian material. If this is correct, they were probably obtained by Telfair (Newton 1896) from an unknown collector. While compiling their monograph, the Newton brothers in 1868 had specifically asked Owen about the whereabouts of these bones, but Owen appears to have purposely denied knowing this (Hume et al. 2009). This resulted in a series of bad-tempered exchanges (Newton 1872a, 1872b; Owen 1872a), especially as Owen said he had returned the material to Mauritius prior to the Newtons visiting him at the British Museum in 1868. As a final insult, Richard Owen presented Edward Newton with the very same bones in 1877, long after the Newtons had completed their solitaire monographs (Newton 1896; Hume et al. 2009). Edward returned them to the collections of the RSAS Mauritius (Newton 1896), but they were not found in the MI collections in 2001 (JPH, personal observation).

Although a large number of extinct giant tortoise bones were collected by these pioneers (Günther 1879), just 21 solitaire bones were obtained before Edward Newton's visit to Rodrigues in 1864 (Newton 1896).

Edward Newton (1832–1897)

Edward Newton was stationed on Mauritius from 1859 to 1877, initially as Assistant Colonial Secretary, before becoming Colonial Secretary (Wollaston 1921). Both Edward and his brother Alfred, who was to become the first professor of comparative anatomy at the University of Cambridge, UK, were extremely interested in the original avifauna of the Mascarenes, especially the dodo. Edward

regularly reported back to Alfred the events that took place on Mauritius and sent scientific specimens to Cambridge. After Alfred had lost the opportunity to describe the dodo's skeleton (see Hume et al. 2009), the Newton brothers turned their attention to Rodrigues and the solitaire. Edward planned an expedition to the caves to rectify the shortage of solitaire bones, a fact that had been lamented by Strickland and Melville (1848) when they wrote their monograph. He supposedly travelled on official government business, but spent most of the time in the field (Cheke and Hume 2008). Edward left Mauritius for Rodrigues on 26 October 1864, but arrived late due to poor navigation. Furthermore, a reconnaissance party that had left a week before him to start collecting specimens had not begun work. The Plaine Corail could only be reached by traversing the shallow lagoon in a small boat at high tide, which restricted the time spent there. Edward was forced to return to Mauritius on 3 November, having spent just 2 days on Rodrigues (E. Newton 1865). Edward was furious, but in the short time that he was there, he collected the type specimens of the only two surviving land birds, the Rodrigues Fody *Foudia flavicans* and Rodrigues Warbler *Acrocephalus rodericanus*, and a complete tarsometatarsus and the diaphysis of a humerus of the solitaire (A. Newton 1865a).

According to Edward's account (E. Newton 1865), the party comprised Edward, Captain Anson and 'Captain Barkly' (correct spelling: Barclay), the police magistrate George Jenner, the police sergeant Thomas Morris and five others, all divided between two whale-boats. They left Port Mathurin, the capital of Rodrigues, at 1.00 a.m. on 2 November, and 'poled' (punted) anti-clockwise around the main island (Figure 1), passing a number of bird-covered islets within the lagoon (probably Ile Frégate and Ile Crabe). The boats landed at 6.00 a.m. on a flat coral plain and the party walked a quarter of a mile inland until they reached a cave entrance. Edward described it:

The cave was much the same as all other caves – plenty of stalactites and stalagmites; the width about 50 feet, the height from 20 to 70 feet; the floor nearly flat, and generally covered with a deep fine sand, perfectly dry.

Edward was also informed that the cave was three quarters of a mile long. We suggest that Edward's description best applies to the southern entrance of Caverne Patate (S19°45.494'; E063°23.190') (Figure 3). This cave is situated to the north of a small sandy bay called Anse Patate (S19°45.707'; E063°23.218') that is the only safe place to land a boat on that part of the coast (Figure 4a). This bay lies just to the west of Pointe Patate, which at the time was a fishing post called Patates, and remains a small remote fishing village to this day. The bay is linked to Caverne Patate by a shallow ravine of less than 1.5 m depth (Figure 4b), which ultimately leads directly to another large cave called Caverne Safran (S19°45.462'; E063°23.143') (Figure 5). The ravine appears to have been made by a



Figure 3. (Colour online) Tourist entrance to the southern end of Caverne Patate.

stream, but was dry at the time of our visits (April–May and September 2013), and made walking to both caves comparatively easy. Edward found a few crumbling pieces of tortoise shell just inside the cave, but was hampered by a lack of basic equipment such as digging tools or torches. After an unknown duration, the party returned to the boats and started the return journey westwards to Port Mathurin.

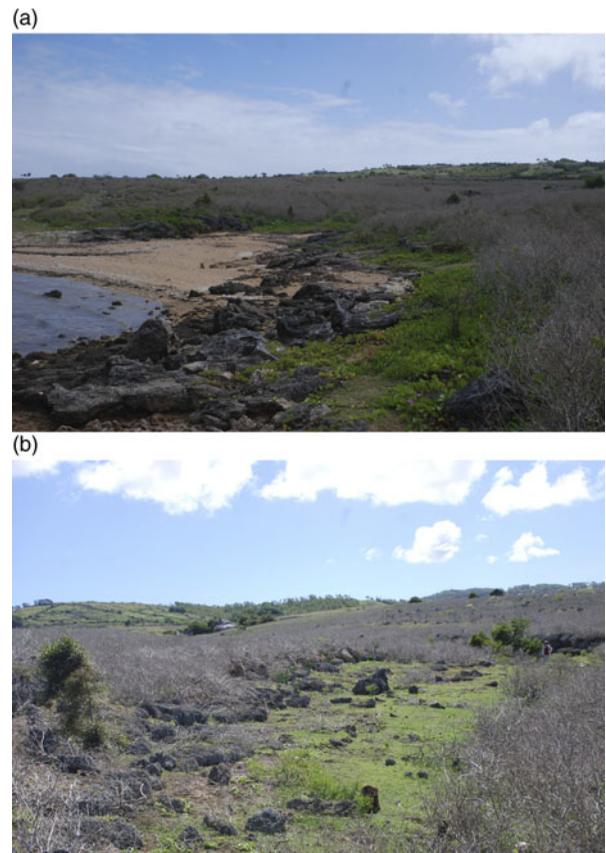


Figure 4. (Colour online) (a) The probable landing point at Anse Patate used by Edward Newton and Henry H. Slater. (b) A view of the shallow ravine from the southern end looking north, which ultimately leads to Caverne Patate and Caverne Safran.



Figure 5. (Colour online) Southern entrance to Caverne Safran. The dead sheep appears to have been a sacrificial animal; the caves are still regarded by some Rodriguans as having supernatural associations.

Edward stated that they travelled 3 miles along the coast by boat after which they stopped for breakfast at an unspecified location, before setting off at 11.00 a.m. (presumably on foot, not by boat) for another cave about 2 miles away. Their guide could not find the way so he went ahead, leaving Edward and the party to rest for an hour before the guide returned with correct directions. The group passed through a 'high-sided rivulet of brackish water' before reaching the cave. Edward had only minutes to explore the cave before the party was ordered to return to the boats for fear of missing the tide (E. Newton 1865). Before departing, he and an unnamed companion went about 100 yards into the cave, and collected the above-mentioned two solitaire bones. Captain Barclay picked up a third from the same cave (Newton and Newton 1868, 1869).

We believe that the 3-mile (4.8 km) distance between the first and second landings was an exaggeration, as it is likely that the second stop was at Anse Quitar (Figure 6), which is about 1.5 km by boat to the west of Anse Patate. This is the only tidal river estuary on the Plaine Corail and has the high-sided banks described by Edward. The cave that they entered is almost certainly Grande Caverne



Figure 6. (Colour online) A view of the estuary looking east at the southern end of Rivière Anse Quitar. Edward Newton almost certainly walked up here during his visit in 1864 to reach Grande Caverne. The cliffs on the opposite side of the river lead to Caverne Papaye.

(S19°45.189'; E063°22.232'), one of the largest caves on the Plaine Corail (Figure 7). It has a large entrance (approximately 20 m wide) that admits daylight for a considerable distance and extends for 490 m (Middleton 2008; Middleton and Burney 2013). We found that by

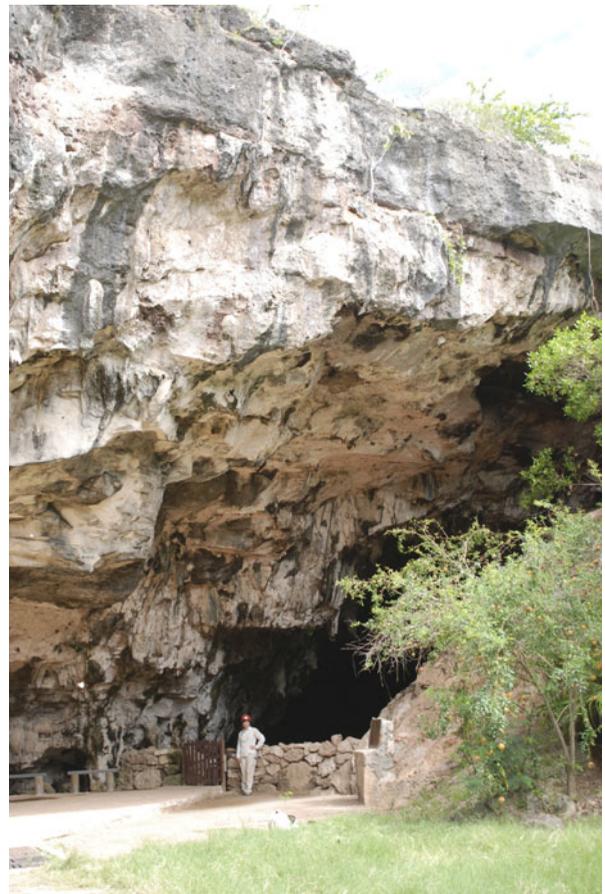


Figure 7. (Colour online) The modern entrance to Grand Caverne.

following the Rivière Anse Quitor, Grande Caverne can be reached within an hour and a half on foot. Another cave, Caverne Papaye (S19°45.650'; E063°22.329'), is situated at the end of another high-sided valley which branches off from the east bank of Rivière Anse Quitor, about 120 m from the coast. We do not believe that Edward visited Caverne Papaye, as it can only be entered by crawling and it is far from '100 yards' in length (Figure 8). We estimate that the group arrived at Grand Caverne at approximately 1.30 p.m., and departed a few minutes later. It would have taken at least 1.5 h to get back to the boat, restricting Edward's time on the Plaine Corail to less than 8 h. The group arrived back in Port Mathurin at 6.00 p.m.

Although Edward Newton never visited Rodrigues again, George Jenner promised him that he would return to the caves and collect more specimens for him.

George Jenner

1865

George Jenner had served in the Crimean War from 1848 to 1858, after which he was appointed inspector of police

on Mauritius and transferred to Rodrigues in 1862 (North-Coombes 1971). After Edward Newton's visit in 1864, Jenner managed to procure 85 solitaire bones representing at least 16 individuals, sending them to Edward on Mauritius in August 1865 (A. Newton 1865b). It is not known whether Jenner returned to Grand Caverne or collected material from elsewhere on the Plaine Corail. Perhaps, this excavation provided Jenner with some knowledge of the whereabouts of more caves in the vicinity of Grand Caverne, but he was unable to do any further work because of the lack of willing labourers (Jenner 1871).

There is evidence of three major excavations in Grande Caverne (Figure 9a and b), and we believe that two of them were made by Jenner. Although speculative, it is most likely that the smallest pit, situated 23 m from the entrance, was made during Jenner's 1865 excavation (irregular circle, 4.5 m diameter and 1 m deep) and the next largest at 25 m from entrance (oval, approximately 8.5 m long and between 1 and 1.5 m deep) was excavated during 1866, (Figure 9b) when he had four coolies (Indian labourers) to assist him. The largest pit, (Figure 9a) situated 46 m from



Figure 8. (Colour online) The southern entrance of Caverne Papaye.

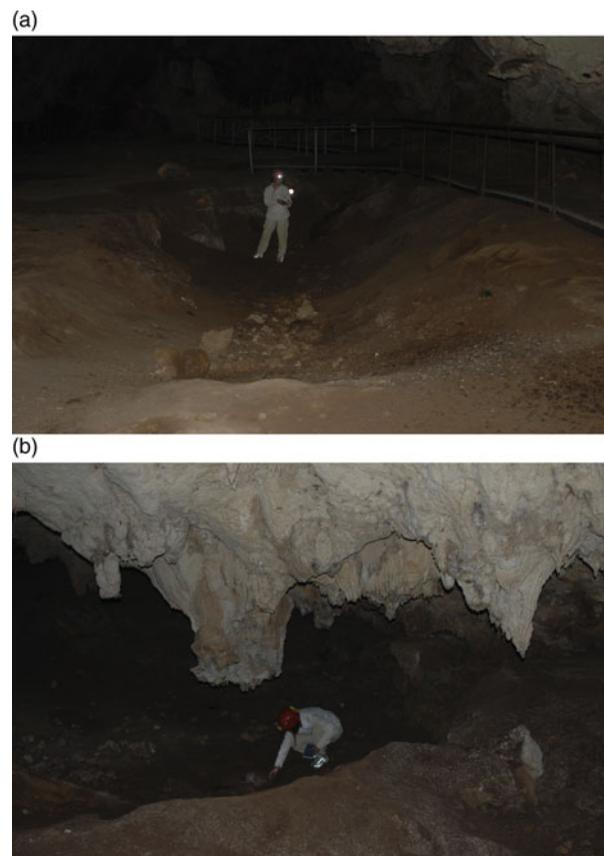


Figure 9. (Colour online) (a) A view of the largest excavation pit in Grande Caverne. This was almost certainly the work of Henry H. Slater and his labourers. (b) One of two smaller pits that were probably the work of George Jenner in 1866.

(a)



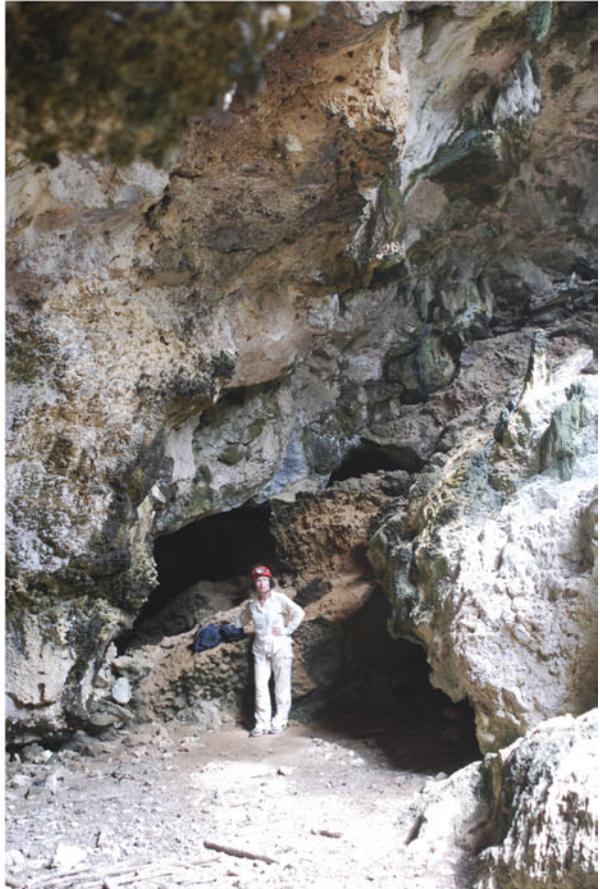
(c)



(b)



(d)



(e)



the entrance (irregular oval, 9 m long, 1 m deep), was almost certainly the work of Slater (see below), who had at least seven men to help with all aspects of the excavations.

August, September and October 1866

Due to the success of Jenner's 1865 excavation, Newton was able to fund another dig in 1866 with the aforementioned BAAS money, which paid for the four labourers to assist Jenner (Hume et al. 2009). It is likely, therefore, that Jenner excavated Grande Caverne during this time, especially as he had extra manpower to accomplish the task. Little information survives concerning this excavation, as Jenner later claimed that he had lost the original 1866 report which described the circumstances of the bone discoveries during that year (Jenner 1871) (Appendix 2 in the Supplementary data). Jenner admits that he was called away to Mauritius on urgent business and had to leave in charge an unnamed subordinate (we believe this was Sergeant Thomas Morris), who also was unable to properly oversee the cave excavations. This resulted in insufficient notes being taken, if any, and Jenner was unable to accurately rewrite his report. It must be remembered, however, that although Jenner was a public servant and had no formal scientific training, he still managed to collect at least 2000 solitaire bones (Newton and Newton 1869). Through Jenner's efforts, the Newtons were provided with enough material to be able to write their solitaire monographs (Newton and Newton 1868, 1869). Because the solitaire exhibited the greatest size sexual dimorphism in any carinate bird (Livezey 1993; Hume and Steel 2013), the obvious size discrepancy in the bones was originally thought to represent two species, *Didus solitarius* and *D. nazareus* (Bartlett 1851) or *Pezophaps solitaria* and *P. minor* (Strickland 1853). This notion was followed by subsequent authors (e.g. A. Newton 1865a), until Jenner's collection and Edward's study proved this untenable (Newton and Newton 1869). Owen stubbornly believed that there were two species (Owen 1872b), but eventually had to quietly accept that Edward Newton was correct (Owen 1878), much to the delight of Alfred Newton (Newton 1896, p. 890 footnote).

15 January–15 February 1871

The report of Jenner (1871) is the most detailed written by any of the bone collectors, but even this leaves much to be desired (Appendix 2 in the Supplementary data). Some of Jenner's cave descriptions can almost certainly be correlated

with particular caves or cave systems on the Plaine Corail, whereas others are almost impossible to determine. After giving his excuses for the failure to record the 1866 excavation, Jenner describes the general geography of Rodrigues, then the 'extremely curious formation' of the limestone plain and its abundant caves. Jenner encountered numerous difficulties; the locals were unwilling to enter the caves due to their superstitions, so Malagasy labourers were brought from Mauritius. Working conditions in the caves were very unpleasant, with a combination of the tropical heat, uneven surfaces, difficult climbs, and the smoke from torches and fires used as a light source underground. Despite this, Jenner was able to excavate 'in thirteen places', some of which were different sites within the same cave. He packed the bones from each of these places separately. He lists each lot as 'Bones N^o. 1, Bones N^o. 2', etc. and attempts to describe the relative location of each site and depositional environment of the bones within each cave. All of Jenner's fossil material was sent to the UMZC (Table 1).

Using Jenner's notes combined with our extensive knowledge of the limestone plain, we suggest that Jenner excavated the following caves:

Bones Nos. 1–6

Jenner named this locality 'Caverne Vangasaille' and described it as a 'beautiful dell, forming an ellipse about 95 yards long (86 m) and 50 wide (45 m), its greatest depth 35 feet'. The dell was described as having two long caverns with several smaller ones branching off it. We do not believe that this is Canyon Tiyel as the canyon's length is approximately 240 m with a width of 35 m. After interviewing an elderly resident and former cave tour guide, Benjamin Peermamode, we found that the name 'Vangasaille' was formerly applied to the valley north of Grand Caverne, which is the source of Rivière Anse Quitor. Despite this, we believe that Jenner was describing the nearby Bambara series, Caverne Bambara I, II, III and IV (Figure 10a–e), where he collected material from the main caverns and side passages. His *Bones No. 1* were collected in two caves, possibly Caverne Bambara II (Figure 10c) and III (S19°45.305'; E063°22.081') (Figure 10d), and he collected *Bones Nos. 2–5* from various side passages and between boulders sometimes just a few feet apart within this cave complex. Jenner's description of *Bones No. 6* (see Appendix 2 in the Supplementary data) almost certainly refers to Caverne Bambara IV (S19°45.361'; E063°22.074') (Figure 10e) because of two reasons: the size dimensions are similar and this cave is the only one that opens out onto Rivière

Figure 10. (Colour online) (a) The 'dell' of Caverne Bambara I looking southwest. (b) A view inside Caverne Bambara I. (c) A view of Caverne Bambara II looking west. (d) Entrance to Caverne Bambara III. (e) A view into Caverne Bambara IV.



Figure 11. (Colour online) (a) Caverne Vosmaeri. View looking east. The cave entrance is obscured by the bushes on the left. (b) The entrance to Caverne Vosmaeri.

Anse Quitar. The sediments are also compacted, which correlates with regular flooding, as described by Jenner (1871).

Bones No. 7

Jenner discovered an unusual feature, which comprised a semi-circular fissure measuring 20 ft long, 2 ft wide and 10 in. depth which he says was situated about 400 yards from Caverne Vangasaille and in an almost direct line between the latter and Grande Caverne. A second semi-circular fissure formed the opposite side of an irregular circle and went down obliquely to a cave of 40 ft deep. The bones were found wedged in the former fissure, but not a single bone was found in the cave. This cave was situated on the north face of a circular depression on the flat surface of the plain. Jenner's account is somewhat ambiguous, but his description best matches Caverne Vosmaeri (S19°45.452'; E063°22.155') (Figure 11a and b), which lies to the southeast of the Caverne Bambara series.

Bones No. 8

This cave locality was extremely difficult to determine, as Jenner's directions appear entirely inaccurate (see Appendix 2 in the Supplementary data). He describes it as being '100 feet long and 30 wide on the edge of a slope, coming down south of Rivière Quitarde' (= Rivière Anse Quitar). We believe that he was referring to Caverne Tortue (S19°45.168'; E063°22.189') (Figure 12), which lies to the west of Grande Caverne and overlooks the upper reaches of the Rivière Anse Quitar.

Bones No. 9

This is another locality that was difficult to determine. As Jenner appeared to be still in the vicinity of Caverne Tortue and the Caverne Bambara series, he may have been referring to Caverne Six Sting (S19°45.238'; E063°22.026') or Caverne de l'Etrave (S19 45.254'; E063 22.016'). His description of entering via a fissure 10 ft long and 4 ft wide, which opens into a cave of 30 ft



Figure 12. (Colour online) The entrance to Caverne Tortue.

long \times 20 ft wide, certainly tallies with the dimensions of either of these caves.

Bones No. 10

Caverne l’Affouche (S19°45.373’; E063°22.175’) (Figure 13), as its name implies, is characterised by the roots of a giant fig tree or l’Affouche growing down into the base. Jenner reported this when describing the cave, stating that it was situated 200 yards south of Caverne Vangasaille, and that the cave dropped down perpendicularly 25 ft; entrance was only obtained by climbing down the roots of the tree. There are in fact at least two well-hidden entrances to the cave, including a narrow crawl on the side nearest Canyon Tiyel, and a steep rift on the northern side, but both are safer than attempting to climb down the roots of the l’Affouche. This cave is still productive. Our excavations in May 2013 unearthed an associated female solitaire, associated Rodrigues Turtle Dove *Nesoenas rodericana*, and an almost complete carapace of the extinct Rodrigues Domed Tortoise *Cylindraspis peltastes*. This material and all other recent collections are housed at FLMR.



Figure 13. (Colour online) The entrance to Caverne l’Affouche, complete with the roots of a l’Affouche (Fig tree), viewed from within the cave.

Bones No. 11

Jenner appears to have been continually moving south across the Plaine Corail and noted that the next cave was 250 yards south from the previous one i.e. Caverne l’Affouche. His description was of an elliptical ‘land slip’ about 50 ft long and 25 ft wide, with a low cave entrance at the southern end, and that it was necessary to crawl on hands and knees through part of it. This description matches Caverne Papaye (S19°45.650’; E063°22.329’). This cave runs under the present road entering the François Leguat Giant Tortoise and Cave Reserve, and where it exits to the south of the road (S19°45.635’; E063°22.308’) (Figure 8), opens into a large canyon that joins the Rivière Anse Quitor just 120 m from the coast.

Bones No. 12

Jenner crossed over the Rivière Anse Quitor to reach the west side, and discovered a fissure 10 ft long and 2 ft wide, with a perpendicular depth of 25 ft. We strongly suspect that this is Caverne Gastonia (S19°45.750’; E063°22.303’)

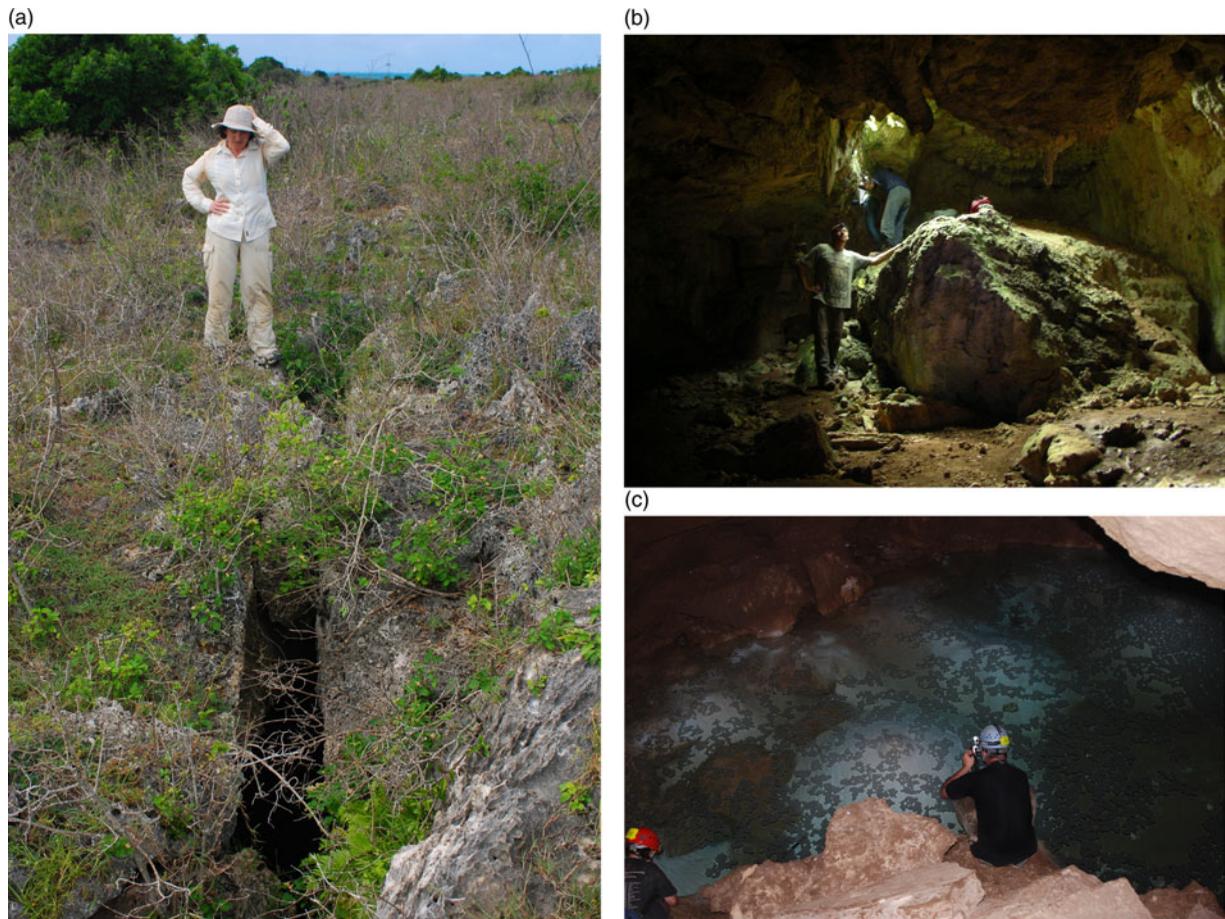


Figure 14. (Colour online) (a) The narrow entrance to Caverne Gastonia. (b) The landing rock and main chamber of Caverne Gastonia. (c) The small, permanent calcium carbonate-saturated pool at the far end of Caverne Gastonia. The floating calcite crystals ('cave raft') and the underwater mounds can be clearly seen.

(Figure 14a and b). This cave is difficult to enter as it requires a daunting climb down the side of the fissure, followed by a daring jump to land on a large boulder at the bottom. Caverne Gastonia has also proved to be extremely productive, and the natural 'pitfall trap' entrance resulted in large numbers of bones being collected inside. This cave has an unusual small lake at the end, which is so calcium carbonate-saturated that flakes of calcium carbonate form on the surface ('cave raft') and sink to the bottom, forming small domes on the lake floor (Figure 14c).

Bones No. 13

Jenner's last excavation took place in a cave 300 yards east of Caverne Gastonia, where he entered a fissure 10 ft long with a gentle slope of about 25 ft leading to the cave. This best fits Electricity Pole Cave (S19°45.677'; E063°22.293'), which lies to the east of the Rivière Anse Quitor and close to Caverne Papaye, to which it might once have been connected.

It is apparent from Jenner's report and from historical evidence (see North-Coombes 1971) that he was impatient to leave Rodrigues. He had made his first application to be transferred in 1868, but was finally relieved of duty on 13 November 1871, having been Police Magistrate on Rodrigues since 14 May 1862. Edward Newton had strongly supported Jenner's application to leave the island.

Reverend Henry Horrocks Slater (1851–1934)

Henry H. Slater was appointed naturalist for the Transit of Venus expedition to Rodrigues in 1874, just 1 year after graduating in Natural Sciences at Cambridge (Mathews 1936). Slater arrived on Mauritius on 4 August, staying with Edward Newton, before leaving for Rodrigues on 9 September. Slater was frustrated at the delay, as he had to wait for the provision of supplies and a team of 10 men including a cook, and was advised by Newton and Jenner not to travel to Rodrigues without a supporting team (Slater 1879a; Appendix 3 in the Supplementary data). This suggests that Jenner was also advising Slater about

remains, especially at depth, which may be due to compaction of the sediments from periodic flooding.



Figure 15. (Colour online) A view from half way along Canyon Tiyel looking north.

cave locality details. Like Jenner, part of Slater's quest was to ascertain why solitaires had become deposited in the caves. The team arrived on Rodrigues on 14 September, but was prevented by bad weather from reaching the Plaine Corail until 18 September. Slater did not state where he landed, but it is most likely that it was at Anse Quitor, which is close to most of the caves (Figure 2a). From there Slater unloaded the boats and proceeded to 'the caves', setting up camp on 19 September. Slater began excavations the next day and was disappointed to find that of 13 caves examined, 12 showed signs of previous disturbance. We assume that Jenner had advised Slater how to find the caves that he had dug in 1866 and 1871. Undeterred, and up to October 6, Slater excavated in all of these caves to a depth of 3 feet where he unearthed more bones. Slater discovered some new caves and a marsh site, continuing excavations until 8 December, and spent the last week (9–15 December) packing the specimens (Slater 1879b).

After Slater had seen the excavation work of Jenner, he criticised Jenner's lack of professionalism and pointed out with some agitation that someone better qualified should have been involved with the excavations (see Appendix 3 in the Supplementary data; Slater c.1875b). However, Slater's own account of the cave locations is much less informative than Jenner's, and only five sites can be determined with any certainty.

Grand Caverne

Newton, Jenner and Slater were all familiar with Grande Caverne, and it was probably Slater and his team that made the largest excavation pit, which is approximately 9 m long, 5 m wide and about 1 m deep (Figure 9a). It is situated about 46 m inside the cave. Our work in Grande Caverne has shown the sediments to be comparatively poor in fossil

Canyon Tiyel

Slater based himself near or in Canyon Tiyel (Figure 15), calling it a 'ravine or gorge', and, according to his report, made the best of his discoveries from caves within it. There are a number of significant fossiliferous caves within Canyon Tiyel, the most important of which are Caverne Solitaire (S19°45.281'; E063°22.181'), Caverne Mapou (S19°45.300'; E063°22.177'), Caverne Dora (S19°45.438'; E063°22.209') and Caverne de la Vierge (S19°45.468'; E063°22.209'). It is a great pity that Slater gave no indication about where exactly he excavated, as he discovered a pair of complete, associated male (NHMUK PVA3505) and female (NHMUK PVA3506) solitaires, noting that they were found in one of the caves previously excavated by Jenner, and in another cave he discovered the crania of at least 24 others. Newton and Clark (1879) remarked that due to the mixing of specimens during shipping (see Appendix 3 in the Supplementary data), neither Jenner's nor Slater's associated individuals of solitaires could be correctly re-associated. This may have been the case with Jenner's specimens, but Slater had marked the words 'MB' (= Miscellaneous Bones) in ink on all of the unassociated solitaire specimens to prevent confusion, in case the bones were accidentally mixed during transit.

The Newtons were given permission by the Council of the Royal Society to examine Slater's collection; this combined with their earlier work on the osteology of the solitaire (Newton and Newton 1868, 1869), resulted in every part of the solitaire's anatomy being described (Newton and Clark 1879). Furthermore, the Royal Society of London presented the RCSHM with a pair of associated skeletons collected by Slater (figured in Hume and Steel 2013).

Caverne Bouteille

Slater reported that 'Captain Wharton of H.M.S. *Shearwater* opened a cave about a mile and a half W.S.W. of the Gorge, and descended by means of a rope' (see Appendix 3 in the Supplementary data). Wharton saw stalactites, but reported that the cave contained no sediments. This is almost certainly Caverne Bouteille (S19°45.904'; E063°22.444') (Figure 16), which has permanent fresh water at the base and is an important resource for local livestock herders.

Petit Lac

Slater spent 3 days excavating a small marsh, but stated that it was at 450 ft (137 m) above sea level. We found no evidence of a marsh at that altitude on the limestone plain



Figure 16. (Colour online) The small entrance to Caverne Bouteille.

or surrounding hills. However, a small marsh called Petit Lac (S19°46.048'; E063°22.588') (Figure 17), which measures approximately 12 m × 14 m and is situated 8 m above sea level close to the coast, may be the marsh site that Slater was referring to. It is the only marsh in the area and presently contains a depth of <500 mm of sediment; but this may not have been the case in the past.



Figure 17. (Colour online) A view looking southwest of the small marsh, Petit Lac.

Caverne Patate

Although it appears that Slater never collected any fossil material from Caverne Patate, he certainly explored the cave because he illustrated a cave feature within it (Slater c.1875b). Slater was an accomplished artist, and his ink sketch (Figure 18) within his unpublished manuscript is the only known cave drawing executed by any of the nineteenth-century bone collectors.

All of Slater's fossil materials were sent to the British Museum (now in NHMUK) (Table 1).

Isaac Bayley Balfour (1853–1922)

On the same expedition as Slater, the botanist Isaac Bayley Balfour provided a brief overview of the geology of the island including the Plaine Corail (Balfour 1879),

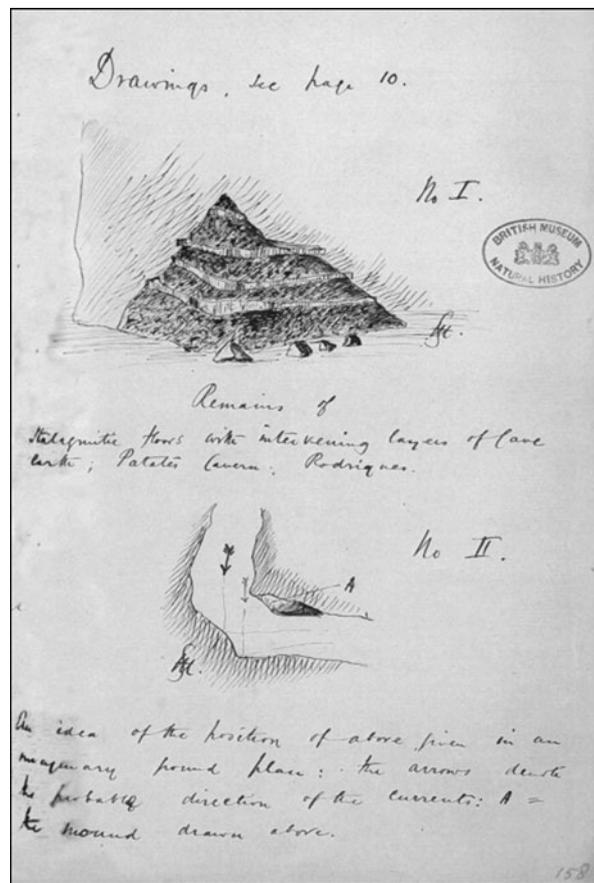


Figure 18. Drawing of a cave feature by H.H. Slater (c. 1875b) in Caverne Patate. This is the only illustration made of the caves by any of the nineteenth-century bone collectors. The text states: No. I. Remains of stalagmitic floors with intervening layers of cave earth; Patates Cavern, Rodrigues. No. II. An idea of the position of the above, given in an imaginary found place: the arrows denote the probable direction of the currents: A = the mound drawn above.

collecting at least 21 bones of the solitaire, which are now registered in the Hunterian Museum, University of Glasgow (GLAHM) (Table 1). Balfour (1875) gave no details about where he collected the specimens, other than to briefly state at the end of his unpublished manuscript ‘I should have mentioned that I found no palaeontological specimens save bones of various birds, etc. along with a few shells in the caves, but as their investigation was the work of one of my colleagues, I need say nothing regarding them’. These bones were never mentioned by the Newtons, Slater or any other authors, presumably because the final paragraph of Balfour’s manuscript was not included in his publication (Balfour 1879).

William James Caldwell (1820–1887)

William James Caldwell, Assistant Colonial Secretary under Edward Newton, arrived on Rodrigues to investigate fraudulent activities of Jenner’s successor, Henry Reid Bell (North-Coombes 1971). Caldwell had a warrant to suspend Bell, which he did on 12 May 1875. Caldwell stayed on Rodrigues for three months as acting magistrate, and working with police sergeant Thomas Morris took full advantage of his time there by exploring the caves on the Plaine Corail (North-Coombes 1971). Caldwell (1875) published the results of his excavations and made the following note:

The cave which I explored was in a sort of cliff, and the entrance was about eight feet above the bed of the ravine, which ultimately became a cavern; and there were no marks whatever of any action of water beyond the filtration from the roof in a few spots . . .

Caverne Solitaire

Caverne Solitaire (S19°45.281'; E063°22.181') (Figure 19) is situated at the north end of Canyon Tiyel and is approximately 8 ft above the canyon floor, so we believe that this is the cave that Caldwell excavated. The cave is still productive, and specimens of note include a number of elements of the solitaire which, along with solitaire bones from Caverne Poule Rouge are now displayed at the Grand Montagne Visitor and Information Center, Rodrigues. Caldwell found the remains of at least 37 birds, as well as ‘gulls’¹ and two associated solitaires, and noted the reduced size of the ‘fighting bones’ in one of the specimens, which he correctly considered to be a female. The ‘fighting bones’ are the bony exostoses (musket-balls), which developed from the processus extensorius of the carpometaarpus in both sexes, and were used by the birds for aggressive territorial combats (Hume and Steel 2013). Caldwell himself mounted the solitaire specimens (Caldwell 1875), and photographed the female of the pair (Figure 20a–c), but unfortunately their whereabouts



Figure 19. (Colour online) Inside Caverne Solitaire in which William James Caldwell may have collected his two associated solitaires.

are now unknown. However, it is possible that the mounted solitaire skeleton currently displayed in the MI (Figure 21), which is made up from the legs and feet of a possibly associated male, the rest by the bones of a possibly associated female, may be a composite of Caldwell’s two associated individuals (Table 1). Alternatively, it may have been put together using bones collected later by O’Halloran in 1881 (see below).

William Vandorous

William Vandorous was a Native American sailor, who originally came from a whaling vessel in 1875, but had decided to stay on in Rodrigues. He was the ships’ pilot until at least the 1890s and made some courageous voyages from Rodrigues to Mauritius in small boats to raise the alarm when Rodrigues was suffering from famine, outbreaks of measles and typhoid, droughts and the effects of bad cyclones (North-Coombes 1971). Vandorous was also responsible for obtaining the last specimen of the Rodrigues Parakeet *Psittacula exsul*, almost certainly the same individual that had been observed by Slater (Hume 2007), and presented it to Caldwell who forwarded it to Alfred Newton at Cambridge in 1875 (Newton 1875). After the departure of Caldwell, Vandorous managed to collect some solitaire bones, stating that they were the only ones on the island (North-Coombes 1971), but there are no details as to which cave or caves he obtained them from.

Joseph Clanfergael O’Halloran (b. 1846)

The collection of solitaire bones obtained by Vandorous prompted the Governor of Mauritius, Frederick Napier-Broome, who visited Rodrigues in June 1881, to supply

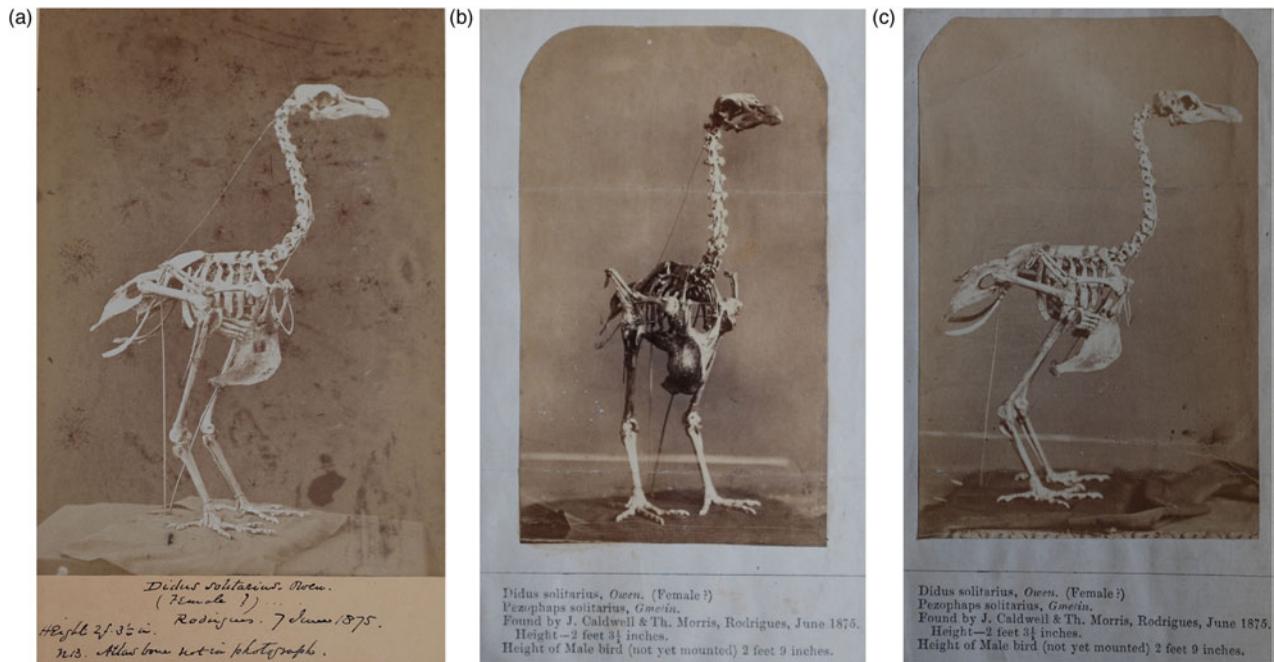


Figure 20. (Colour online) (a) A female solitaire, mounted and photographed by Caldwell, who sent the images to Edward Newton. This is one of the two birds that he collected, but their present whereabouts are unknown. This is the first time that this photograph along with (b) and (c) have been reproduced (Courtesy of the Newton Library, Cambridge). The text states: *D. solitarius*, Owen. (Female ?). Rodrigues 7 June 1875. Height – 2 ft 3.25 in. NB. Atlas bone not in photograph. (b) The text states: *D. solitarius*, Owen. (Female ?). *Pezophaps solitarius*, Gmelin. Found by J. Caldwell & T. Morris, Rodrigues, June 1875. Height – 2 ft 3.25 in. Height of male bird (not yet mounted) – 2 ft 9 in. (c) Text as (b).

funds for another excavation (North-Coombes 1971). The work was undertaken by the police magistrate, Joseph Clanfergael O'Halloran, and the resultant findings, 'a box of bones', were sent to the RSAS, Mauritius (North-Coombes 1971). There are no records as to where O'Halloran excavated, and the bones' whereabouts are presently unknown. There is a possibility that the mounted skeleton (Figure 21) currently displayed in the MI was made up using bones collected by O'Halloran (Table 1).

Discussion

The cave excavations during the 1860s and 1870s resulted in the collection of thousands of subfossil remains, which not only included the solitaire, but also the type material of other extinct birds. Jenner collected the types of the Rodrigues Night Heron *Nycticorax megacephalus*, Rodrigues Rail *Erythromachus leguati*, Rodrigues Turtle Dove *Nesoenas rodericana*, Rodrigues Parrot *Necropsittacus rodericanus* and Rodrigues Lizard Owl *Mascarenotus murivorus*. Alfred Newton generously gave the French palaeontologist Alphonse Milne-Edwards the opportunity to study Jenner's subfossil bird material, from which Milne-Edwards subsequently described all of these taxa. Slater's excavations produced the Rodrigues Starling *Necropsar rodericanus*, which was described by Günther

and Newton (1879), and the first subfossil remains of the endemic *Phelsuma* geckos (Günther 1879). It was another 132 years before a new fossil bird species, the Rodrigues Blue Pigeon *Alectroenas payandeei*, was added to the list (Hume 2011).

Much credit must go to Edward Newton, who instigated the exploration of the caves and advised Jenner, Slater and Caldwell about the logistics of their excavations. Edward Newton regretted that his brother Alfred published what Edward considered to be 'rough notes' of his Rodrigues trip, and stated that 'I did not write my Rodrigues notes for publication, had I done so I think I should have made a better paper of it' (Newton 1861–1862, letter 3 August 1865, in Cheke and Hume 2008). Newton left Mauritius permanently in 1877, but remained interested in the Mascarenes until his death on 27 April 1897, aged 65 years.

George Jenner had obviously been instructed by Edward Newton to search especially for solitaire gizzard stones (Newton 1878) and to ascertain why the remains of solitaires had collected in the caves. Newton wanted to know whether introduced pigs and cats had dragged the carcasses into the caves, or whether solitaires had been driven there in bad weather or by natural fires. Jenner's field measurements cannot be relied on, but he admits that the difficulty of assessing distances was confounded by the



Figure 21. (Colour online) The mounted solitaire in the Mauritius Institute. This specimen is made up from the skull, vertebrae, pectoral and wing elements of a female, and the legs and feet of a male. Could this be a remounted individual made up from the supposedly lost male and female mounts (see Figure 20a–c) by Caldwell? Alternatively, it could have been put together from bones collected by O'Halloran in 1881.

locations being filled or covered with trees during his visit, which, as he stated in his description, impaired his view. Despite Jenner's lack of academic training, his absence during the 1866 excavation, the 'loss' of his initial report and his ambiguous descriptions, he left by far the best indication of where he was excavating. Jenner continued working the caves, despite being desperate to leave Rodrigues, until relieved of duty in 1871. He later became the director of immigrants and sanitation in Port Louis, Mauritius.

Henry H. Slater was a priest as well as an academic. Although he had the largest field team, Slater was mostly digging in caves already worked by Jenner, so his excavations were not as productive. He quelled the idea that gizzard stones were present with solitaire bones, and discussed the causes of the solitaire's extinction (see Appendix 3 in the Supplementary data). The great mystery is that after having spent a great deal of time describing the bone material, including a new fossil species of starling, he failed to publish on the subject. For example, Günther and Newton (1879) used Slater's (c. 1875b) manuscript name

for the Rodrigues starling, *N. rodericanus*, in their formal description of this taxon. Equally mysterious was why Slater's report on the caves was published rather than Jenner's report, when the former was much less informative than the latter. Newton and Clark (1879, p. 438) stated that as 'Mr. Slater had gone over the same ground, and composed a report of a similar character to that by Mr. Jenner, we were reluctantly compelled to acquiesce in the suppression of the latter.' This must have annoyed Jenner, especially as he had worked the caves on three separate occasions and endured serious hardships. After returning to England, Slater continued his interest in natural history, but in later life he apparently resigned all of his society memberships, went into decline and was defrocked as a curate (Jill Warwick, personal communication, 31 July 2013). He died on 26 November 1934, aged 83 years.

William James Caldwell was multi-talented, being a professor of Classics and English, as well as an accountant and administrator. He held the post of Assistant Colonial Secretary from 1873 to 1875, excavating extensively during 1875 on Rodrigues, before leaving for Mauritius later that year (North-Coombes 1971). He was a keen natural historian and an active member of RSAS, Mauritius, until his death on 20 May 1887, aged 67 years (Barnwell and Rae 1944). Caldwell discovered what he thought were solitaire gizzard stones (probably basalt pebbles), and disagreed that pigs and fires were responsible for driving the solitaires into the caves, suggesting instead that cyclonic weather was probably the main factor. The hypotheses that flocks of solitaires suddenly became trapped in the caves as a result of fires and bad weather have proved extremely popular, but have since been dispelled (Hume 2005); solitaire remains were almost certainly accumulating over millennia. It is not known how much material Caldwell excavated during his



Figure 22. (Colour online) The narrow, well-hidden entrance to Caverne Poule Rouge is probably the reason why the cave was not discovered by the nineteenth-century bone collectors.

3-month stay on Rodrigues. The whereabouts of his collection, which included two associated solitaires, is unknown (Table 1).

Our attempt to follow in the footsteps of these bone collectors has been fraught with difficulty. In some cases, the names of the caves, if they ever had one, have changed since the 19th century, and even Grande Caverne was known by an alternative name, Caverne Tamarin, in the 1990s (Middleton 1996; Middleton and Burney 2013) (Table 2). We have also had to contend with poor descriptions and incorrect measurements, and the lack of any maps in any of

the accounts; only one account contains a sketch of a cave feature (Figure 18; see Appendix 3 in the Supplementary data). Furthermore, intensive human-induced changes, such as the removal of stone for building animal pens, and clearance of rocks to plant crops, may have dramatically changed the cave entrances in recent years.

Such was the efficiency of the nineteenth-century collectors, only one cave unquestionably eluded their searches and thus can be considered pristine. Caverne Poule Rouge (S19°45.325'; E063°22.189') (Figure 22) was discovered by Richard Payendee in 2003 on the western

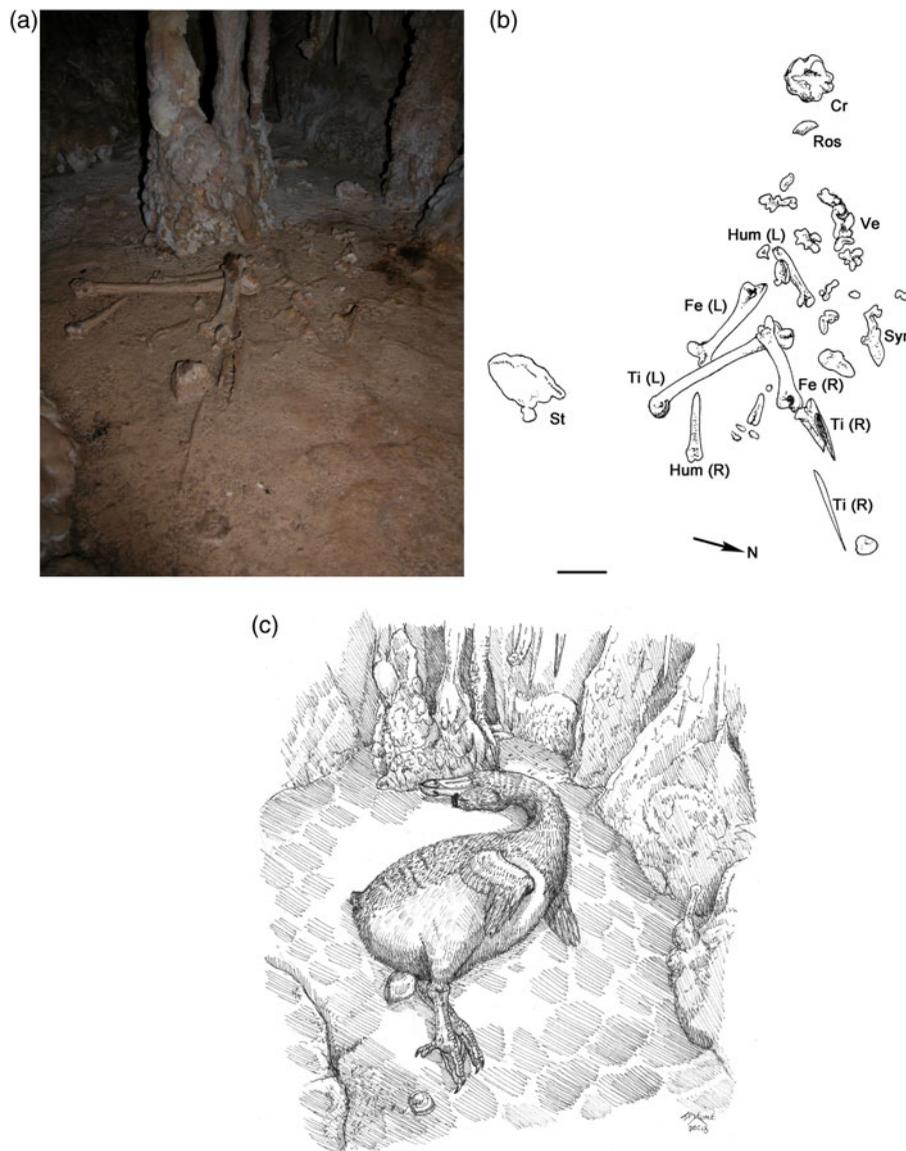


Figure 23. (Colour online) (a) The associated *in situ* solitaire skeleton discovered in 2005 by JPH embedded in flow stone in a small chamber at the far end of Caverne Poule Rouge. Of all the thousands of solitaire bones that have been collected, this is the only specimen that has been photographed *in situ*. (b) A measured drawing of the solitaire skeleton by JPH and LS. Key: (Cr) Cranium; (Ros) Rostrum; (Ve) Vertebrae; (St) Sternum; (Hum) Humerus; (Fe) Femur; (Ti) Tibiotarsus; (L, left; R, right). Scale bar = 60 mm. Note that the cranium (Cr), rostrum (Ros) and sternum (St) are disarticulated and situated at some distance from the main body. (c) A reconstruction of the solitaire by JPH in the position of death.

edge of Canyon Tiyel. When it was first entered, Richard and his team found associated individuals of Rodrigues rail, night heron and a domed tortoise, including the external scutes, on the floor of the main chamber. Furthermore, a complete, associated solitaire skeleton discovered by JPH and, partially buried in flowstone, still resides in a small chamber at the furthest point from the entrance (Figure 23a–c). Had the bone collectors discovered this cave, they would have certainly removed all of the specimens.

Acknowledgements

The authors thank Greg Middleton, Pierre Brial and Robert Prys-Jones and an anonymous reviewer for their constructive comments. Richard Payendee and the Mauritius Wildlife Foundation (Rodrigues) team are thanked for their assistance on the Plaine Corail. The authors also thank the staff of the General Library (NHMUK), and Claire Castle and Jane Acred (Balfour & Newton Libraries, UMZC) for access to the manuscript reports. For access to collections and associated information, the authors thank Sandra Chapman (NHMUK), Mike Brooke and Matt Lowe (UMZC), Milly Farrell and Martyn Cooke (RCSHM), Neil Clark, Malcolm Chapman and Maggie Reilly (GLAHM), Jeff Liston (ex-GLAHM), Ronan Allain and Claire Sagne (MNHN) and Owen Griffiths (FLMR). The authors thank Jill Warwick for information about H. H. Slater. Mauritius Bioculture, Francois Leguat Ltd, and Marie Paule at Caverne Patate are thanked for logistical support and access to cave sites on Rodrigues. The NHMUK Departmental Investment Fund generously funded part of the field work.

Supplementary data

Supplementary data for this article can be accessed at doi:10.1080/08912963.2014.886203.

Note

1. The remains of ‘gulls’ are almost certainly referable to the White-tailed Tropic Bird *Phaethon lepturus*, one of the commonest species found in the cave deposits (Hume 2013).

References

Arnold EN. 2000. Using fossils and phylogenies to understand evolution of reptile communities on islands. *Bonn Zool Monogr.* 46:309–323.

Balfour IB. 1875. Report on the botany of the Island of Rodrigues. The collections from Rodrigues of the Philosophical Transactions of the Royal Society Vol. 168 [two volumes]. MSS. ROY Manuscript. General Library Collection NHMUK.

Balfour IB. 1879. The physical features of Rodriguez. *Phil Trans Roy Soc Lond.* 168:289–292.

Barnwell PJ, Rae WC. 1944. William James Caldwell. Port Louis, Mauritius. *Dictionary of Mauritian Biography* No. 15.

Bartlett AD. 1851. On some bones of *Didus*. *Proc Zool Soc Lond.* 19:280–284.

Bouton L. 1848a. Letter from Hon. Mr. G.C. Cuninghame. Port Louis, 22nd March 1847 for September 1846–August 1847 *Trans Roy Soc. Mauritius.* 1(1):91–93.

Bouton L. 1848b. Report of meeting held Thursday 8th April 1847. *Proc Roy Soc Mauritius.* 1(1):xiii–xixv.

Bouton L. 1861. Annual report. *Trans Roy Soc Mauritius.* NS2:130–146.

Brial P. 1996. Atlas des cavernes de L’Ile Rodrigues. Réunion: Privately published.

Burney DA, Burney LP, Hume JP, Middleton GJ, Porch N, Steel L. in press. Stratigraphy and chronology of Karst features on Rodrigues Island, SW Indian Ocean. *J Cave Karst Stud.*

Caldwell J. 1875. Notes on the zoology of Rodrigues. *Proc Zool Soc Lond.* 1875:644–647.

Cheke A, Hume JP. 2008. Lost land of the Dodo: the ecological history of the Mascarene Islands. London: A&C Black Publishers, (Poysner imprint).

Cuvier C. 1830. Note sur quelques ossements qui paraissent appartenir au dronte, espèce d’oiseau perdue seulement depuis deux siècles: lue à l’Académie des sciences, séance due 12 juillet 1830. *Bull Sci Nat Géol.* 22:122–125.

Desjardins J. 1831 [1972]. Deuxième rapport annuel sue les travaux de la Société d’Histoire Naturelle de l’Ile Maurice. [MS, published pp. 25–51 in Ly-Tio-Fane (1972), q.v.].

Eudes H. 1832. [Letter to Charles Telfair from Rodrigues 20.04.1832]. Library of the Zoological Society of London.

Griffiths OL, Florens VFB. 2006. A field guide to the non-marine molluscs of the Mascarene Islands (Mauritius, Rodrigues and Réunion) and the northern dependencies of Mauritius. Mauritius: Bioculture Press.

Günther A. 1879. The extinct reptiles of Rodriguez. *Phil Trans Roy Soc Lond.* 168:452–456.

Günther A, Newton E. 1879. The extinct birds of Rodriguez. *Phil Trans Roy Soc Lond.* 168:423–437.

Hume JP. 2005. Contrasting taphofacies in ocean island settings: the fossil record of Mascarene vertebrates. *Mon Soc Hist Nat Balears.* 12:129–144.

Hume JP. 2007. Reappraisal of the parrots (Aves: Psittacidae) from the Mascarene Islands, with comments on their ecology, morphology and affinities. *Zootaxa.* 1513:1–76.

Hume JP. 2011. Systematics, morphology, and ecology of pigeons and doves (Aves: Columbidae) of the Mascarene Islands, with three new species. *Zootaxa.* 3124:1–62.

Hume JP. 2013. A synopsis of the pre-human avifauna of the Mascarene Islands. In: Göhlich UB, Kroh A, editors. *Proceedings of the 8th International Meeting Society of Avian Paleontology and Evolution.* Wien: Naturhistorisches Museum; p. 195–237.

Hume JP, Cheke AS, McOran-Campbell A. 2009. How Owen ‘stole’ the Dodo: academic rivalry and disputed rights to a newly-discovered subfossil deposit in nineteenth century Mauritius. *Hist Biol.* 21(1–2):1–18.

Hume JP, Steel L. 2013. Fight club: A unique weapon in the wing of the solitaire, *Pezophaps solitaria* (Aves: Columbidae), an extinct flightless bird from Rodrigues, Mascarene Islands. *Biol J Linn Soc.* 110:32–44.

Jenner G. 1871. Report on the Remains of the Solitaire found in the Caverns at Rodrigues in the months of January and February 1871. Balfour & Newton Libraries, University of Cambridge: Indian Ocean MS. Volume Item No. 29.

Leguat F. 1708. Voyage et aventures de Francois Leguat et des ses compagnons en deux isles desertes des Indes Orientales. London: David Mortier, Marchand Libraire.

Livezey BC. 1993. An ecomorphological review of the dodo (*Raphus cucullatus*) and solitaire (*Pezophaps solitaria*), flightless columbiformes of the Mascarene Islands. *J Zool Lond.* 230:247–292.

Ly-Tio-Fane, M (ed.). 1972. Société d’Histoire Naturelle de l’Ile Maurice. Rapports annuels I-IV, 1830–1834. Port Louis: Royal Society of Arts & Sciences of Mauritius.

Mathews GM. 1936. Obituary Henry H. Slater. *Ibis.* 13(6):385–386.

Middleton GJ. 1996. Early accounts of caves in Mauritius. *Proc Roy Soc Arts Sci Mauritius.* 6:49–87.

Middleton GJ. 1998. The conservation and management of the caves of Mauritius. Report to Ministry of Environment, Human Resources Development and Employment, Mauritius.

Middleton GJ. 2008. Grande Caverne – a new show cave for Rodrigues, Mauritius. In: Smith D, editor. *Cave and Karst Management in Australasia 17, Proceedings of the 17th Australasian Conference on Cave & Karst Management, 2007.* p. 105–110. Buchan, Victoria.

Middleton GJ, Burney DA. 2013. Rodrigues – An Indian Ocean Island calcarenite: its history, study and management. In: Lace MJ, Mylroie

- JE, editors. Coastal karst landforms. Coastal Research Library, vol. 5. Dordrecht: Springer; p. 261–276.
- Montaggioni L. 1973. Histoire géologique de l'île Rodrigue. Info-Nature, Ile Réunion. 9:52–59.
- Newton A. 1865a. On some recently discovered bones of the largest known species of dodo (*Didus nazarenus*, Bartlett). Proc Zool Soc Lond. 1865:199–201.
- Newton A. 1865b. On the remarkable discovery of didine bones in Rodrigues. Proc Zool Soc Lond. 1865:715–718.
- Newton A. 1872a. Miscellaneous (Osteology of the Solitaire). Ann Mag Nat Hist. 4(9):168–169.
- Newton A. 1872b. Miscellaneous (Osteology of the Solitaire). Ann Mag Nat Hist. 4(9):321.
- Newton A. 1875. A note on *Palaeornis exsul*. Ibis. 3(5):343–344.
- Newton A. 1878. Exhibition of, and remarks upon, a stone supposed to be from the gizzard of *Pezophaps solitaria*. Proc Zool Soc Lond. 1878:291–292.
- Newton A. 1896. A dictionary of birds. Part IV. London: Adam and Charles Black.
- Newton A, Newton E. 1868. On the osteology of the solitaire or didine bird of the island of Rodriguez, *Pezophaps solitaria* (Gmel.). Proc Zool Soc Lond. 16:428–433.
- Newton A, Newton E. 1869. On the osteology of the solitaire or didine bird of the island of Rodriguez, *Pezophaps solitaria* (Gmel.). Phil Trans Roy Soc Lond. 159:327–362.
- Newton E. 1865. Notes of a visit to the island of Rodriguez. Ibis. 2(1):146–153.
- Newton E, Clark JW. 1879. On the osteology of the solitaire (*Pezophaps solitaria*, Gmel.). Phil Trans Roy Soc Lond. 168:438–451.
- North-Coombes A. 1971. The Island of Rodrigues. Port Louis, Mauritius: The Standard Printing Establishment (Henry & Co.).
- North-Coombes A. 1991. The vindication of François Leguat. 3rd ed. Mauritius: Author.
- North-Coombes A. 1994. Histoire des tortues de terre de Rodrigues. 2nd ed. Mauritius: Author.
- Owen R. 1866. Memoir on the Dodo (*Didus ineptus* Linn.). London: Taylor and Francis.
- Owen R. 1872a. Miscellaneous (Osteology of the Solitaire). Ann Mag Nat Hist. 4(9):241–242.
- Owen R. 1872b. On the Dodo (Part II)—notes on the articulated skeleton of the Dodo (*Didus ineptus* Linn.) in the British Museum. Trans Zool Soc Lond. VII:513–525.
- Owen R. 1878. On the solitaire (*Didus solitarius*, Gm; *Pezophaps solitaria* Strkl.). Ann Mag Nat Hist. 5(1):87–98.
- Saddul P. 2002. Mauritius: a geomorphological analysis. revised ed. Moka: Mahatma Gandhi Institute, Geography of Mauritius series.
- Slater HH. c.1875a. Account of proceedings in Rodrigues. The collections from Rodrigues of the Philosophical Transactions of the Royal Society Vol. 168 [two volumes]. MSS. ROY Manuscript. General Library Collection, NHMUK.
- Slater HH. c.1875b. Report on the bone caves of Rodrigues and their contents. The collections from Rodrigues of the Philosophical Transactions of the Royal Society Vol. 168 [two volumes]. MSS. ROY Manuscript. General Library Collection, NHMUK.
- Slater HH. 1879a. Reports of proceedings of the naturalists. 2. Report of Henry H. Slater, Esq., B.A. Phil Trans Roy Soc Lond. 168:294–295.
- Slater HH. 1879b. Observations on the bone caves of Rodrigues. Phil Trans Roy Soc Lond. 168:420–422.
- Strickland HE. 1844. On the evidence of the former existence of Struthious birds distinct from the Dodo in the islands near Mauritius. Proc Zool Soc Lond. 12:77–79.
- Strickland HE. 1849. Supplementary notices regarding the Dodo and its Kindred. Nos. 1, 2, 3. Ann Mag Nat Hist. 2(3):136–139.
- Strickland HE. 1853. On some bones of birds allied to the Dodo, in the collection of the Zoological Society of London. Trans Zool Soc Lond. 4:187–196.
- Strickland HE, Melville AG. 1848. The dodo and its kindred. Reeve: London.
- Tafforet J. c. 1726. Relation de l'île Rodrigue. MS in the Archives Nationales in Paris. [published in full, in original orthography, in PRSAS 4: 1–16].
- Telfair C. 1833. Letter on the bones of the Dodo (*Didus ineptus*), Linn., and other zoological subjects. Proc Zool Soc Lond. 1:31–32.
- Wollaston AFR. 1921. Life of Alfred Newton: late Professor of Comparative Anatomy, Cambridge University 1866–1907. London: John Murray.