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News and views

Giant subfossil lemur graveyard discovered, submerged, in Madagascar

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In October, 2014, we organized a paleontological expedition to investigate flooded freshwater caves in Tsimanampetsotsa National Park, Madagascar, located in the arid southwestern region of the country where the karst landscape is pocked with dry caves and large water-filled sinkholes (Fig. 1). Our team of nine scuba divers was led by Phillip Lehman of the Dominican Republic Speleological Society (Supplementary Online Material [SOM] Video 1). The discovery of subfossils in Tsimanampetsotsa was made initially by Ryan Dart of Antananarivo. The director of Tsimanampetsotsa National Park, Mr. Lovasoa Dresy, immediately recognized their importance to science and encouraged the work reported here. Substantial numbers of subfossil remains were found in three caves. In Aven Cave we discovered what is likely to be the single largest cache of giant subfossil lemurs ever uncovered. The other two fossiliferous caves were Mitoho and Malaza Manga. Subfossils had been previously reported from around the entrance to Mitoho Cave (Perrier de la Bâthie, 1934; Goodman and Jungers, 2014) but no underwater investigation of remains inside any of these caves had been conducted prior to this expedition. Thus the primary objective was to establish the paleontological potential of these caves, with the principal aim of assessing the biodiversity of the subfossil content of Aven (Fig. 1).

Aven is a karstic dissolution cave or sink hole produced by water draining through the porous limestone shelf. It is a classic vertical sink hole with deep horizontal cave passageways, each ending in a collapse of limestone blocks. In the complex of tunnels and passages, many sections can be accessed only through narrow restrictions, a challenge that requires advanced cave diving techniques as a precondition to safe exploration of this dark, uncharted subterranean environment (Fig. 2C). It is readily apparent that these spaces were dry in the past as there is substantial speleothem (stalactite and stalagmite) formation. The full extent of Aven's passageways has yet to be explored, but our team laid about 268 m of safety line during the expedition, running at an average depth of 42 m.

The opening of the sink hole is some 25 m in circumference, and the water table is located 10–12 m below the rim. A small island in the center of the water pool is the very top of a debris cone, what's left of the collapsed overhead rock (Fig. 1). The mound falls gently into the depths of the lit cavern to about 25 m, from where the cave extends into the blackness in all directions. It is in this transitional zone where most of the more visible subfossil remains have been located. During the survey, standard cave mapping techniques were employed to locate and mark areas with materials of interest, such as dense bone accumulations or the location of important specimens. It became immediately apparent that there were multiple sites of import and hundreds of cranial and postcranial remains

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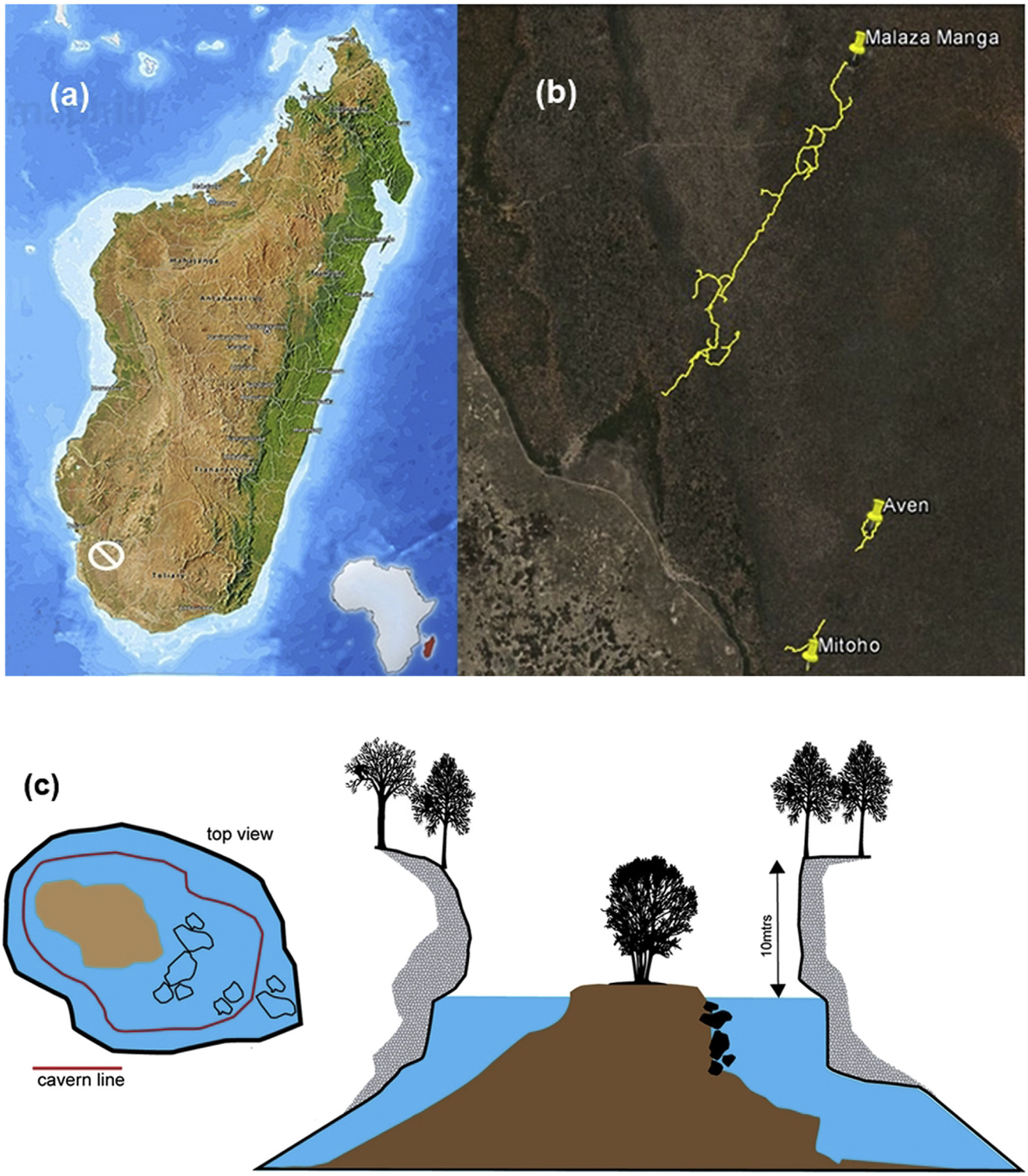

Figure 1. Locational maps of caves and sketches of the Aven Cave sink hole. (a) Base map of Madagascar with symbol at lower left showing location of Tsimanampetsotsa National Park; (b) relative positions and sizes of Aven, Mitoho and Malaza Manga Caves, the last being 1.2 km long; (c) cross sectional sketches of the Aven Cave sink hole (right) and the cavern debris cone (left). Sketch map by Phillip Lehman.

that deserve close attention. We also employed 3D photographic techniques to document the morphology and *in situ* context of specimens, such as the horned crocodile *Voay robustus* (SOM Fig. 1).

The geological context, age, speleology and taphonomy of Aven will be subjects of future studies. Considering the importance of establishing a stratigraphic chronology, we tested the sediment by pushing meter-length probes into it at three widely separated areas where bones were exposed on the surface. The probes were easily inserted and met little or no bottom resistance. Furthermore, since speleothems would have formed only when the cave was not