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The Mescal Cave Fauna (San Bernardino County, California) and testing assumptions of habitat fidelity in the Quaternary fossil record

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ABSTRACT

The late Pleistocene and Holocene vertebrate fossil record for the northern Mojave Desert (southwestern USA) is known primarily from five sites. Until now, only two of these have been radiometrically dated, and temporal placement of the others has been based on stratigraphic or biostratigraphic correlation, leading to circular interpretations of mammal extirpations in the Mojave. Here, I report a revised and complete faunal list for Mescal Cave, along with 22 AMS radiocarbon dates from 5 vertebrate taxa recovered from its deposits. The results reported here demonstrate time-averaging in Mescal Cave encompassing around ~34 ka, a maximum age 14 ka older and minimum age 10 ka younger than previously thought. Furthermore, radiocarbon analyses suggest local extirpation of *Marmota flaviventris* around 3.6 cal ka BP, considerably younger than expected based on regional patterns of warming and aridification in the Mojave. Conversely, radiocarbon dates from another presumably boreal species, *Neotoma cinerea*, are considerably older than expected, suggesting either that climate change at this site did not directly mirror regional patterns, that habitat requirements for these two species are not strictly boreal or cool/mesic as has often been assumed, or that local edaphic conditions and/or competitive interactions override the regional climatic controls on theses species' distribution.

Introduction

The late Pleistocene and Holocene vertebrate fossil record for the northern Mojave Desert (southern physiogeographic Great Basin), southwestern USA, is known primarily from five cave sites: Quien Sabe Cave (UCRRV64-34; Holocene), Kokoweef Cave (SBC1.11.13; glacial), Antelope Cave (SBC1.10.10; glacial), Mitchell Caverns (LACM 3497; Late Wisconsin), and Mescal Cave (SBC1.10.12, UCMP V3864; previously presumed glacial). Of these sites, only specimens from Kokoweef and Antelope Caves have been radiometrically dated prior to this report, while the temporal placement of the others has been based on stratigraphic or biostratigraphic correlation. Here, I report a revised and complete faunal list for Mescal Cave along with 22 AMS radiocarbon dates on 5 vertebrate taxa from Mescal Cave. These results demonstrate high time-averaging in Mescal Cave (~34 ka), a maximum age more than 14 ka older and minimum age 10 ka younger than previously thought, and dates of local extirpation for taxa thought to be indicative of cooler climates, *Marmota flaviventris* and *Neotoma cinerea*. While dated material from *M. flaviventris* is much younger than would be expected based on regional patterns of the timing of warming and aridification in the Mojave, *N. cinerea* disappears from Mescal Cave deposits predictably at the onset of regional aridification (Grayson, 2011).

End-Pleistocene and Holocene climate

Between 30 and 15 ka, the southern Great Basin was cool and mesic, pluvial lakes covered much of the area, marshes and ponds were abundant, and juniper woodland was the dominant vegetation (Quade, 1986; Mensing, 2001; Grayson, 2011). The shores of Pleistocene Lake Mojave were within approximately 35 km of Mescal Cave, and Lake Mojave fluctuated in extent and depth until about 15.5 ka, when the basin dried completely (Grayson, 2011) (Fig. 1). On a regional scale, Pleistocene lakes across the Great Basin began to shrink around 14 ka (Quade, 1986; Mensing, 2001). From ~11.3–8.3 ka, the environment was still relatively cool and wet, and Lake Mojave returned intermittently; however, desert shrubs became more abundant, piñon and juniper were largely absent, and marshes were less common (Grayson, 2000, 2011; Mensing, 2001). Grayson (2000) documents higher species richness and evenness in the Great Basin during the early Holocene than any time afterward. During the middle Holocene, from around 8–5 ka, aridity increased sharply and climate warmed: again, Lake Mojave completely dried (Grayson, 2011). Extirpations of mesic-adapted or boreal vertebrate species occurred on Great Basin mountain ranges at this time (Brown, 1978; Grayson, 2000). Because the mountain ranges are separated by wide valleys, subsequent recolonization via dispersal is thought to have been rare for most species, though there is evidence that some mammals readily disperse across these arid basins, and the faunas of these ranges have been impacted by both extinction and

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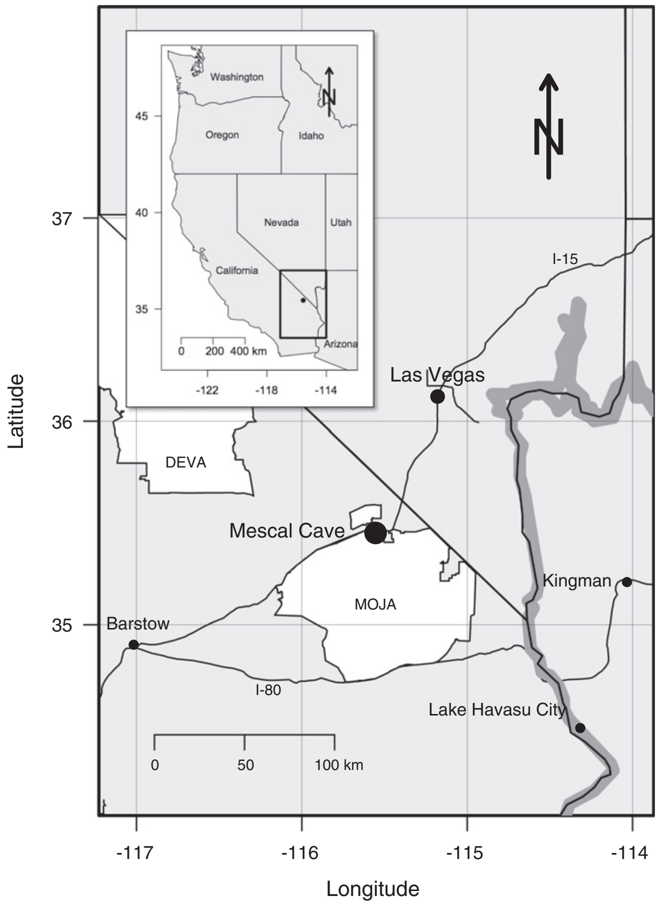

Figure 1. Map showing location of Mescal Cave; regional map of the western United States is inset. MOJA: Mojave National Preserve; DEVA: Death Valley National Park.

colonization (Lomolino et al., 1989; Floyd, 2004; Floyd et al., 2005; Rickart et al., 2008).

The Great Basin reached a thermal maximum around 6.8 ka and temperatures cooled somewhat afterward, allowing timberline to move downslope. Although precipitation did not recover to pre-middle Holocene levels, some lakes and springs returned and some species apparently extirpated during the middle Holocene recolonized (Grayson, 2000). In the Mojave, higher water tables and soils high in organic material did not return until about 2.3 ka (Grayson, 2011).

Overall, the northern Mojave experienced more drying and warming than other parts of the Great Basin during the Holocene (Kueppers et al., 2005). Currently, this region receives the lowest rainfall amounts (~100 mm average annual rainfall) and has the highest evaporation rates in the Great Basin (~2100 mm average annual evaporation) (Grayson, 2011), and, by as early as 2080, is projected to experience a ~3–5°C increase in annual temperature and as much as 35% less spring precipitation (USGCRP, 2009). Each of the past biotic and abiotic changes in the Mojave may have had a pronounced, but as yet poorly-understood, impact on the fauna. Understanding these impacts is important in light of the currently changing climate, in order to identify whether the responses of biota presently are paralleling those of past climate changes, and what might be expected in the near future. This requires a more detailed record of faunal change in this area with accompanying radiometric dates, a key focus of this paper.

Study site

Mescal Cave (University of California Museum of Paleontology (UCMP) Locality #V3864) (N 35°27′0.45″ latitude and W 115°32′60″ longitude) is a limestone cave located in the Mescal Range, approximately 1550 m in elevation, at the northern edge of the Mojave Desert. This site was excavated in 1938 by a University of California Museum of Paleontology party led by R.A. Stirton, and it contains material that was evidently accumulated by woodrats (*Neotoma*). The cave is comprised of two chambers, approximately 6.4 m wide and extending into the rock about 14 m in total, but fossils were recovered only from the outer chamber, nearest the cave entrance. Stirton's crew initially dug a 46-cm-deep trench but continued excavations laterally in several directions; no stratigraphic information was recorded. They hauled the un-sifted material out of the cave, dumped it, then "sifted and picked out the bones" (Stirton, 1938). Although, according to the field notes, the sediment contained abundant plant macrofossils and scat (primarily from *Neotoma*), these materials never entered the UCMP collection and may not have been saved during excavation. Furthermore, Stirton writes that "not all of the tiny bone scraps were saved" (Stirton, 1938), which may explain the paucity of small teeth in this collection. The site also contained archeological evidence, most notably a "large pine bowl" (Stirton, 1938), though the current location and disposition of this bowl is unknown. Stirton estimated the age of the site to be younger than Pleistocene based on the overall faunal composition and stratigraphy; however, Jefferson (1991) suggests a date between 20 and 10 ka, based again on faunal composition and geographic context.

Methods

I examined over 3300 skeletal specimens from Mescal Cave; these specimens are reposited at the UCMP and records are publically available through the UCMP database (http://ucmpdb.berkeley.edu/). Measurement methods follow von den Driesch (1976) and were taken with Fowler Sylvac Ultra-Cal IV 6″/150 mm digital calipers, accurate to 0.01 mm. Statistical analyses were performed in R, version 2.14 (R Core Team, 2013).

Taxonomic identification

Skeletal specimens from Mescal Cave were identified by direct comparison to modern skeletal specimens of known species identity in the UCMP element collection and Museum of Vertebrate Zoology (MVZ). When direct comparison was not possible (i.e., relevant comparative material was not available in the UCMP or MVZ), fossil specimens were identified using published descriptions and illustrations (see Supplemental Data 1) (Fig. 2).

Radiocarbon dating

Given the potential for stratigraphic mixing in the site, 22 specimens representing 4 taxa (see Table 1) were radiocarbon dated using Accelerator Mass Spectrometry (AMS) dating techniques at the Center for Accelerator Mass Spectrometry (CAMS), Lawrence Livermore National Labs (Livermore, California, USA). The taxa selected for dating included two morphologically distinct *Neotoma* (*N. cinerea* and *N.* spp.) and two size classes of leporid. Because Mescal Cave was excavated without stratigraphic control, dating specimens of known taxonomic identity was the only way to identify if there were turnover within these taxonomic groups through time. Woodrats and leporids were the most abundant taxa in these deposits and so were particularly valuable for establishing a chronology (Table 3).

Specimen preparation follows the modified longin method described by Brown et al. (1988) for collagen extraction, and methods outlined in Vogel et al. (1987) for converting CO_2 into graphite for AMS analysis. Results include a matrix-specific background correction and an estimate of the $\delta^{13}C$ value of the material, and are reported as a conventional radiocarbon years before present (Stuiver and Polcah, 1977). To obtain calendar years BP, I used OxCal Online, version 4.2 (Bronk Ramsey, 2009), implementing the IntCal 13 calibration curve (Reimer et al., 2013).