

A preliminary restudy of felid footprints housed at the Alf Museum from the Barstow Formation (Miocene) of southern California

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ABSTRACT—The Barstow Formation of San Bernardino County, California, preserves a rich Miocene (Barstovian NALMA) vertebrate ichnoassemblage. Many previously described and figured specimens are housed at the Raymond M. Alf Museum of Paleontology (Claremont, California), but most have not been studied using modern ichnological techniques. Here, we reexamine a sample of 19 individual tracks presumably made by Felidae. All were collected as individual prints, although some may be from disassociated trackways. Precise locality data are uncertain in some cases, hindering reassociations. Tracks were measured and digitized using photogrammetry, allowing a clearer differentiation of features on each individual print. The tracks range in length from 56 mm to 78 mm, and were originally assigned to two ichnospecies (*Felipeda bottjeri* and *Felipeda scrivneri*) based on differences in shape (e.g., relative elongation and the angle between digits). Differences between tracks are subtle, and even though measurements show some footprints are more elongated than others, we conclude that they potentially represent differences between manual and pedal tracks or else reflect taphonomic effects. Thus, we suggest that there is only one felid ichnotaxon (*F. bottjeri*) in the Alf Museum sample from the Barstow Formation.

Introduction

The Barstow Formation of southern California dates to the Miocene (Hemingfordian–Barstovian NALMA, ~19.3–13.4 Ma), and it hosts abundant vertebrate trace and body fossils (Pagnac 2009; Woodburne et al. 1990). Felids are a rare component of the faunal assemblage, represented by body fossils of *Pseudaelurus intrepidus* and *Nimravides* sp., and trace fossils assigned to *Felipeda scrivneri* and *Felipeda bottjeri* (Lofgren et al. 2006; Pagnac 2009). Both *Pseudaelurus intrepidus* and *Nimravides* sp. are roughly similar in size to the modern-day cougar (Lofgren et al. 2006).

The cat tracks described in this paper (Figures 1, 2) were collected by Ray Alf and students from The Webb School of California as individual prints in the 1950s and 1960s, and are housed at the Raymond M. Alf Museum of Paleontology (RAM) in Claremont, California (Lofgren et al. 2006). Some may be from weathered out trackways, but locality data are unclear in many cases, making associations difficult to determine. Based on a recent review of records, some tracks that had previously been assigned to a general Barstow track locality (RAM V94281) were able to be more precisely assigned and associated (to RAM V201103; see Table 1). Where precise data are known, all tracks are from the Middle Member of the Barstow Formation, below Skyline Tuff (sensu Woodburne et al. 1990).

Sarjeant et al. (2002) described the Alf Museum felid tracks and assigned them to two ichnospecies, *Felipeda*

bottjeri and *Felipeda scrivneri*. Tracks assigned to *F. bottjeri* were identified as more elongate and narrower than those of *F. scrivneri*, among other differences. Reynolds and Milner (2012) later reviewed these same occurrences and others from California and Utah, but evaluated the tracks in a taxonomy-free approach (i.e., they were only referred to as Felidae, without any reference to ichnotaxon). Here, we present a preliminary redescription and reevaluation of the 19 felid tracks from the Barstow Formation in the Alf Museum collection. Our hope is that this will spur additional research into the variation, taphonomy, and ichnotaxonomy of tracks from the Barstow Formation.

Material and methods

All fossils are housed at the Raymond M. Alf Museum of Paleontology. We used digital calipers to measure each print to the nearest mm (Table 1). In order to create digital models, we took approximately 25 photos of each print from different angles using an iPhone 6 and reconstructed photogrammetric models using Agisoft PhotoScan Professional 1.1.6.2038. Terminology follows that of Sarjeant et al. (2002) and Reynolds and Milner (2012).

Description

All specimens are natural casts (relief) of tracks (Table 1, Figures 1, 2). Nine out of the 19 tracks from the RAM collection are complete. All are isolated prints and lack obvious claw marks. Each of the complete tracks has a

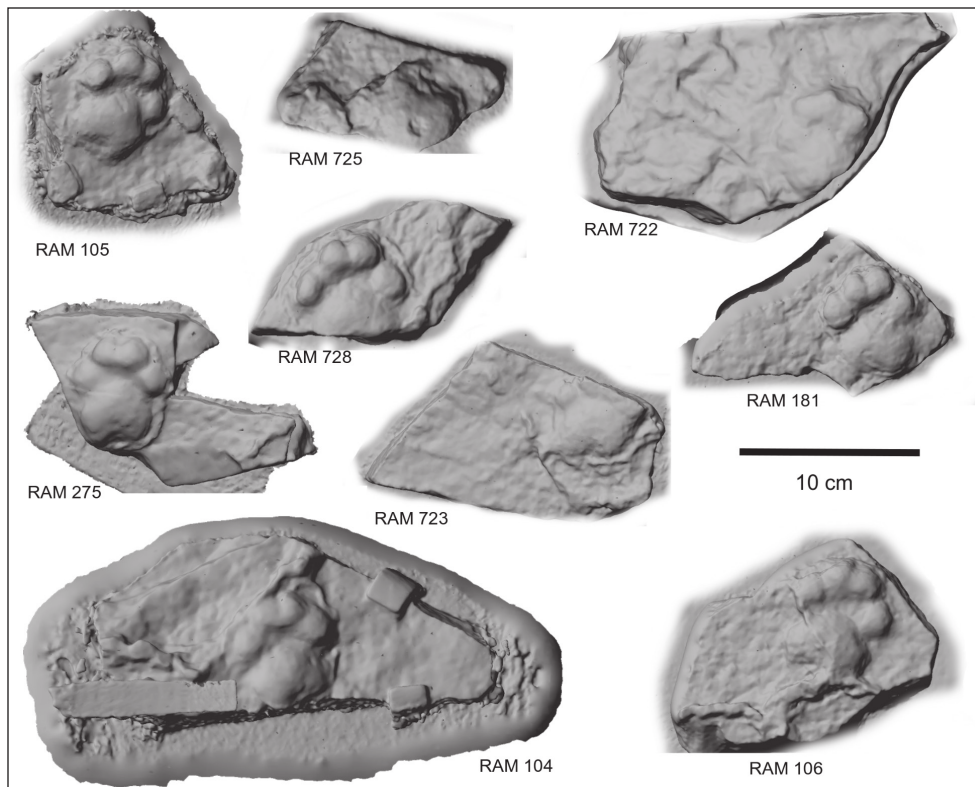


Figure 1. Digital surface models of track fossils from the Barstow Formation assigned to Felidae.

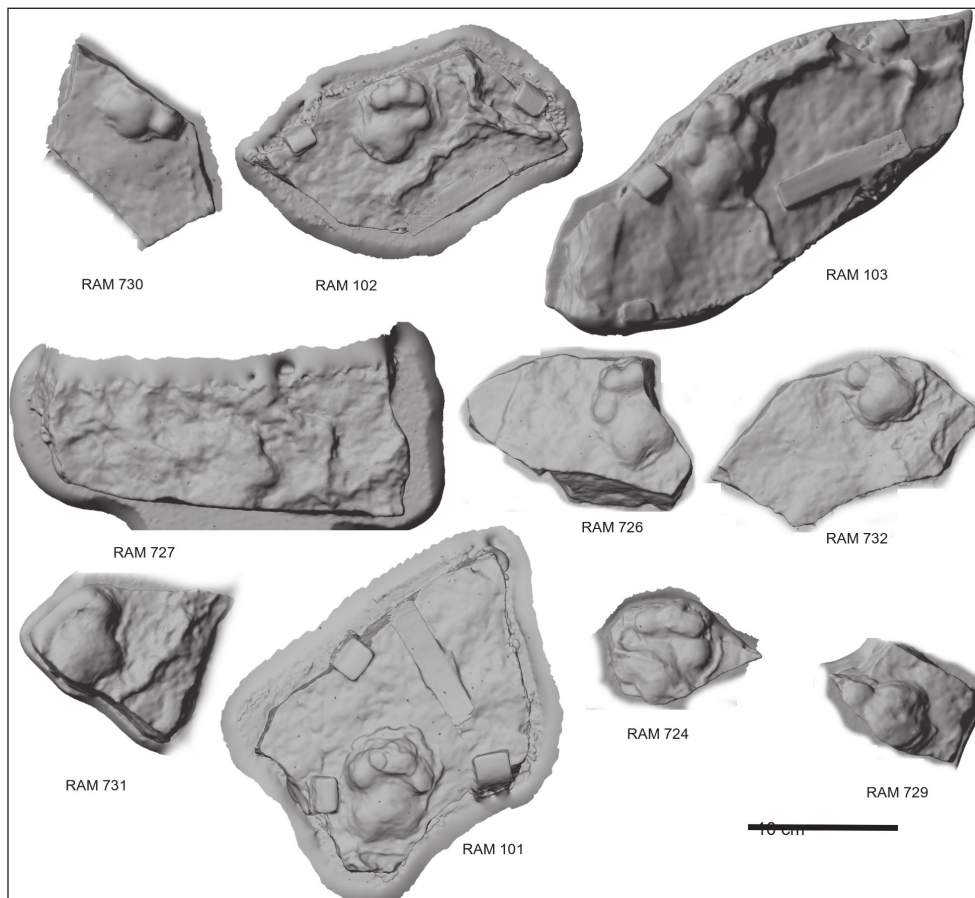


Figure 2. Digital surface models of track fossils from the Barstow Formation assigned to Felidae.

similar, generally circular shape and a cleft on the heel of the metapodial pad (bilobed). Every print has four digits, and all of the digits are oval in overall shape, with a width to length ratio of approximately 1:1.14. The metapodial pad of each track is roughly ovoid and bilobed where preserved, with a width to length ratio of approximately 1.1:1, and the digits span wider than the central pad for all tracks. The two middle digits of each track are more anteriorly placed than the two outside digits, and the toes form an arch along the top of the central pad. The length:width ratio varies slightly between prints (Table 1).

Some tracks, such as RAM 724 and RAM 106, have a protruding thin ridge superimposed over the track (Figures 1, 2). Based on their irregular positions, we hypothesize that the ridges are most likely sediment deformation. Two tracks, RAM 725 and RAM 729, have small indentations on the central pad, which are also most likely caused by sediment deformation. RAM 727, RAM 722, and RAM 723 do not have distinct impressions and have shallow indentations for most features of the track. However, digits and metapodial pads can still be faintly seen. RAM 727 is missing part of the lower central pad, RAM 722 is missing part of the metapodial pad, and RAM 723 only partially preserves its four digits.

Discussion

A single Barstow Formation specimen in the Alf Museum collection (RAM 105) was previously assigned to *Felipeda scrivneri*, RAM 105 (Sarjeant et al. 2002); the holotype of this ichnotaxon is from younger sediments in Death Valley. Relative to specimens of *F. bottjeri*, tracks of *F. scrivneri* are described as less elongate and with a greater overall angulation of digits, in addition to a more prominent separation between the digital pads and the metapodial pads. Based on our examination of the RAM specimens, we hypothesize that variation in digital/metapodial pad separation is at least in part a function of substrate consistency and/or other taphonomic factors. Furthermore, relative elongation of the overall track is variable, and also likely due to being either a manus/pes track or individual variation. For instance, the length/width ratio of the track varies between 1.15 and 1.25 in *F. bottjeri* identified by Sarjeant et al. (2002), contrasting with 1.12 in the *F. scrivneri* referred specimen (Table 1). However, we suggest that the latter is within the potential realm of variation for the former, particularly when considering differences between manus and pes. We also attempted to measure interdigital angles, but due to the variation in preservation as well as the relatively round shape of the digital pads, it was difficult to take consistent measurements. Considering the overall evidence, we suggest that only a single felid ichnotaxon (*Felipeda bottjeri*) is represented by the Alf Museum sample from the Barstow Formation.

Based on our preliminary observations, we suggest that a more comprehensive evaluation of felid tracks from the Barstow Formation would be fruitful, including fossils from other collections as well as description of *in situ* trackways. In particular, more thorough documentation of variation is necessary, as is a more detailed comparison with other known felid tracks.

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