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First report of bird tracks (*Aquatilavipes*) from the Cedar Mountain Formation (Lower Cretaceous), eastern Utah

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ABSTRACT

More than 130 footprints representing ~43 trackways of birds (avian theropods) and two non-avian theropods occur as seven separate assemblages on loose blocks recovered from the Poison Strip Member of the Cedar Mountain Formation, near the Stikes Quarry locality in eastern Utah. Six of assemblages, four with bird tracks and two with small non avian theropod tracks, are inferred to originate from the same stratigraphic horizon, and can therefore be considered part of the same ichnofauna. The seventh assemblage comes from a different horizon a few meters above that yielding the other six assemblages. The bird tracks are all attributed to the ichnogenus *Aquatilavipes*, a track type morphologically similar to those of modern shorebirds. The ichnogenus is also known from broadly coeval ichnofaunas from South Dakota and Canada, and the identification is confirmed by detailed comparative analysis of available *Aquatilavipes* samples using bivariate and multivariate analyses. This is the first definitive report of bird tracks from the Cedar Mountain Formation and the first evidence of birds from this otherwise richly fossiliferous unit. The ichnofauna is therefore quite unique in comparison with others from this same formation.

1. Introduction

Avian dinosaurs (birds) evolved during the Late Jurassic and have a diverse fossil record by the Early Cretaceous, particularly in China and other parts of Asia, but also in Spain and Australia (Padian, 2004). Bird tracks are known from a number of deposits world-wide but are particularly abundant in Asia, and the oldest known unequivocal bird tracks are currently from the basal part of the Early Cretaceous (e.g., Lockley et al., 2006a; Lockley and Harris 2010). As with other geologic ages, abundant tracks and diverse bone assemblages of associated faunas do not always occur in the same formations (Lockley 1991), but tracks may indicate the presence of otherwise unknown elements of a fauna. Such is the case with the Cedar Mountain Formation in the western United States.

The Cedar Mountain Formation, exposed in the Rocky Mountain west, especially in eastern and central Utah, is particularly well-known as a major source of vertebrate remains spanning as much as the last 30 Ma of the Early Cretaceous. It is best known for dinosaurs, such as the giant dromaeosaur *Utahraptor*, the primitive therizinosaur *Falcarius*, the ankylosaurs *Gastonia*, *Animantarx*, *Peloroplites*, and *Cedarpelta*, the iguanodonts *Iguanacolossus*, *Planicoxa*, and *Hippodraco*, and the sauropods *Venenosaurus* and *Cedarosaurus*, from such major excavations such as Dalton Wells, Crystal Geyser, Don's Ridge, Tony's Bonebed, and the Gaston Quarry (Kirkland et al., 1997, 1999, 2005; Carpenter et al., 1999, 2008; Tidwell et al., 1999; Eberth et al., 2006; Suarez et al., 2007; Britt et al. 2009; McDonald et al., 2010).

However, until recently relatively few important tracksites have been reported. Most of the recently documented tracksites are quite small (Lockley et al., 1999; Lockley et al., 2004a; Cowan et al, 2010) and have yielded mostly dinosaur tracks attributed to theropods, sauropods and ornithischians, that collectively indicate a relatively diverse fauna comparable to that known from the body fossil record. Thus the Cedar Mountain Formation a type 4a deposit as defined by Lockley and Hunt (1994) as one in which body fossil sites are more abundant that tracksites, while both indicate generally similar, rather than significantly different, faunas. This general consistency between body and trace fossils has been underscored by the discovery of the large Mill Canyon Dinosaur Tracksite (MCDT) which has, at one site, yielded well-preserved examples of most of the main dinosaurian trackmaking groups reported from all the other sites (Lockley et al., 2014a,b). The MCDT site however has yielded only two very poorly preserved and somewhat dubious examples of bird tracks, discovered after the ichnofaunas described here, which were originally briefly noted by Wright et al. (2006).

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Thus, the discovery in 2005 of avian theropod (bird) footprints, near the bone-rich Stikes Quarry north of Arches National Park in Grand County, Utah, by Rob Gaston and one of us (JF), adds a new dimension to the tetrapod ichnology of the Cedar Mountain Formation and is significant for several reasons: 1) it represents the first report of bird tracks from the Cedar Mountain Formation; 2) no bird remains are known from the body fossil record in the Cedar Mountain Formation; 3) bird tracks are rare in the Early Cretaceous of the entire region; 4) the occurrence reported here is arguably the oldest known for the region, though not globally as reported by Wright et al. (2006); and 5) the tracks are abundant, well-preserved and clearly different from those reported from the overlying Dakota Group, thus indicating some measure of avian diversity, and differential stratigraphic and facies distribution at this time.

2. Geological setting

In the study area north of Arches National Park, sedimentary rocks dip gently northeast off the Salt Valley Anticline, and the Cedar Mountain Formation is exposed along several kilometers of this outcrop area north and east of the Park. (To south and east of the Colorado River, the Cedar Mountain Formation is sometimes referred to as the otherwise equivalent Burro Canyon Formation.) The stratigraphy of the Cedar Mountain Formation is well known and has been extensively studied in eastern Utah, between the San Rafael Swell and the Colorado-Utah border (Stokes, 1952; Young, 1960; Carter and Gualtieri, 1965; Kirkland and Madsen, 2007; Currie et al., 2008; Sprinkel et al., 2012). The Cedar Mountain Formation overlies the Upper Jurassic Morrison Formation and is under the upper Lower Cretaceous Dakota Formation; in the present study area, the Cedar Mountain Formation consists of three members from bottom to top: the Yellowcat, Poison Strip Sandstone, and Ruby Ranch members. The blocks containing the bird tracks were lying loose on the Upper Jurassic Morrison Formation and lower Cedar Mountain Formation on the slope below and lateral to the Stikes Quarry, which is in the upper Yellowcat Member, about 18 km southeast of Crescent Junction, Utah (Fig. 1). During the present study, a detailed stratigraphic section was compiled, indicating that the bird track-bearing units originated from the Poison Strip Sandstone Member (Figs. 2–3), exposed in a steep cliff section above the Stikes Quarry. However, the lacustrine shoreline facies preserving the tracks is genetically part of the largely lacustrine upper Yellow Cat Member rather the the coarse gravelly fluvial facies of the main portion of the Poison Strip Member overlying the sandstone unit preserving the tracks (Kirkland and Madsen, 2007). Measurement of this portion of the section required ropes and harnesses. The upper Yellow Cat Member has been dated at basal Aptian (~124 Ma) based on detrital zircons (Greenhalgh et al.

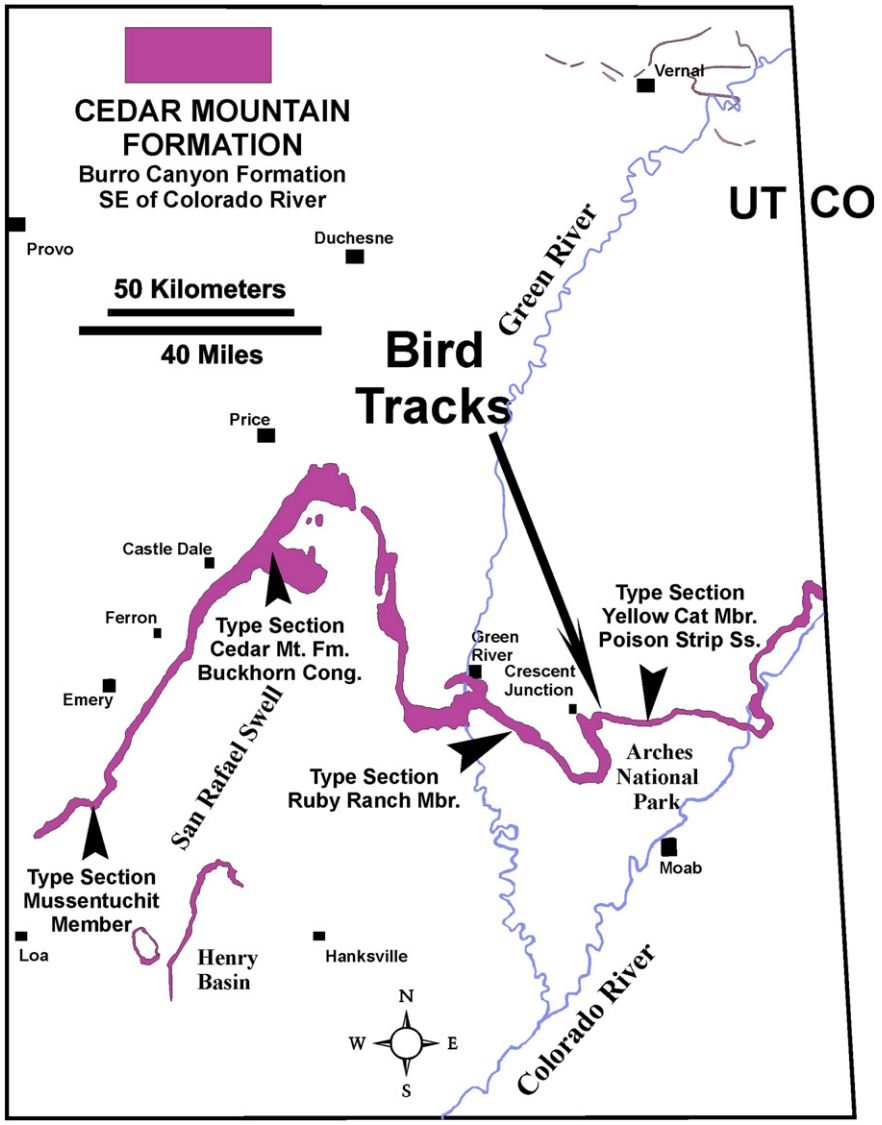

Fig. 1. Locality map showing location of bird tracks site in relation to the outcrop of the Cedar Mountain Formation in eastern Utah.