A DESCRIPTION OF THE DINOSAUR FOOTPRINTS ON DISPLAY AT THE SPRINGFIELD SCIENCE MUSEUM, SPRINGFIELD, MASSACHUSETTS

Patrick Ryan Getty
Department of Geosciences, University of Massachusetts, Amherst, MA 01003; (413)348-6288; prgetty@ns.m.umass.edu

ABSTRACT: While conducting a study of the dinosaur footprints in the ichnology collection at the Springfield Science Museum in Springfield, Massachusetts, it became apparent that most of the footprint-bearing slabs were not adequately described or labeled. Here I describe and figure the slabs and the footprints on them, and where possible I indicate the stratigraphy and locality of origin for the slabs. Measurements of footprints, such as length and digit III projection, were used to assign the footprints to an ichnogenus, and I calculated the speed of an Anchisauripus trackmaker on SSM-93/12-6, which indicated that the animal was trotting or slowly running.

The slab labeled ACM 51/12 is of particular interest. Part of Edward Hitchcock’s original collection that was amassed during the mid-19th century, earlier descriptions failed to mention any footprints on the slab. However, a short trackway referable to the ichnogenus Selenichnus is preserved on the slab. Currently there is disagreement about the animal made the trackway; the footprints described herein could have been made by a normally bipedal animal or a quadruped walking through wet mud. Consequently, I reject the inclusion of Selenichnus within the Batrachopodidae, which recently has been proposed by some workers, until further, more conclusive, evidence is found.

Keywords: Paleontology, ichnology, dinosaur footprints, Eubrontes, Anchisauripus, Grallator, Batrachopus, Selenichnus, Batrachopodidae, Early Jurassic, Hartford basin, Deerfield basin, Springfield Science Museum

INTRODUCTION

The Mesozoic Hartford and Deerfield basins in Connecticut and Massachusetts have produced numerous and spectacular examples of dinosaur footprints for nearly two centuries. Edward Hitchcock of Amherst College first formally reported what he called “stony bird footprints” in a seminal paper in the American Journal of Science in 1836. By his death in 1864, Hitchcock had collected 21,773 footprints (not all of dinosaurs) (C.H. Hitchcock 1864). The collection, now located at the Amherst College Museum of Natural History, remains intact and is the largest collection of early Jurassic footprints in the world (Belt 1989).

Throughout the late 19th and early 20th centuries, other large institutions amassed collections of dinosaur footprints from the Connecticut Valley. These include the Peabody Museum at Yale University in New Haven, CT, Mount Holyoke College in South Hadley, MA, Wesleyan University in Middletown, CT, amongst others (Weishampel and Young 1996). With the exception of the Peabody Museum, most of the collections are dismantled, and fire destroyed the collection at Mt. Holyoke College.

In addition to large institutions, smaller institutions have played a role in collecting dinosaur footprints from the Connecticut Valley. One such institution is the Springfield Science Museum (SSM) in Springfield, Massachusetts. The ichnology collection at the museum consists of 51 slabs, 10 of which are on public display. The collection contains many of the ichnogenera common to the Connecticut Valley (e.g., Eubrontes, Anchisauripus, Grallator, Anomoepus, and Batrachopus), as well as less common forms such as Selenichnus. The footprints demonstrate variations in animal behavior (e.g., running) as well as differences in preservation, such as that caused by substrate variability.

The collection has grown by informal accession by previous museum staff and through the donation of specimens.

The collection at the SSM is a valuable educational resource for students from public and private schools, as well as from local colleges, who visit the museum. In addition, the collection has unutilized research potential.

OBJECTIVES

This paper illustrates and describes the specimens on public display at the Springfield Science Museum. Most of the footprints were previously referred to as reptile tracks; locality and stratigraphic information for many specimens is inadequate or lacking altogether. However, an important part of a specimen description includes locality and stratigraphic information, lithology of the slab, and recording measurements from footprints.

The measurements that I took include length, width, angle of divarication, and digit III projection (Olsen et al. 1998, fig. 3). I recorded these measurements and used them to assign the footprints to an ichnogenus. I follow the diagnoses of Eubrontes, Anchisauripus, and Grallator found in Olsen et al. (1998), the diagnosis of Anomoepus found in Olsen and Rainforth (2003), the diagnosis of Batrachopus found in Olsen and Padian (1986), and the diagnosis of Selenichnus found in Lockley et al. (2004), although the diagnosis of Selenichnus is inadequate for reasons mentioned below. Where applicable, the pace, pace angle, and stride between footprints were recorded, and approximate velocity was calculated using an equation for speed generated by Alexander (1976).

Some specimens could not be identified by their original catalogue number and some specimens lacked one. In such circumstances, I attempted to assign them to ichnogenera based on their overall appearance and features such as the length and projection of digit III or divarication.
cases the museum’s curator generated a new catalogue number. Where new catalogue numbers have been generated they will be preceded by the word “new” in parentheses. Institutional abbreviations are:
- SSM- Springfield Science Museum
- ACM- Amherst College Museum of Natural History

Description of Specimens

SSM-6995 (Fig. 1).— No locality or stratigraphic information is known. The medium-grained gray sandstone slab is 43.0 cm wide and 54.0 cm long. One right *Eubrontes* footprint is impressed on the surface. The footprint length is 37.0 cm, width is 27.3 cm, and the angle of divarication between digits II and IV is 30°. Digit II is 19.0 cm long, digit III is 24.0 cm long, and digit IV is 25.0 cm long (including the metatarsal-phalangeal pad). There are two pads on digit II, both of which are 6.9 cm long. Additionally, claw impressions are associated with digits II and III, the claw impressions are 1.3 and 2.4 cm long, respectively. There is an oval-shaped hallux impression located behind digit II with approximate length and width of 5 cm and 3 cm respectively.

(NEW) SSM-2005/3-3 (Fig. 2).— No locality or stratigraphic information is known. This tan to brown shale slab is irregularly shaped. A single *Eubrontes* footprint with high relief is preserved as a cast, which is wider at the top (the foot-sediment interface) than at the bottom. There are numerous slump structures within the footprint, suggesting that the sediment was very wet and moved fluidly after the animal removed its foot, partly collapsing the footprint. The digits are not united at their base, indicating that the animal walked in a digitigrade manner. Footprint length and width are 39.0 cm, digit III projection is 17.7 cm, and the angle of divarication between digits II and IV is 64°. Digit II is 20.0 cm long and digits III and IV are 25.0 cm long.

Figure 1. SSM-6995. Scale in cm.

Figure 2. (NEW) SSM-2005/3-3. Scale in cm.
SSM-93/12-6 (Fig. 3) – This slab of gray micaceous shale is
from the Portland Formation of Cromwell, which is located
in central Connecticut approximately 5 km from the Eastern
Border Fault in the Hartford basin. The lower portion of the
Portland Formation consists of playa red beds, lacustrine
gray strata, and fluvial and alluvial-fan red beds. In central
Connecticut near the fault, rivers flowed west from fault
block mountains to the east, depositing sediments within
the basin (Hubert et al. 1992).

The slab preserves ripple marks, but they were nearly
planned off during excavation of the slab. There are
two footprints on the slab, one partial and one complete.
Measurements of the complete footprint are: length 13.8
cm, width 7.5 cm, digit III projection 4.9 cm, and angle of
divariation 42°. Based on size, I attribute the footprints
to the ichnogenus *Grallator*, rather than *Achelosaurus*,
as has been previously suggested. The pace between
the two footprints is 80 cm, suggesting that the animal’s stride
was nearly 1.6 m. I calculated an approximate speed, using
Alexander’s (1976) equation, of 3.5 m/s (7.8 mph), which
indicates that the dinosaur was trotting or slowly running,
according to the proposed gait for dinosaurs suggested by
Thulborn (1982). Trotting and running behavior, recorded
in trackways, is rare in dinosaurs (Alexander 1976; Thulborn
1989; Thulborn 1990; Ibry 1996); however, new trackways
exhibiting these behaviors are routinely being discovered
(Day et al. 2002; Mossman et al. 2004; Getty 2005).

(NEW) SSM-2005/3-1 (Fig. 4) – No locality or stratigraphic
data are known. It is a small (6.9 by 6.9 by 0.5 cm)
laminated slab of pitted, brown micaceous shale on which
is impressed a complete *Batrachopus* footprint and part of
another. The complete footprint is tetradactyl with the third
digit being the longest. Digit lengths are: Digit I- 0.5 cm,
digit II- 1.2 cm, digit III-1.6 cm, and digit IV-1.4 cm. The
footprint is 2.5 cm long and is 2.0 cm wide. *Batrachopus*
footprints were made by small, early crocodile-like animals
and are not of dinosaurian origin.

SSM-7044 (Fig. 5) – No locality or stratigraphic information
is known. The brownish-yellow shale slab has maximum
dimensions of 96.0 by 55.0 by 2.5 cm. Desiccation
cracks on the surface indicate subaerial drying of the
sediment. Six, lightly impressed footprints are highlighted
with shellac to make them stand out on the surface. The
desiccation cracks and shallow nature of the footprints
suggest that the surface was rather dry when the dinosaurs
walked across the sediment. Alternatively, the footprints
could be underprints or overprints. The shallowness of
the footprints and their highlighting made determining
the boundary of the footprints difficult; consequently, I
did not take measurements or assign the footprints to an
ichnotaxon.

(NEW) SSM-2005/3-4 (Fig. 4) – No locality or stratigraphic
information is available. The tan mudstone slab is

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irregularly shaped with a rough surface and has maximum dimensions of 97.5 by 87.0 cm. There is a single indeterminate plant fragment on the surface as well as a number of highlighted footprints, some of which might be inorganic in origin and could have been misinterpreted as footprints. This is a common mistake, for example, ripple marks were misinterpreted as footprints on a slab housed at Mt. Holyoke College (Getty 2005). Other impressions are clearly footprints made in a thick mud that collapsed back into the footprint once the foot was removed, leaving very thin toe impressions and indistinct print boundaries.

Thus, no measurements were taken and I did not assign the footprints to an ichnotaxon.

(New) SSM-2005/3-5 (Fig. 7).—No locality or stratigraphic information is available. The brownish red shale slab is rectangular, having maximum dimensions of 152.0 by 113.0 by 3.0 cm. The surface is the sole of more than one bedding plane; footprints occur as natural casts on all of the bedding surfaces. The footprints fall within a length range of 8.0 to 20.5 cm and are referable to *Grallator* and *Anchisauripus*. The footprints could be the result of
underprinting or successive periods of trackmaking on different bedding planes. The slab bears desiccation cracks indicating subaerial drying of the sediment. In addition to the dinosaur footprints, numerous horizontally and vertically oriented invertebrate burrows are present.

(New) SSM-2005/3-6 (Fig. 8).- The gray shale slab is parallelogram shaped and a single Anchisaurus footprint is preserved on it as a natural cast. The slab was collected from an outcrop approximately 150 m downstream of the French King Bridge on the east bank of the Connecticut River (Ed Klekowski, personal communication 2005). This bridge links Erving and Gill, MA along MA Rte. 2. The outcrop consists of shale from the Turner’s Falls Formation of the Deerfield basin. This formation comprises playa and playa-lake redbeds, lacustrine gray to black strata, and minor fluvial redbeds: a river flowed west from the hinged eastern portion of the topographically closed basin and deposited sediments (Hubert and Dutcher 2005).

The footprint is ~16.5 cm long and 6.0 cm wide. The angle of divergence between digits II and IV is 22°. Digit lengths and widths are: Digit II- 8.6 and 1.9 cm, Digit III- 10.7 and 2.6 cm, and digit IV- 10.4 and 1.8 cm.

ACM 57/02 (Fig. 9).- This slab is on loan to the SSM and is from Hitchcock’s original collection. From the Horse Race in Gill, MA, the slab is from the Turners Falls Formation in the Deerfield basin. C.H. Hitchcock (1865, p. 88) described the slab as: “Shale...2[feet] X 1[foot] 4[inches], in two pieces with hinge, showing the foot of Brontosaurus giganteus.” This ichnospecies is now known as Eubrontes giganteus (Olsen et al. 1998). The specimen is an excellent example that shows a footprint impressed on one layer with subsequent deposits filling the print to make a cast of the foot.

ACM 51/12 (Fig. 10).- The slab is on loan from the ACM. C.H. Hitchcock’s original description (1865, p. 83) is: “Red sandstone, 2[feet] X 10[inches], with fine impressions of rain-drops. Ferry, above Turner’s Falls”. The locality indicates that the slab is from the Turners Falls Formation.

Edward Hitchcock did not have possession of this slab when he described the ichnogenus Selenichnus in 1858. Therefore, it was acquired by 1865 when his son, C.H.
Hitchcock, described the slab. Unfortunately, C.H. Hitchcock missed an important aspect of this specimen: a Selenichnus trackway consisting of four footprints and a tail drag. Two of the footprints are partial and cannot be measured; other measurements are recorded in Table 1.

Selenichnus is an unusual trackway made by an animal walking in wet mud; therefore, the morphology of the trackway does not represent the pedal morphology of the trackmaker (Lockley and Meyer 2004; Rainforth 2005; Paul Olsen personal communication 2005). This ichnogenus traditionally has been interpreted as that of a small bipedal animal (e.g. Hitchcock 1858; Lull 1953); however Hitchcock (1858) did suggest that the trackmaker could have been quadrupedal and allied with salamanders.

Discussion of ACM 51/12

Lockley et al. (2004) and Lockley and Meyer (2004) have suggested that Selenichnus might represent a preservational variant of the ichnogenus Batrachopus based on possible manus impressions as well as pedal impressions that might show four digits. They have therefore included
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Table 1. Measurements from the Selenichnus trackway (ACM 51/12). All measurements except pace angle are in mm.

<table>
<thead>
<tr>
<th>Footprint</th>
<th>Length</th>
<th>Width</th>
<th>Pace</th>
<th>Pace angle</th>
<th>Stride</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>39.2</td>
<td>104°</td>
<td>75.9</td>
</tr>
<tr>
<td>2</td>
<td>39.9</td>
<td>16.0</td>
<td>52.2</td>
<td>160°</td>
<td>97.8</td>
</tr>
<tr>
<td>3</td>
<td>43.5</td>
<td>13.4</td>
<td>57.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Selenichnus* within the ichnofamily Batrachopodidae, which includes trackways made by quadrupeds, as revised by Lockley and Meyer (2004). One of the characteristics of the Batrachopodidae is that the trackway is narrow, with both manus and pedes close to the midline of the trackway (Olsen and Padian 1986; Lockley and Meyer 2004). However, manus impressions associated with a *Selenichnus* trackway on ACM 42/6 are splayed far from the midline of the trackway, unlike those of *Batrachopus*.

The evidence presented by Lockley et al. (2004) is inconclusive and is subject to alternative interpretations. Indeed, as these authors point out in regards to *Selenichnus* “...all the details of well-preserved *Batrachopus* morphology cannot be recognized” (p. 146). Given that very small bipedal dinosaur trackways have been found in the Connecticut Valley that show tail drags, tetradactyl pedes, and occasional manus impressions (Dalman and Getty 2003, Dalman in preparation), *Selenichnus* may represent an extramorphological variant of a normally bipedal ichnogenus. The trackway on ACM 51/12 does not have manus impressions or four digit pedes and therefore does not show two of the defining characteristics of the ichnofamily Batrachopodidae. Taken together, the evidence from all *Selenichnus*-bearing slabs does not offer conclusive evidence as to the nature of the trackmaker. Consequently, the proposed inclusion of *Selenichnus* within the Batrachopodidae is tenuous at best and I reject this inclusion until more conclusive evidence is found.

CONCLUSIONS

This paper describes and figures the footprints on public display at the SSM in Springfield Massachusetts. Using the information provided by the original SSM catalogue descriptions, I identified the formation from which many of the slabs came, and as a result I provided interpretations on the sedimentary formation of the slabs and their trackways. I used measurements of footprints to assign them to an ichnogenus, and for one specimen I calculated the speed of the trackmaker. A previously unknown *Selenichnus* trackway is associated with ACM 51/12. This trackway, along with observations of similar trackways in the ACM collection, suggests that this ichnogenus could be the trackway of a quadruped or the trackway of a normally bipedal animal traversing wet mud. Consequently, until more conclusive evidence is found, I reject the inclusion of *Selenichnus* within the ichnofamily Batrachopodidae.

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