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Using extant taxa to inform studies of fossil footprints

Peter Falkingham (1) and Stephen Gatesy (2)

(1) Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, United Kingdom (p.l.falkingham@ljmu.ac.uk), (2) Ecology and Evolutionary Biology, Brown University, Providence, USA (stephen_gatesy@brown.edu)

Attempting to use the fossilized footprints of extinct animals to study their palaeobiology and palaeoecology is notoriously difficult. The inconvenient extinction of the trackmaker makes direct correlation between footprints and foot far from straightforward. However, footprints are the only direct evidence of vertebrate motion recorded in the fossil record, and are potentially a source of data on palaeobiology that cannot be obtained from osteological remains alone.

Our interests lie in recovering information about the movements of dinosaurs from their tracks. In particular, the Hitchcock collection of early Jurassic tracks held at the Beneski Museum of Natural History, Amherst, provide a rare look into the 3D form of tracks at and below the surface the animal walked on. Breaking naturally along laminations into 'track books', the specimens present sediment deformation at multiple levels, and in doing so record more of the foot's motion than a single surface might. In order to utilize this rich information source to study the now extinct trackmakers, the process of track formation must be understood at a fundamental level; the interaction of the moving foot and compliant substrate.

We used bi-planar X-ray techniques (X-ray Reconstruction of Moving Morphology) to record the limb and foot motions of a Guineafowl traversing both granular and cohesive substrates. This data was supplemented with photogrammetric records of the resultant track surfaces, as well as the motion of metal beads within the sediment, to provide a full experimental dataset of foot and footprint formation.

The physical experimental data was used to generate computer simulations of the process using high performance computing and the Discrete Element Method. The resultant simulations showed excellent congruence with reality, and enabled visualization within the sediment volume, and throughout the track-forming process.

This physical and virtual experimental set-up has provided major insight into how to interpret the track-books within the Amherst Collection, and as such begin to understand how these early Jurassic dinosaurs moved. More broadly, this complete view of track formation afforded by experimental techniques will aid in interpretation of fossil vertebrate tracks throughout the fossil record.