The Ins and Outs of Dinosaur Track Diversity: Animation, X-rays, and Edward Hitchcock

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Hitchcock's classic studies of footprints from the Connecticut River valley in the mid-1800's marked the beginning of ichnology as a science. Like most paleontologists to follow, he largely attributed differences in track morphology to differences in pedal anatomy. As new fossils were discovered, escalating disparity led Hitchcock to infer the presence of dozens of species of ancient birds. Although we now recognize most of his Early Jurassic tracks as dinosaurian, the problem of equating tracks with feet remains. Experimental studies of living birds walking in substrates of different consistency reveal the amazing range of track morphologies a single species can create. Steps involving deep foot penetration are particularly insidious, as track surfaces are frequently exposed at bedding planes below the original air-substrate interface. This "one-to-many" problem can confound interpretations of trackmaker identity, behavior, faunal composition, taxonomic range, geographic distribution, and stratigraphic correlation. We seek a more fundamental understanding of the origin of track morphology during formation. Using a biplanar X-ray methodology developed at Brown, we image and animate the subsurface motion of birds in different artificial substrates. These 3-D reconstructions serve as inputs for discrete element method simulation of track formation. Particle simulations reveal the "ontogeny" of footprints across time and depth, relating track features to moving anatomy for the first time. We are currently bringing our analyses full-circle by CT scanning some of Hitchcock's original specimens, which reveal internal evidence of dinosaur locomotion.