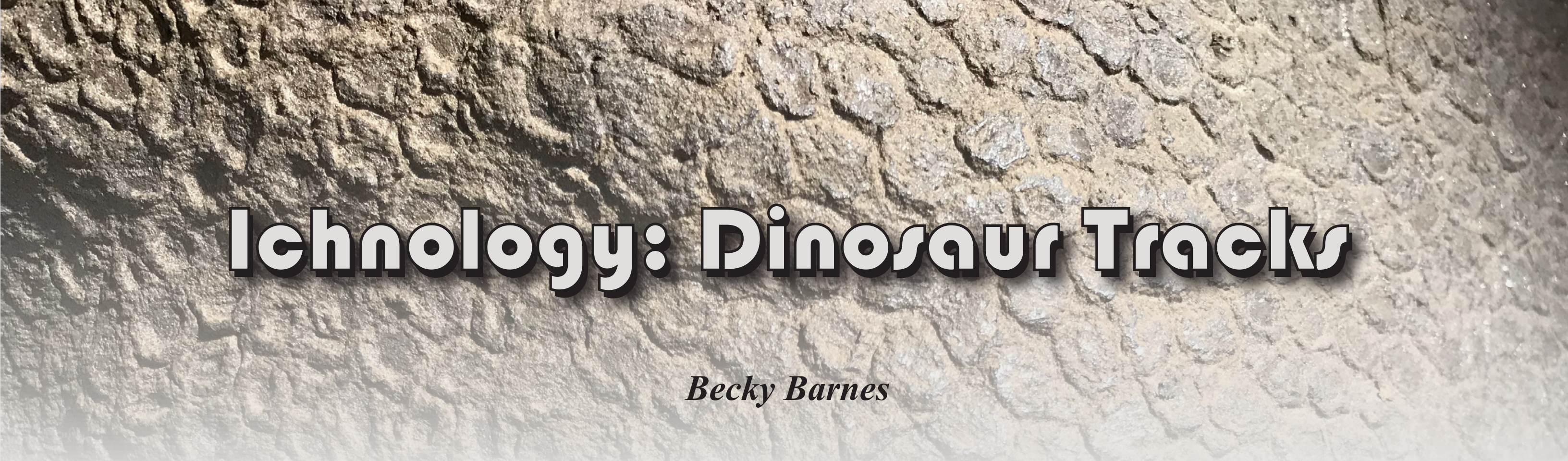


Ichnology: Dinosaur Tracks

Becky Barnes

Ichnology is a branch of paleontology focusing on the study of trace fossils, such as tracks, burrows, gnaw marks, and feces; pretty much anything made by a living plant or animal. Trace fossils are different than fossils of bone or shell most people envision – rather than the animal itself, it's something made or left by the creature. To put it poetically – the memory of a creature, etched in stone. The word ichnology comes from the Greek word ikhnos, meaning footprint, or track, which is what we'll focus on for this article.

The problem with tracks (and many other trace fossils), is we don't have a clear identity of exactly what made them. Once an animal steps down and makes a track, they leave! At least with a bone, we can generally identify what that bone comes from, or at least where in the body. Tracks are trickier. Because of this, tracks and traces are often given a different descriptive name as an identifier, and if it so happens the trace is finally matched with the organism that made it, the trace and creature simply have different names. A non-track example would be the case of *Ophiomorpha* (a burrow) and *Callianassa* (the shrimp that made the burrow).

With dinosaurs, most of the time scientists only have the bones to work with, so they must make guesses on what the tracks left behind would look like. Other times, they find fossilized tracks, and guess at what kind of animal made them. Sometimes they get them right, other times terribly wrong! There have been times when finding tracks have actually changed how we view an animal or answered questions about how they moved on land. Speed and gait can be calculated (Falkingham et al., 2016), or in the case of pterosaurs (the flying reptiles) how they walked or landed after flight (Padian, 2003; Mazin et al., 2009). Extant (living) animals are used as learning tools – especially birds with the study of dinosaur tracks. We have the living animal with all the soft tissue, we have the bones, AND we can observe the tracks that the animal makes. Putting all three of these together can help us Figure out connections when there is missing information from fossil animals.

Before we get in to fossil tracks, let us examine an animal alive today that is very dinosaur-like: the emu. Emu are large flightless birds (ratites) with three toes. Ostriches may be more familiar to you, but they have a modified foot with only two toes – not very dinosaur-like.

Here I have drawn a LEFT emu foot, from below (Fig. 1). So, what you see is the bottom of the left foot, not the top. We call toe bones "phalanges," and the series of phalanges that make up a single toe is a "digit." Roman numerals are given to different digits to distinguish which toe it is. For instance, your thumb would be digit I, while your pinky is digit V. If a specific phalanx (singular) ends in a claw or nail, then it is called an "ungual." An emu, and many dinosaurs, have lost digit I (your big toe) – whereas others have rotated it around to the back of the foot, like perching birds (sparrows, crows, etc.) and many meat-eating dinosaurs. It's then called a hallux. On some dinosaurs like *Tyrannosaurus* it's really tiny and can't do much – like the dew claw on a dog.

The drawing on the right of Figure 1 shows the bones of the emu foot, with an outline of where the soft tissue would be. Included are the pads on the feet, a little bit of skin and scales, muscles, etc. When looking at footprints, we notice deeper spots where pads are, and higher spots where wrinkles were. Wrinkles occur where your skin needs to bend and flex – such as over bone joints.

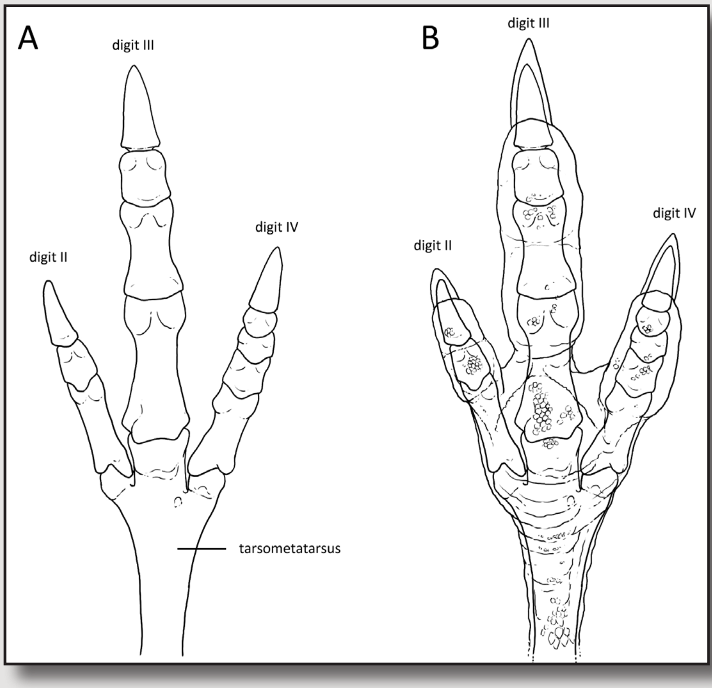


Figure 1. Bottom/ventral view of bones from the left foot of an emu (A), with an outline of soft tissue (B).

There are wrinkles in the skin on that right emu foot, but maybe not as many as you might imagine. Digit IV is made from 4 bones, plus the claw – but the bones are very short and squat. They act together and flex a little, but not as much as your fingers would where they attach to your knuckle.

Here is the rear-left foot of a type of hadrosaur (duck-billed dinosaur) called *Edmontosaurus*, seen from the top (Fig. 3). Their feet are a little different from our emu in the metatarsal area – they still have three separate long bones, rather than one fused bone connecting to the toes. Based on our emu, we might guess

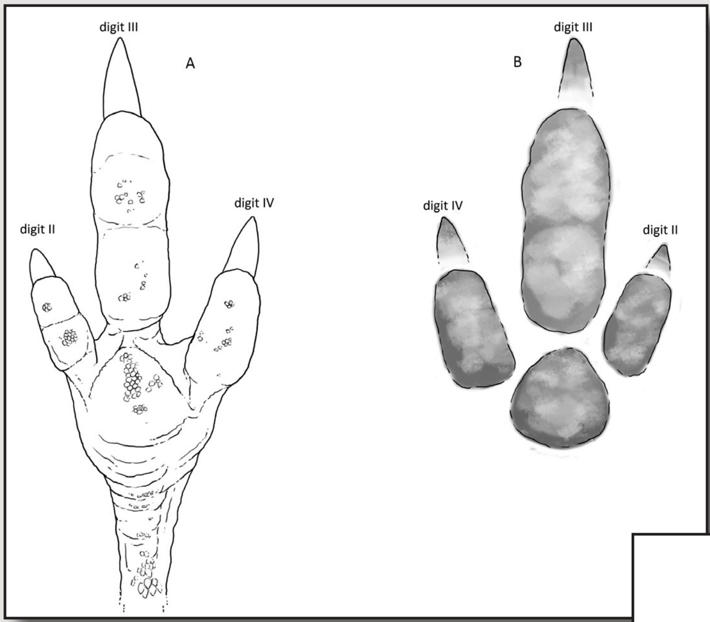
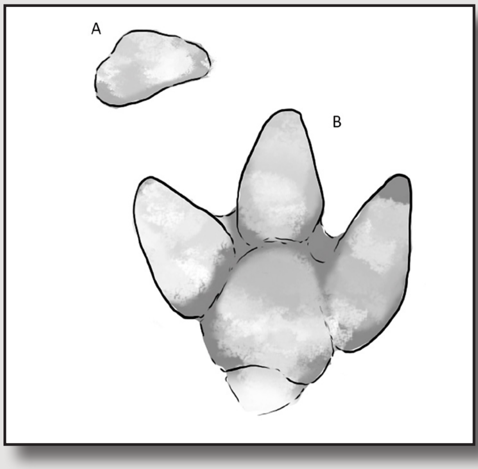


Figure 2. Bottom/ventral view of a left emu foot, showing soft tissue (A), and the corresponding footprint it would make (B). The imprint is reversed, much like using a stamp.

Figure 4. Tracks made from the front foot (A) and rear foot (B) of a hadrosaur (duck-billed dinosaur).



Next is the emu foot with the bones removed so you can see the pads easier (Fig. 2). When the animal steps and makes a track, think of it like when you use a stamp – you get a reverse image of the rubber, so the track is backwards to the foot. On the track at top-right, you can see the dents of where the thicker toe pads are, including the base of what is called the tarsometatarsus. This is simply a fusing of the tarsals (ankle bones) and the metatarsals (the arch of your foot) into one bone, and is found only in birds – what you can see as the flat part of your foot, before the toes. Even the claw tips can be seen in some tracks.

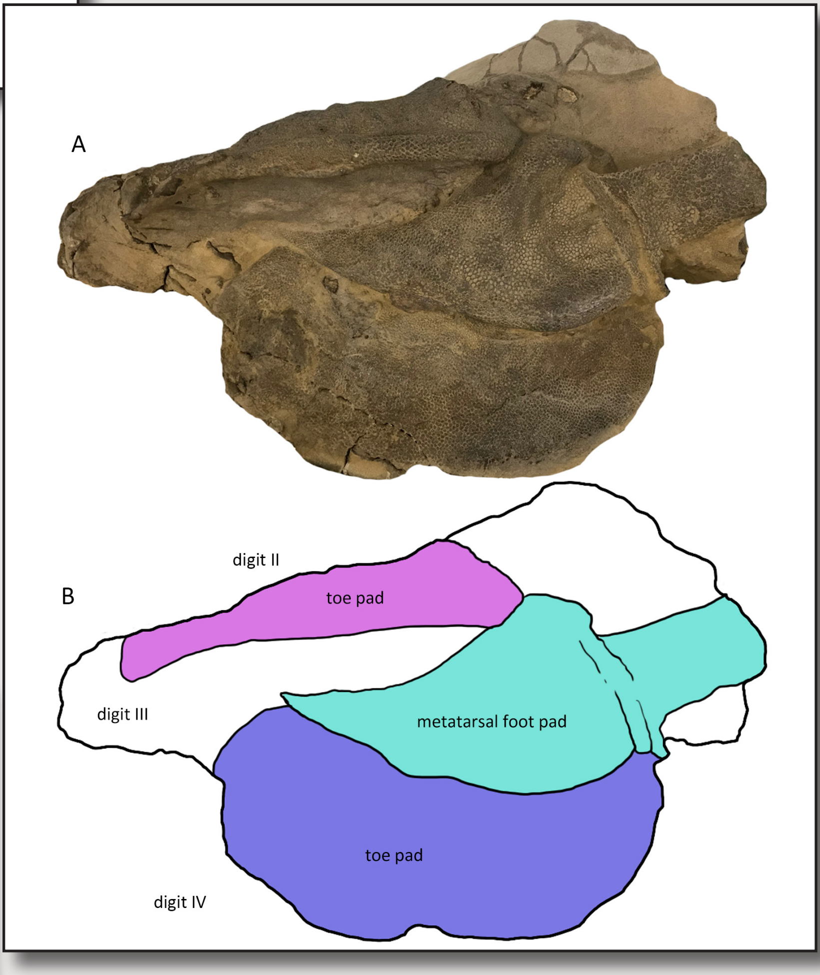


Figure 5. Mummified (fossilized skin) *Edmontosaurus* hind foot from "Dakota the dinomummy" (A), with line-drawing explanation of areas (B).

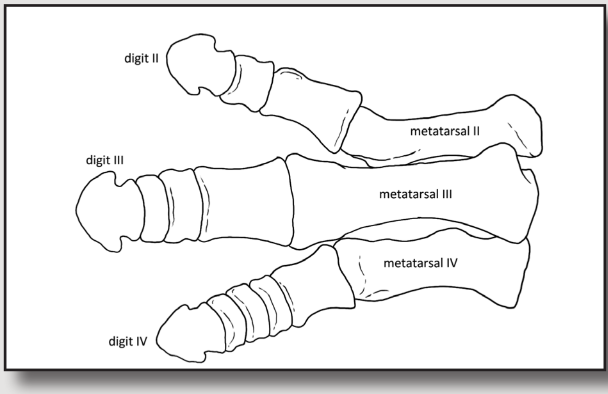


Figure 3. Top/dorsal view of a left *Edmontosaurus* hind-foot.

that it would also have large toe-pads. Known trackways support this hypothesis – Figure 4 shows a rear track from a hadrosaur (duck-billed) dinosaur... as well as a track from the hand!

But how can we be SURE that the track came from a foot similar to our *Edmontosaurus*? If we're very lucky, we find a foot with soft tissue, much like "Dakota the dinomummy" soon to be back on display at the ND State Museum and Heritage Center. Some people used to think that duck-billed dinosaur feet were webbed for a more watery habitat. The nickname "duck-bill" got into peoples' heads, and artists reconstructed them swimming and wading through water. When "Dakota" was found, and work began on the feet, it was discovered quite quickly that the toes were not webbed. They did have wide toe-pads however. In the line-drawing in Figure 5, the middle toe, digit III, is tucked a little farther back so the toe-pad there is difficult to see.

If you look at the hand of Dakota the dinomummy in Figures 6 and 7, you may notice some interesting things. The ends of digits II and III have hoof-like nails, while digits IV and V do not have any claws or nails. Digits II, III, and IV are wrapped together in a mitten of flesh, with digit V separate. When this animal walked on all fours, using its front arms for stability, most of the weight came down on digit III, with a little weight distributed to digits II and IV. If you take your right hand, hide your thumb, tape your middle three fingers together, then try to walk on all fours using the tips of your now mittened-fingers, that's pretty much what Edmontosaurus was doing. This is what the trackways and the mummified dinosaur together show.

Sometimes we are lucky enough to observe an animal as it makes a track. Other times, all we have is the trace. Ichnology is there to help bridge the gaps in our knowledge and bring some clarity to what is otherwise clear as mud.

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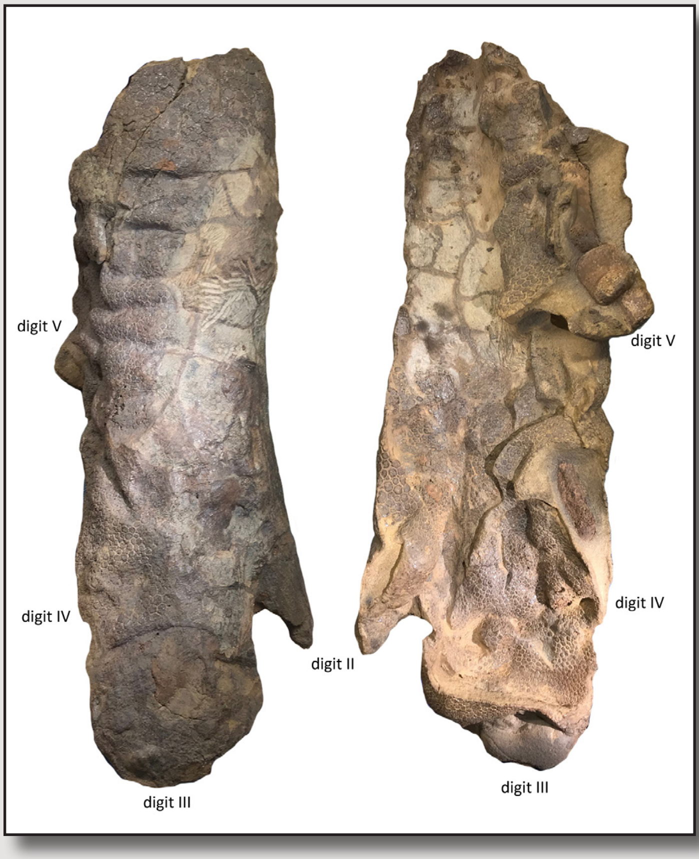

Figure 6. Mummified (fossilized skin) *Edmontosaurus* front right foot from "Dakota the dinomummy", showing the top/dorsal surface (left) and bottom/ventral surface (right).

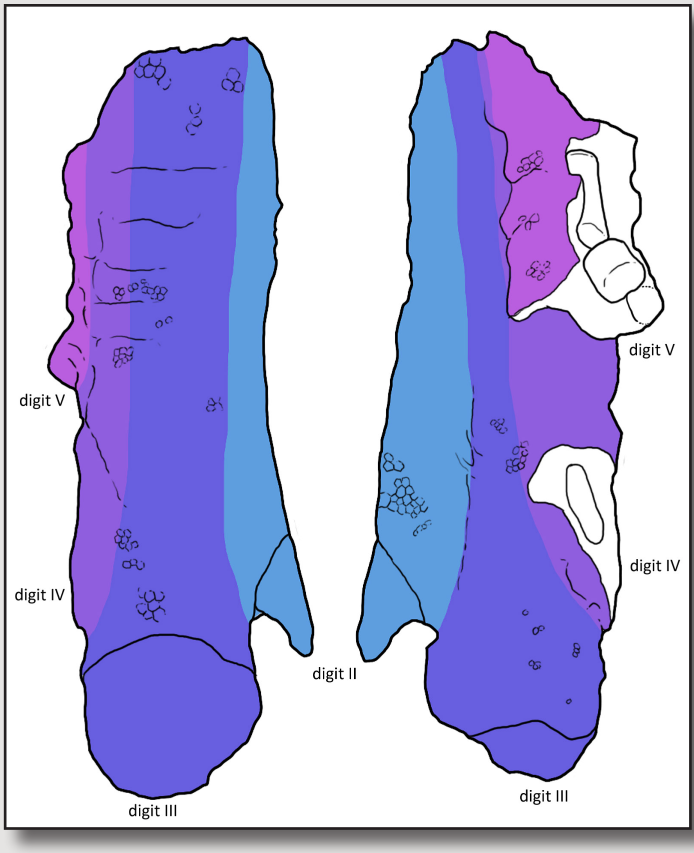

Figure 7. Line-drawing explanation of *Edmontosaurus* hand showing general positioning of digits within the fleshy-mitten. Top/dorsal surface (left) and bottom/ventral surface (right).