Dinosaurs with killer claws yield new theory about flight

December 14 2011

New research from Montana State University reveals how dinosaurs like Velociraptor and Deinonychus used their famous killer claws, leading to a new hypothesis on the evolution of flight in birds. (Illustration by Nate Carroll).

(PhysOrg.com) -- New research from Montana State University's Museum of the Rockies has revealed how dinosaurs like *Velociraptor* and *Deinonychus* used their famous killer claws, leading to a new hypothesis on the evolution of flight in birds.

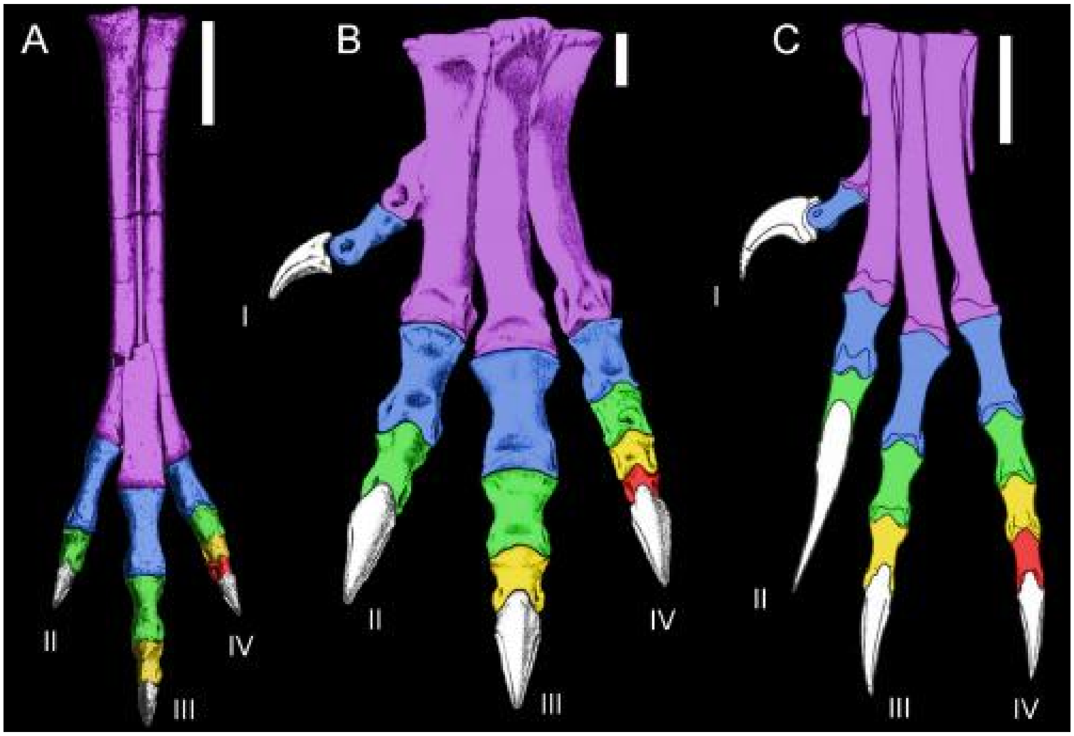
In a paper published Dec. 14 in PLoS ONE, MSU researchers Denver W. Fowler, Elizabeth A. Freedman, John B. Scannella and Robert E. Kambic (now at Brown University in Rhode Island), describe how comparing modern birds of prey helped develop a new behavior model for sickle-clawed carnivorous dinosaurs like Velociraptor.

"This study is a real game-changer," said lead author Fowler. "It completely overhauls our perception of these little predatory dinosaurs, changing the way we think about their ecology and evolution."

The study focuses on dromaeosaurids; a group of small predatory dinosaurs that include the famous *Velociraptor* and its larger relative, *Deinonychus*. Dromaeosaurids are closely related to birds, and are most famous for possessing an enlarged sickle-claw on digit two (inside toe) of the foot. Previous researchers suggested that this claw was used to slash at prey, or help climb up their hides, but the new study proposes a different behavior.

"Modern hawks and eagles possess a similar enlarged claw on their digit 2's, something that hadn't been noted before we published on it back in 2009," Fowler said. "We showed that the enlarged D-2 claws are used as anchors, latching into the prey, preventing their escape. We interpret the sickle claw of dromaeosaurids as having evolved to do the same thing: latching in, and holding on."

As in modern birds of prey, precise use of the claw is related to relative prey size.



Dinosaurs that are adapted for running or walking have a foot that is proportioned like a modern emu, with a large middle toe, and side toes that are shorter and about equal in length (e.g. Gallimimus, left, and Allosaurus, middle). Deinonychus (right) is very different, with an unusually long outer toe (D-4), and very short inner toe (D-2); proportions more suited to grasping. (Image by Denver Fowler).

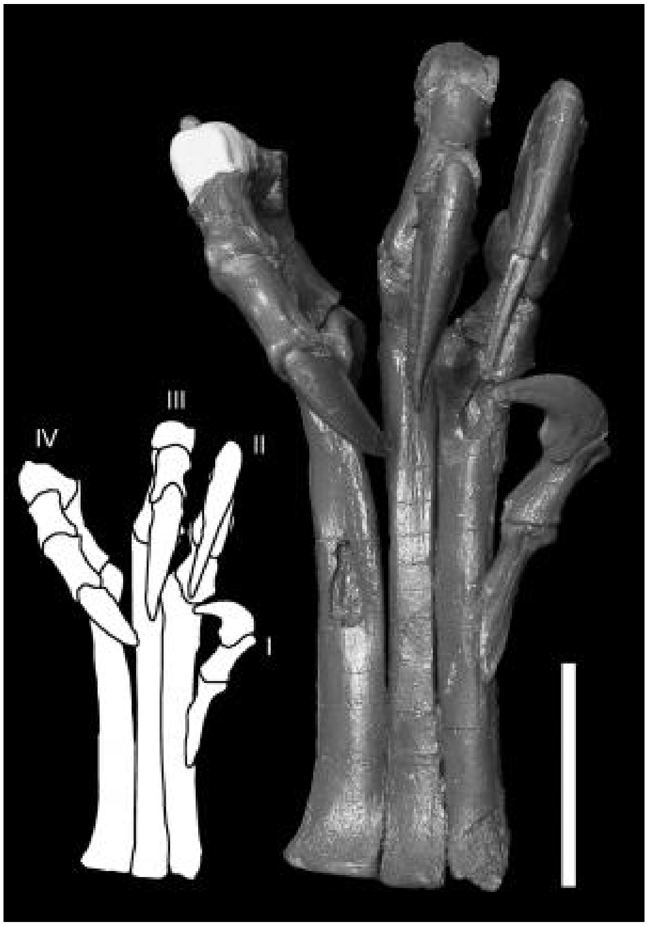
"This strategy is only really needed for prey that are about the same size as the predator; large enough that they might struggle and escape from the feet," Fowler said. "Smaller prey are just squeezed to death, but with large prey all the predator can do is hold on and stop it from escaping, then basically just eat it alive. Dromaeosaurs lack any obvious adaptations for dispatching their victims, so just like hawks and eagles, they probably ate their prey alive too."

Other features of bird of prey feet gave clues as to the functional anatomy of their ancient relatives; toe proportions of dromaeosaurids seemed more suited for grasping than running, and the metatarsus (bones between the ankles and the toes) is more adapted for strength than speed.

"Unlike humans, most dinosaurs and birds only walk on their toes, so the metatarsus forms part of the leg itself," Fowler said. "A long metatarsus lets you take bigger strides to run faster; but in dromaeosaurids, the metatarsus is very short, which is odd."

Fowler thinks that this indicates that *Velociraptor* and its kin were adapted for a strategy other than simply running after prey.

"When we look at modern birds of prey, a relatively short metatarsus is one feature that gives the bird additional strength in its feet," Fowler continued. "Velociraptor and *Deinonychus* also have a very short, stout metatarsus, suggesting that they had great strength but wouldn't have been very fast runners."



This may look like a hand, but it is a cast of a Deinonychus foot, shown as it grasps. (Image by Denver Fowler).

The ecological implications become especially interesting when dromaeosaurids are contrasted with their closest relatives: a very similar group of small carnivorous dinosaurs called troodontids, Fowler said.

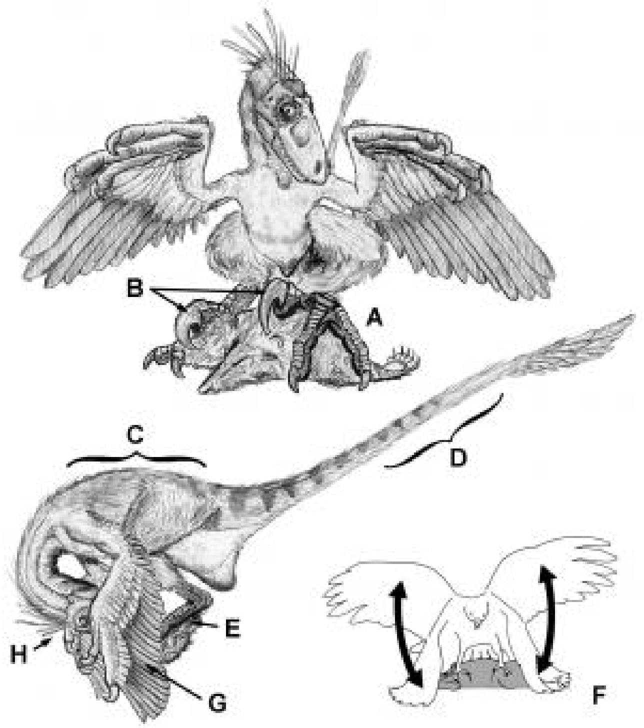
"Troodontids and dromaeosaurids started out looking very similar, but over about 60 million years they evolved in opposite directions, adapting to different niches," Fowler said. "Dromaeosaurids evolved towards stronger, slower feet; suggesting a stealthy ambush predatory strategy, adapted for relatively large prey. By contrast, troodontids evolved a longer metatarsus for speed and a more precise, but weaker grip, suggesting they were swift but probably took relatively smaller prey."

The study also has implications for the next closest relatives of troodontids and dromaeosaurids: birds. An important step in the origin of modern birds was the evolution of the perching foot.

"A grasping foot is present in the closest relatives of birds, but also in the earliest birds like *Archaeopteryx*," Fowler said. "We suggest that this originally evolved for predation, but would also have been available for use in perching. This is what we call 'exaptation:' a structure evolved originally for one purpose that can later be appropriated for a different use."

The new study proposes that a similar mechanism may be responsible for the evolution of flight.

"When a modern hawk has latched its enlarged claws into its prey, it can no longer use the feet for stabilization and positioning," Fowler said. "Instead the predator flaps its wings so that the prey stays underneath its feet, where it can be pinned down by the predator's bodyweight."



New MSU research proposes that the enlarged sickle-claw of dromaeosaurids evolved for impaling prey, preventing it from escaping. Dromaeosaurids lacked physical structures for quick dispatch of prey, so probably ate their victims alive. (Lower right drawing by Lee Hall, others by Nate Carroll).

The researchers suggest that this 'stability flapping' uses less energy than flight, making it an intermediate flapping behavior that may be key to understanding how flight evolved.

"The predator's flapping just maintains its position, and does not need to be as powerful or vigorous as full flight would require. Get on top, stay on top; it's not trying to fly away," Fowler said. "We see fully formed wings in exquisitely preserved dromaeosaurid fossils, and from biomechanical studies we can show that they were also able to perform a rudimentary flapping stroke. Most researchers think that they weren't powerful enough to fly; we propose that the less demanding stability flapping would be a viable use for such a wing, and this behavior would be consistent with the unusual adaptations of the feet."

Another group of researchers has proposed that understanding flapping behaviors is key to understanding the evolution of flight, a view with which Fowler agrees.

"If we look at modern birds, we see flapping being used for all sorts of behaviors outside of flight. In our paper, we are formally proposing the 'flapping first' model: where flapping evolved for other behaviors first, and was only later exapted for flight by birds."

The researchers believe their new ideas will open multiple new lines of investigation into dinosaur paleobiology, and the evolution of novel anatomical structures.

"As with other research conducted at the Jack Horner paleo lab, we're looking at old paleontological questions with a fresh perspective, taking a different angle," Fowler said. "Just as you have to get beyond the idea that feet are used just for walking, so we are coming to realize that many unusual structures in modern animals originally evolved for quite different purposes. Revealing the selection pathways that mold and produce these structures helps us to better understand the major evolutionary transitions that shaped life on this planet."

Provided by Montana State University

Citation: Dinosaurs with killer claws yield new theory about flight (2011, December 14) retrieved 27 April 2024 from https://phys.org/news/2011-12-dinosaurs-killer-claws-yield-theory.html