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Press Release 09-236

Newly Discovered Dinosaur Illuminates Ancient Lineage

Pristine skeletons of carnivorous *Tawa hallae* shed light on early days of dinosaur evolution



A reconstruction of the newly discovered Triassic, carnivorous dinosaur, *Tawa hallae*.
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December 10, 2009

View an [audio slideshow](#) and a [video interview](#) with Sterling Nesbitt of the University of Texas.

When Darwin's finches diverged from their common ancestor, the isolation of their island home allowed many species to arise from one.

When their dinosaur ancestors emerged in the Triassic, the island home was the unified landmass Pangea, and the evolution was far more complicated.

In the Dec. 11, 2009, issue of *Science*, a team of paleontologists introduces the Triassic dinosaur *Tawa hallae*, an animal that may answer longstanding questions about the earliest years of dinosaur evolution.

The *Tawa* fossils, collected along with other specimens during recent field excursions to Ghost Ranch in New Mexico, are some of the most complete and best preserved dinosaur skeletons from the Late-Triassic time period.

Tawa possesses features that appear in its contemporaries and

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Audio Slideshow



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Sterling Nesbitt discusses a brand new dinosaur unearthed at Ghost Ranch in New Mexico.
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The researchers believe dinosaurs originated in what is now South America, and soon after diverged.
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A reconstruction of the *Tawa hallae* skeleton.
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features that do not, a finding that helps unite all Triassic carnivorous dinosaurs into one group, the theropods, the same group that included *Tyrannosaurus rex*, and now includes birds.

The recent finds also support the hypothesis that dinosaurs first originated in what is now South America and soon after diverged into theropods, sauropodomorphs (the line that includes the ground-shaking giants like *Apatosaurus*) and ornithischians (a line that includes a range of body types, including *Stegosaurus* and *Triceratops*).

Only after this divergence did dinosaurs disperse across the Triassic world more than 220 million years ago.

"Tawa gives us an unprecedented window into early dinosaur evolution, solidifying the relationships of early dinosaurs, revealing how they spread across the globe, and providing new insights into the evolution of their characteristics," says Sterling Nesbitt of the University of Texas at Austin, the lead author on the paper.

Nesbitt's co-authors included Nathan Smith of the University of Chicago and the Field Museum of Natural History; Randall Irmis of the Utah Museum of Natural History, University of Utah; Alan Turner of Stony Brook University; Alex Downs of the Ruth Hall Museum of Paleontology in Abiquiu, N.M.; and Mark Norell of the American Museum of Natural History, where Nesbitt was a researcher at the time of the discovery.

"If you have continents splitting apart, you get isolation," says Nesbitt. "So when barriers develop, you would expect that multiple carnivorous dinosaurs in a region should represent a closely related, endemic radiation," similar to what occurred with Darwin's finches. "But that is what we don't see in early dinosaur evolution," adds Nesbitt.

Instead, Nesbitt and his colleagues observed three distantly related carnivores in the fossil-rich, Late Triassic beds, implying that each carnivore descended from a separate lineage before arriving in North America, instead of all evolving from a local ancestor. In addition to *Tawa*, the researchers found fossils from a carnivorous dinosaur related to *Coelophysis*, common to that region, and fossils from a carnivore closely related to *Herrerasaurus*, which lived in South America.

The two- to four-meter-long skeletons of *Tawa* display characteristics that exist in both of its contemporaries, and features found in neither, implying a separate lineage. Unlike many theropods, *Tawa's* lineage does not lead directly to birds.

According to Nesbitt, the old view held that *Herrerasaurus* split off of the family tree after the ornithischians, but before the sauropods and theropods diverged. "*Tawa* now appears to show that the three groups split from each other as soon as dinosaurs evolved," he adds, though paleontologists have not yet found a concrete example of a dinosaur that existed before the divergence.

"*Tawa* is a very good example of a fossil that fills in what we call a morphological gap," says Nesbitt, referring to a gap in knowledge about how morphology, or body structures, changed over time, a result of the incomplete nature of the fossil record. While theropods were changing quickly in the Triassic, paleontologists have found few animals that preserve the "steps" that define the sequence of changes.

One of the most significant morphological gaps for early dinosaurs lies between *Herrerasaurus* and animals that are clearly more closely related to birds, such as *Coelophysis*. According to Nesbitt, *Tawa* fits perfectly in between. "It is not a missing link," he adds, "It evolved on its own lineage, but it retains characteristics that existed in *Herrerasaurus* that we thought were more primitive while also possessing features seen



Reconstructed head of the newly discovered Triassic, carnivorous dinosaur, .
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Reconstruction depicting evolutionary relationships between *Tawa* and two other dinosaurs.
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The complete right hand of *Tawa hallae*.
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Co-authors Nathan Smith and Sterling Nesbitt dig for fossils at the Ghost Ranch dig site.
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Co-authors Sterling Nesbitt, Nathan Smith, Alan Turner and Randall Irmis.
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in unmistakable theropods, including birds, such as the presence of air sacs surrounding the braincase and neck."

"Usually, early dinosaur specimens are not as complete or well preserved, so they spur a lot more questions than answers," says Nesbitt. "*Tawa* is so well preserved that every bone we have, we can examine it in three dimensions. And we can analyze five of the skeletons this way, with examples of both mature and immature animals. This is just the tip of the iceberg. All dinosaurs share a common feature, an open hip socket, and you can dissect your Thanksgiving turkey and still see that original feature. But the earliest lineages that lie in between are far from understood."

The research was supported by the National Science Foundation (NSF) through grants to Mark Norell ([0228607](#)), Alan Turner ([0608003](#)), Nathan Smith ([0808250](#)) and NSF Graduate Research Fellowships to Sterling Nesbitt and Randall Irmis. The research was also featured in the NSF-funded IMAX® 3D movie "Dinosaurs Alive!" (itself supported by NSF grant [0337269](#)).

The research was also sponsored by the National Geographic Society with other participating institutions including the University of Chicago, the Field Museum of Natural History, the Utah Museum of Natural History, the University of Utah, Stony Brook University and the Ruth Hall Museum of Paleontology.

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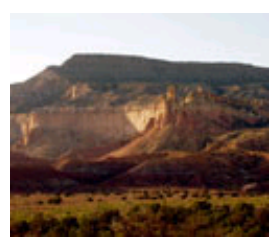
Additional information from the authors

Summary of key findings:

1. *Tawa* is known from entire skeletons, is well preserved, and is one of the most completely known theropods from the Triassic.
2. *Tawa* is found in the same deposits as the primitive carnivorous dinosaur *Chindesaurus* (closely related to *Herrerasaurus*) and an animal closely related to *Coelophysis*.
3. These three animals are not each other's closest relatives, demonstrating that Triassic carnivorous dinosaurs from the Hayden Quarry at Ghost Ranch dispersed multiple times into North America.
4. Dispersal of early dinosaurs was widespread during the Triassic, suggesting that the lack of sauropodomorph dinosaurs in North America was not a result of physical barriers.
5. Anatomical information from *Tawa* helps unite all Triassic carnivorous dinosaurs into one group, called Theropoda. Previously, some scientists thought that carnivorous dinosaurs such as *Herrerasaurus* and *Eoraptor* evolved before the split of sauropodomorphs and true theropods.

Additional facts:

1. Theropoda is the clade (natural group) of dinosaurs containing the carnivorous dinosaurs, including *Tyrannosaurus rex*, *Velociraptor*, and birds.
2. Dinosaurs lived with their closest relatives ("protodinosaur" or "dinosaur precursors") towards the end of the Triassic Period.
3. The Triassic Period lasted from 250 to 201 million years ago, and the following animals arose during this time: dinosaurs, crocodile relatives, mammals, pterosaurs, turtles, frogs, and lizards.
4. *Tawa* is a theropod dinosaur and most likely ate meat.
5. *Tawa* is known from multiple individuals ranging from small juveniles to sub adults.
6. *Tawa* is between 2 and 4 meters long and stood at 1-1.5 meters tall at the hips.
7. The braincase and neck of *Tawa* were surrounded by airsacs, just like living birds.



The cliffs west of Ghost Ranch in New Mexico.

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The researchers' finding appear in the December 11, 2009 issue of the journal *Science*.

[Credit and Larger Version](#)

8. *Tawa* has features of *Herrerasaurus* and coelophysid dinosaurs like *Coelophysis* and *Herrerasaurus*. This mix of features shows that *Herrerasaurus* is the most primitive theropod known (more closely related to birds than to sauropods).
9. The Hayden Quarry is between 215-213 million years old.
10. The fossils described in this paper were found at Ghost Ranch, in northern New Mexico, near the town of Abiquiu. Ghost Ranch is famous for its Triassic fossils, and has been visited throughout the last 130 years by scientists from the University of California, Berkeley; American Museum of Natural History; Carnegie Museum of Natural History; and the famous paleontologist Edward Drinker Cope.
11. The fossils are from a locality known as the Hayden Quarry. This locality is probably several million years older than the famous *Coelophysis* Quarry, also on Ghost Ranch land.
12. The Hayden Quarry was near the equator during the Late Triassic Period (it is currently at 36.2° latitude).
13. Dinosaurs may have originated in South America
14. During the Triassic, the continents were coalesced into a single landmass named Pangea.
15. The specimens of *Tawa* were collected during the filming of the NSF sponsored IMAX film "Dinosaurs Alive!"
16. Sauropodomorph dinosaurs apparently did not live in North America during the Triassic even though they had to pass through North America when dispersing between South America, Africa, and Europe.
17. The name *Tawa* is from the Hopi name for the Puebloan sun god. The second part of the species name, *hallae*, is for Ruth Hall, who collected many of the specimens that formed the genesis of the Ghost Ranch Ruth Hall Museum of Paleontology (GR) collections.

The paper DOES NOT say that...

1. ... the Hayden Quarry dinosaurs are the oldest dinosaurs in the world (or North America).
2. ... *Tawa* is the most primitive carnivorous dinosaur.
3. ... *Tawa* is the oldest dinosaur or theropod in North America.
4. ... *Tawa* was found at the famous *Coelophysis* Quarry at Ghost Ranch.
5. ... *Tawa* is the direct ancestor of *Tyrannosaurus rex*.
6. ... *Tawa* is the direct ancestor of *Velociraptor*.
7. ... *Tawa* is the direct ancestor of birds.
8. ... *Tawa* evolved in South America.

Pronunciation Guide:

Tawa hallae - Ta-WA Hall-A

Chindesaurus - Shin-dee-soar-us

Coelophysis - See-low-phy-sis

Coelophysoid - See-low-phy-soyd

Theropod - THER-o-pod

Chinle - Chin-lee

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Related Websites

Tawa Hallae: Dinosaur Ancient History: <http://www.nsf.gov/tawa>

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