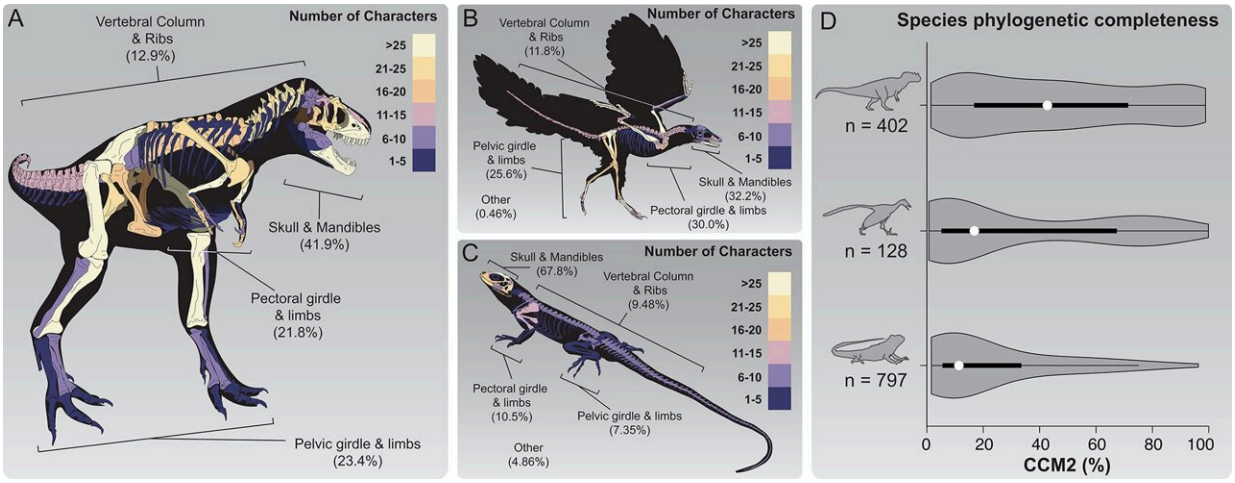
How great fossil sites shape our understanding of evolutionary relationships between fossil groups

February 14 2024



Visualization of the Character Completeness Metric (CCM2) in the fossil record of non-avian theropod dinosaurs, Mesozoic birds, and squamates. Credit: *PLOS ONE* (2024). DOI: 10.1371/journal.pone.0297637

A new study published in the journal *PLOS ONE* explores the weight great fossil sites have on our understanding of evolutionary relationships between fossil groups—the lagerstätten effect—and for the first time, has quantified the power these sites have on our understanding of evolutionary history.

Surprisingly, the authors discovered that the wind-swept sand deposits of the Late Cretaceous Gobi Desert's extraordinarily diverse and well-preserved fossil lizard record shapes our understanding of their evolutionary history more than any other site on the planet.

While famous as the region where Velociraptor was discovered, China and Mongolia's Late Cretaceous Gobi Desert might have more of an impact on our understanding of ancient—and modern—life thanks to its rich record of fossil lizards.

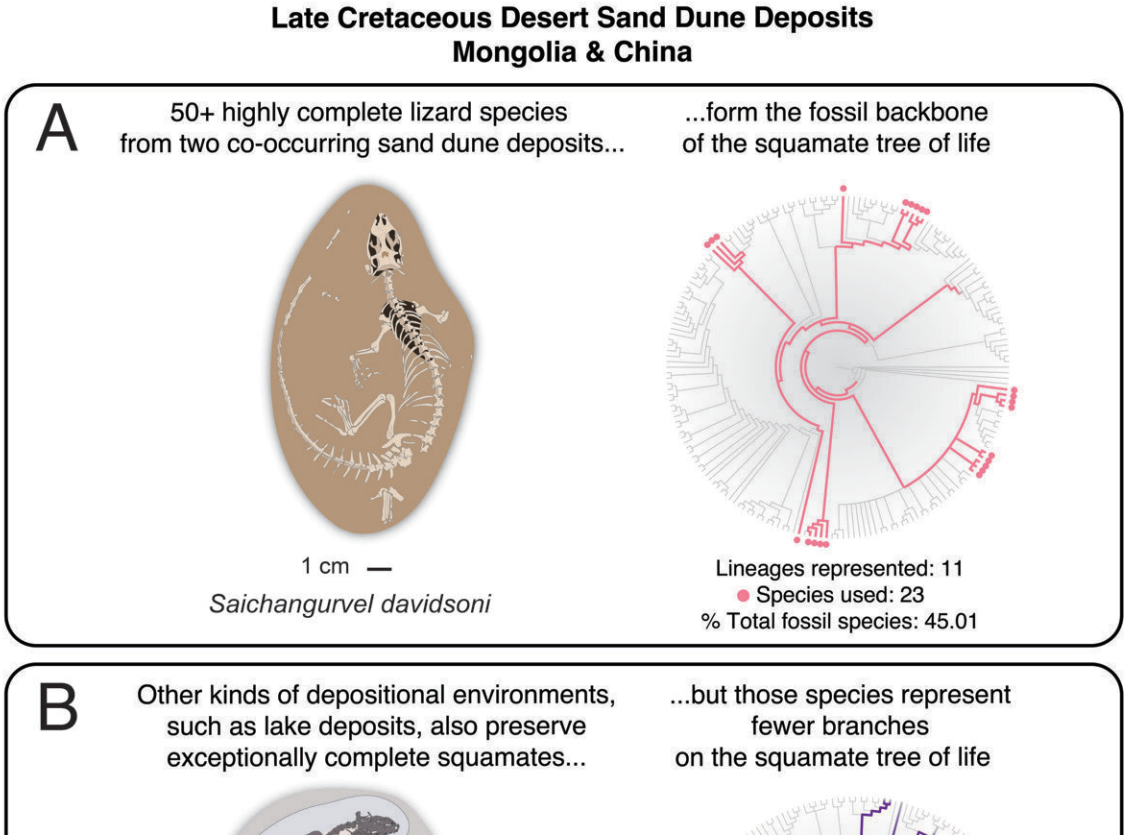
"What's so cool about these Late Cretaceous Gobi Desert deposits is that you're getting extremely diverse, exceptionally complete, three-dimensionally-preserved lizard skeletons," said Dr. Hank Woolley, lead author and NSF Postdoctoral Research Fellow at the Dinosaur Institute. "You're getting many lineages on the squamate Tree of Life represented from this single unit, giving us this remarkable fossil signal of biodiversity in the rock record, something that stands out as a lighthouse in the deep dark chasms of squamate evolutionary history."

More complete skeletons make it easier to trace relationships through time by making it easier to compare similarities and differences. The more complete a skeleton is, the more traits are preserved, and those traits translate into phylogenetic data—data that are used to construct the tree of life.

"Where there's exceptional preservation—hundreds of species from one part of the world at one period of very specific time—that doesn't necessarily give you a good idea of global signals," said Woolley. "It's putting its thumb on the scale."

To measure how impactful deposits of exceptional fossil preservation (known in the paleontology community by the German term "lagerstätten") are on the broader understanding of evolutionary

relationships through time, Woolley and co-authors including Dr. Nathan Smith, Curator of the Dinosaur Institute, combed through published records of 1,327 species of non-avian theropod dinosaurs, Mesozoic birds, and fossil squamates (the group of reptiles that includes mosasaurs, snakes, and lizards).



Graphical summary of the results of the new study. A) Summary of the phylogenetic impact of the Late Cretaceous Gobi Desert lizard assemblage. B) Comparison to other well-preserved squamates found in lake deposits. Credit: Hank Woolley

The fossil meta-narrative

When it came to squamates, the researchers found no correlation between the intensity of sampling and whether any given site impacted phylogenetic data on a global scale. Instead, they found a signal from depositional environments, the different kinds of sites where sediments accumulated preserved markedly different groups.

Because the squamate record from the Gobi Desert is so complete, it shapes our understanding of squamate evolution around the world and across time, a prime example of the "lagerstätten effect"—despite not being a typical lagerstätte. Traditional lagerstätten deposits come from marine chalks, salty lagoons, and ancient lake environments—not from arid sand dunes. The ancient environment shapes what gets preserved in the fossil record.

"We were not expecting to find this detailed record from lizards in a desert sand dune deposit," said Woolley.

"We often think of lagerstätten deposits as preserving soft tissues and organisms that rarely fossilize, or especially rich concentrations of fossils. What makes the Gobi squamate record unique, is that it includes both exceptionally complete skeletons, and a high diversity of species from across the group's family tree," said Smith.

"We're at this frontier between fields within paleontology that rarely overlap: assessing evolutionary relationships of fossil groups (phylogenetics) and assessing how things fossilize (taphonomy). Exploring this frontier will help to incorporate more of Earth's extinct biodiversity in museum collections as we piece together the past," said Woolley.

More information: C. Henrik Woolley et al, Quantifying the effects of exceptional fossil preservation on the global availability of phylogenetic data in deep time, *PLOS ONE* (2024). DOI:

10.1371/journal.pone.0297637