Synchrotron sheds light on the amphibious lifestyle of a new raptorial dinosaur

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Reconstruction of Halszkaraptor escuilliei (by Lukas Panzarin, scientific supervisionby Andrea Cau). This small dinosaur was a close relative of Velociraptor, but in bothbody shape and inferred lifestyle it much closely recalls some waterbirds like modernswans. Credit: Lukas Panzarin and Andrea Cau

An exceptionally well-preserved dinosaur skeleton from Mongolia unites an unexpected combination of features that defines a new group of semi-aquatic predators related to Velociraptor. Detailed 3D synchrotron analysis allowed an international team of researchers to present the bizarre 75 million-year-old predator, named Halszkaraptor escuilliei, in *Nature*. The study describes a new genus and species of bird-like dinosaur that lived during the Campanian stage of the Cretaceous in Mongolia and sheds light on an unexpected amphibious lifestyle for raptorial dinosaurs.

Theropods encompass all carnivorous dinosaurs, including the largest land-living predators in the history of life on Earth, such as Tyrannosaurus, and iconic agile hunters like Velociraptor. During 160 million years of the Mesozoic Era, theropods became the dominant predators on all continents, yet never conquered aquatic environments. Although some theropods reportedly incorporated fish in their diet, proposed indications for aquatic locomotion associated with exclusively aquatic lifestyles remain controversial.

A swan-necked and flipper-forelimbed new dinosaur species that combines an unexpected mix of features now demonstrates that some bird-like dinosaurs did adopt a semi-aquatic lifestyle. The fossil, nicknamed "Halszka" for Halszkaraptor escuilliei, was found at Ukhaa Tolgod. This locality in southern Mongolia has been known by palaeontologists for decades and is often targeted by poachers. "Illicit fossil trade presents a great challenge to modern palaeontology and

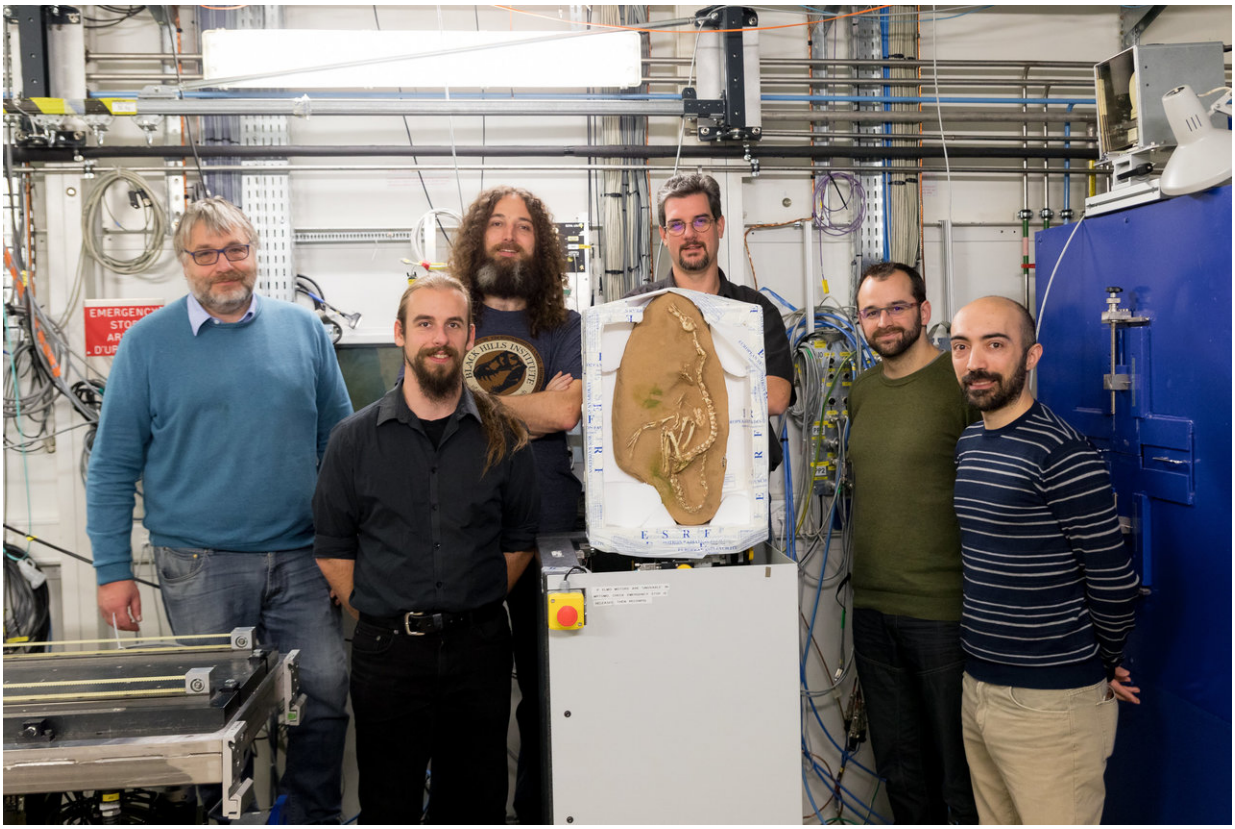
accounts for a dramatic loss of Mongolian scientific heritage," says Pascal Godefroit of the Royal Belgian Institute of Natural Sciences in Brussels. "Illegally exported from Mongolia, Halszka resided in private collections around the world before it was acquired in 2015 and offered to palaeontologists for study and to prepare its return to Mongolia."


70 mm

Credit: ESRF/Paul Tafforeau

Although several important groups of predatory dinosaurs have been discovered in Mongolia, Halszka does not belong to any of them, having a number of strange features that are mostly absent among dinosaurs, but are shared by reptilian and avian groups with aquatic or semiaquatic ecologies. "The first time I examined the specimen, I even questioned whether it was a genuine fossil" says Andrea Cau of the Geological Museum Capellini in Bologna. Although Halszka is unique in many ways, certain parts of the skeleton, including the sickle-shaped "killer claws" on its feet, are shared with well-known dinosaurs such as Velociraptor. "This unexpected mix of traits makes it difficult to place Halszka within traditional classifications," Cau remarks.

In order to ascertain the integrity of the fossil, the specimen was visualised and reconstructed in three dimensions using synchrotron multi-resolution X-ray microtomography. "This technique is currently the most powerful and sensitive method to image internal details without damaging invaluable fossils. The ESRF has become the worldwide leader for high quality X-ray imaging of such precious specimens," notes Paul Tafforeau of the ESRF. "We had to mobilise an ESRF team of palaeontologists to study the complete anatomy of Halzka. So far, it's the specimen for which the greatest number of experiments were made on a single fossil," adds Tafforeau.



The team of scientists at BM05 beamline, at the ESRF, the European Synchrotron, while the set up of Halszkaraptor escuilliei fossil. From left to right: Pascal Godefroit, Vincent Beyrand, Dennis Voeten, Paul Tafforeau, Vincent Fernandez, Andrea Cau. Credit: ESRF/P.Jayet

"Our first goal was to demonstrate that this bizarre and unexpected fossil is indeed a genuine animal: multi-resolution scanning confirmed that the skeleton is not a composite assembled from parts of different dinosaurs," explains Dennis Voeten of the ESRF. "We implemented new methods for the acquisition and optimisation of tomographic scan data, which not only confirmed the integrity of the specimen, but also revealed additional palaeontological information," Vincent Fernandez of the ESRF says.

The synchrotron was even able to reveal, in astonishing detail, those parts of the skeleton that remained deep within the rock since the dinosaur was buried. "Our analysis demonstrated that numerous teeth, which are not visible externally, are still preserved inside the mouth," says Vincent Beyrand of the ESRF. "We also identified a neurovascular mesh inside its snout that resembles those of modern crocodiles to a remarkable degree. These aspects suggest that Halszka was an aquatic predator."

The ESRF data revealed that the fossil represents a new genus and species of amphibious dinosaur that walked on two legs on land, with postural adaptations similar to short-tailed birds (like ducks), but used its flipper-like forelimbs to manoeuvre in water (like penguins and other aquatic birds), relying on its long neck for foraging and ambush hunting.

This new species was named Halszkaraptor escuilliei. Its generic name honours the late palaeontologist Halszka Osmólska. "This important genus is named in recognition of Halszka's contribution to the study of Mongolian dinosaurs from the Gobi," comments Rinchen Barsbold of the Mongolian Academy of Sciences. "The specific name refers to François Escuillié and thereby acknowledges his role in the first recognition and in the return of this specimen to Mongolia," adds Khishigjav Tsogtbaatar of the Institute of Paleontology and Geology in Ulaanbaatar.

Halszkaraptor is not the only strange dinosaur recovered from the Gobi. Several previously described enigmatic Mongolian theropods were closely related to the new species, the study found. United in a new group, named Halszkaraptorinae, "is an unexpected subfamily of dromaeosaurs—the group colloquially known as raptors. This bizarre subfamily appears to have evolved a lifestyle different from all other predatory dinosaurs," says Philip Currie of the University of Alberta.

"When we look beyond fossil dinosaurs, we find most of Halszkaraptor's unusual features among aquatic reptiles and swimming birds," concludes lead author Andrea Cau. "The peculiar morphology of Halszkaraptor fits best with that of an amphibious predator that was adapted to a combined terrestrial and aquatic ecology: a peculiar lifestyle that was previously unreported in these dinosaurs. Thanks to synchrotron tomography, we now demonstrate that raptorial dinosaurs not only ran and flew, but also swam."

More information: Andrea Cau et al, Synchrotron scanning reveals amphibious ecomorphology in a new clade of bird-like dinosaurs, *Nature* (2017). DOI: 10.1038/nature24679

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