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THE MAGIC BEAKS OF stone birds

Discovering an ancient avian superpower

A new study from the University of Cape Town has shown that fossil relatives of ostriches and emus had a remarkable foraging ecology that was more like that of the Hadeda Ibis than their giant flightless living relatives. What is even more fascinating is that they may have inherited this unique 'sixth sense' from their non-avian dinosaur relatives.

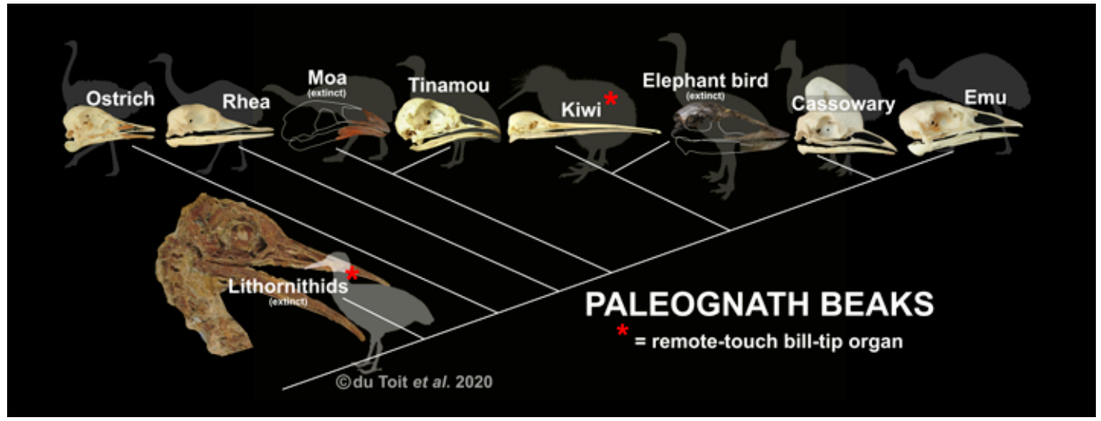
The fossil birds we studied were the lithornithids, whose name means 'stone birds'. These ancient birds co-existed with non-avian dinosaurs more than 65 million years ago and survived the end-Cretaceous mass extinction event that killed off all dinosaurs except for birds. The lithornithids are the earliest members of the paleognathous clade of birds, the group of birds that are sometimes also known as ratites. It includes ostriches, emus and the kiwis from New Zealand, as well as the gigantic, extinct Elephantbirds and moas. The lithornithids went extinct about 40 million years ago, but based on fossil material from North America and Europe, we know that they were roughly the size and shape of oystercatchers, were able to fly and lived in and around wetlands like modern wading birds (for example rails and ibises).

above *A Hadeda Ibis on a beach probes for food using remote-touch.*

We became interested in the beaks of these lithornithid fossils while we were researching the foraging behaviour of modern ibises. We are studying a remarkable 'sixth sense' that ibises possess, which enables them to locate their buried prey items blindly while probing in mud or opaque water. This sense, called remote-touch, is made possible by a specialised sense organ located at the end of their long, thin beaks that detects tiny vibrations in the substrate as the birds probe their beaks into it. This enables the birds to locate prey items at some distance from their beaks in the absence of all other sensory information like sight or sound. Apart from ibises, two other groups of living birds use this bill-tip organ for remote-touch: sandpiper-like shorebirds and the kiwis. The highly specialised bill-tip organ is made up of a honeycomb-like cluster of little pits in the bones of their beaks. Inside each pit are specialised nerve receptors that can sense vibrations out of hearing range. The whole organ is covered by the keratin 'beak skin', so it is not visible in living birds. By examining the bones of the beaks of these modern probe-foraging birds, the little pits or holes are easily identifiable. This is exciting for palaeontologists, since bones are often well preserved in the fossil record and therefore it may be possible to locate bill-tip organs in fossil birds.

What does this have to do with the ancient ratite ancestors, the extinct lithornithids? Firstly, the remote-touching kiwis are also paleognathous birds. And, interestingly, all modern paleognaths (such as ostriches and emus) possess the same type of bill-tip organ on their beaks as the ibises, even though they are not probe-foragers (aside from the kiwis) and have lost the required specialisation in tactile regions of their brains. So why would modern ratites have a bill-tip organ if they aren't using it?

We thought that their bill-tip organ might represent a vestigial structure inherited from an ancestral bird that used remote-touch to probe-forage. Since the lithornithids are basal members of the paleognath group (the ratites), we decided to investigate their beaks. As the fossilisation process can be extremely harsh, we were concerned whether the delicate pits in their beaks would have survived through the millennia. Fortunately for us, the almost intact specimens of lithornithids at the Smithsonian Natural History Museum in the USA have beautifully preserved beaks. One of our team, Carla du Toit, travelled there to analyse the specimens and to her amazement she found that despite being over 45 million years old, the surfaces of their beak bones were literally covered in pits, just like those of modern ibises and kiwis.



CARLA DU TOIT (2)

By comparing the pattern of the bony pits with measures of beak and skull shape of the lithornithid specimens to a massive sample of bird skulls from all orders of living birds, we were able to support the hypothesis that these earliest ratites used the specialised bill-tip organ in the same way that modern kiwis and ibises do. Thus this remarkable avian 'superpower' evolved millions of years ago when non-avian dinosaurs dominated terrestrial landscapes. It is incredible that among all living ratites, this 'superpower' has survived intact in the charismatic kiwis of New Zealand and that traces of this vestigial organ are preserved in the beaks of their giant relatives, the ostriches and emus, even though the latter have evolved new foraging habits. The fact that modern shorebirds and ibises also have such a 'superpower' suggests that it may have evolved independently in these lineages and certainly warrants further investigation.

Furthermore, ducks and geese (which are the sister group to the ratites in terms of their position in the avian family tree) also have a specialised bill-tip organ. They use it for dabbling in water to find food and although it is not exactly the same as the remote-touch bill-tip organ, it is very similar in its structural make-up. If the bill-tip organs in ducks, geese and ratites are derived from a common ancestor, this could suggest that an even earlier relative of all modern birds was able to use remote-touch probing.

What is really intriguing is that there is increasing evidence that some theropods – the group of meat-eating dinosaurs that are the ancestors of all modern birds – had some kind of specialised tactile receptors on the ends of their snouts. These bear some similarity to the bill-tip organs in birds, but the pits are not as numerous and they were more likely used to sense vibrations in water coming from fish and other large vertebrate prey. There is still much work to be done before any firm conclusions can be made about the link between these two types of facial sensitivities and whether non-avian dinosaur senses gave rise to the avian superpower.

above *Fossil beaks of lithornithids, showing the high degree of pitting preserved on the beak bones.*

top *Family tree of ratites, comparing beak shapes and the occurrence of the remote-touch bill-tip organ.*

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About the researchers

Anusuya Chinsamy-Turan is the Honorary President of BirdLife South Africa and a world-renowned palaeontologist, Susie Cunningham is an expert on the behaviour of modern birds, and PhD candidate Carla du Toit is a hybrid of the two. Their work was co-funded by the DSI-NRF Centres of Excellence in Palaeosciences and the FitzPatrick Institute of African Ornithology at the University of Cape Town.