New study using 3D scans of 85% of all known bird species sheds light on extraordinary avian diversity

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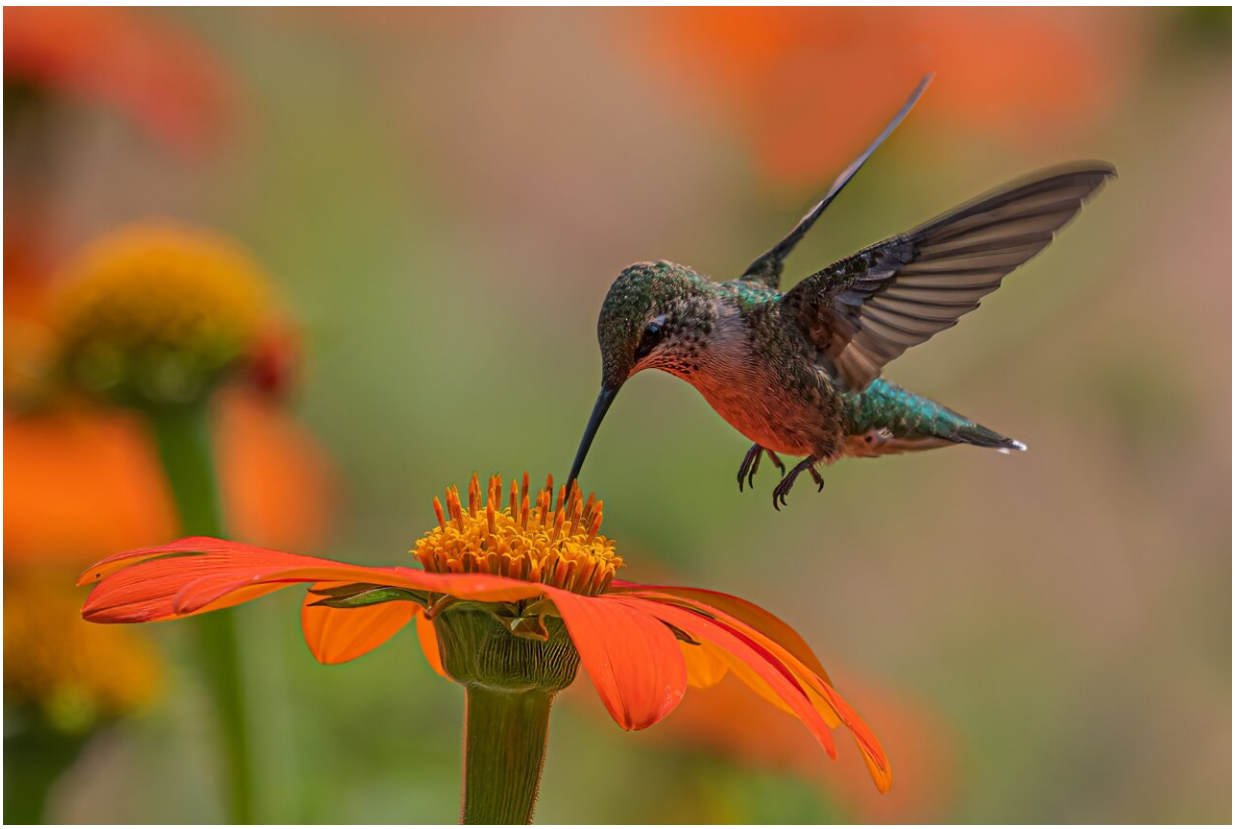

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A new study, using the digitized scans of beaks from over 8,700 bird species, is shedding light on how evolution changes at different scales.

While the general principles of evolution by natural selection have been known for over 160 years, the 3D scanning of specimens housed at Natural History Museum, Tring, and Manchester Museum is not only uncovering information on the evolution of birds but also answering broader questions on how evolution occurs.

The findings of the study "Innovation and elaboration on the avian tree of life" is published in the journal *Science Advances*.

To investigate how evolution compared across three scales (microevolution, macroevolution, and megaevolution) and the different routes evolution takes to form diverging characteristics, the researchers marked out features on the museums' bird specimens (amounting to 85% of all known bird species) so that their beaks could be mathematically modeled. This facilitated comparisons between different parts of the bird family tree.

In their comparisons, the team were particularly interested in elaboration (where evolution takes traits down similar routes which lead to different outcomes) and innovation (where evolution goes in a completely different direction, creating new characteristics that might not be seen in other groups). These terms describe the different routes evolution can take, with bird groups given a score for each.

In general, the team found that at a macroevolutionary scale, elaboration tended to be more important than innovation as species diverged. Innovation tended to be more important at a megaevolutionary scale, with many different routes leading to large shifts between less related groups of birds.

Dr. Natalie Cooper, Senior Researcher at the Natural History Museum and co-author of the research, comments, "While we focused on birds, we're interested in answering big questions about evolution. How exactly

does it happen? Why do we have this amazing diversity of life on Earth?".

"While bird beaks are fascinating in their own right, this research can help to answer much more fundamental questions about evolution."

Some of the best examples of the different evolution routes were found in hummingbirds. There are more than 350 species of hummingbirds, all of which feed on nectar. Their beaks have similarities due to their shared challenges in getting nectar but differ in length depending on the flowers the birds feed on (the sword-billed hummingbird has a bill that can grow up to 12 centimeters long whereas the bee hummingbird has one of the shortest beaks in nature).

Comparing the beaks of hummingbirds to their closest living relatives, the swifts, reveals the impact of innovation. While hummingbirds have long, slender beaks, swifts have wide, short bills to help them catch flying insects.

Using the resulting scores, the team now hope to examine how elaboration and innovation are affected by a bird's ecology.

Dr. Gavin Thomas, co-author of the paper from the University of Sheffield, says, "Bird beaks are an excellent trait to study evolution with as they vary in a consistent way. They have a huge range of shapes that seem to be linked to ecology, such as the food they eat and the way that they forage."

More information: Thomas Guillerme et al, Innovation and elaboration on the avian tree of life, *Science Advances* (2023). DOI: 10.1126/sciadv.adg1641