Microscopic feather features reveal fossil birds' colors and explain why cassowaries shine

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An illustration of Calcaivis, an early relative of ostriches and cassowaries that lived 52 million years ago, showing its iridescent feathers. Credit: Velizar Simeonovski

Cassowaries are big flightless birds with blue heads and dinosaur-looking feet; they look like emus that time forgot, and they're objectively

terrifying. They're also, along with their ostrich and kiwi cousins, part of the bird family that split off from chickens, ducks, and songbirds 100 million years ago. In songbirds and their relatives, scientists have found that the physical make-up of feathers produce iridescent colors, but they'd never seen that mechanism in the group that cassowaries are part of—until now. In a double-whammy of a paper in *Science Advances*, researchers have discovered both what gives cassowary feathers their glossy black shine and what the feathers of birds that lived 52 million years ago looked like.

"A lot of times we overlook these weird flightless birds. When we're thinking about what early birds looked like, it's important to study both of these two sister lineages that would have branched from a common ancestor 80 million or so years ago," says Chad Eliason, a staff scientist at the Field Museum and the paper's first author.

"Understanding basic attributes—like how colors are generated—is something we often take for granted in living animals. Surely, we think, we must know everything there is to know? But here, we started with simple curiosity. What makes cassowaries so shiny? Chad found an underlying mechanism behind this shine that was undescribed in birds. These kinds of observations are key to understanding how color evolves and also inform how we think about extinct species," says Julia Clarke, a paleontologist at the Jackson School of Geosciences at the University of Texas at Austin and the paper's senior author. Eliason began conducting research for this paper while working with Clarke at the University of Texas as part of a larger project funded by the National Science Foundation (NSF EAR 1355292) to study how flightless birds like cassowaries have evolved their characteristic features.

In humans and other mammals, color mostly comes from pigments like melanin that are in our skin and hair. Birds' colors don't just come from pigment—some of their coloration, like the rainbow flecks on

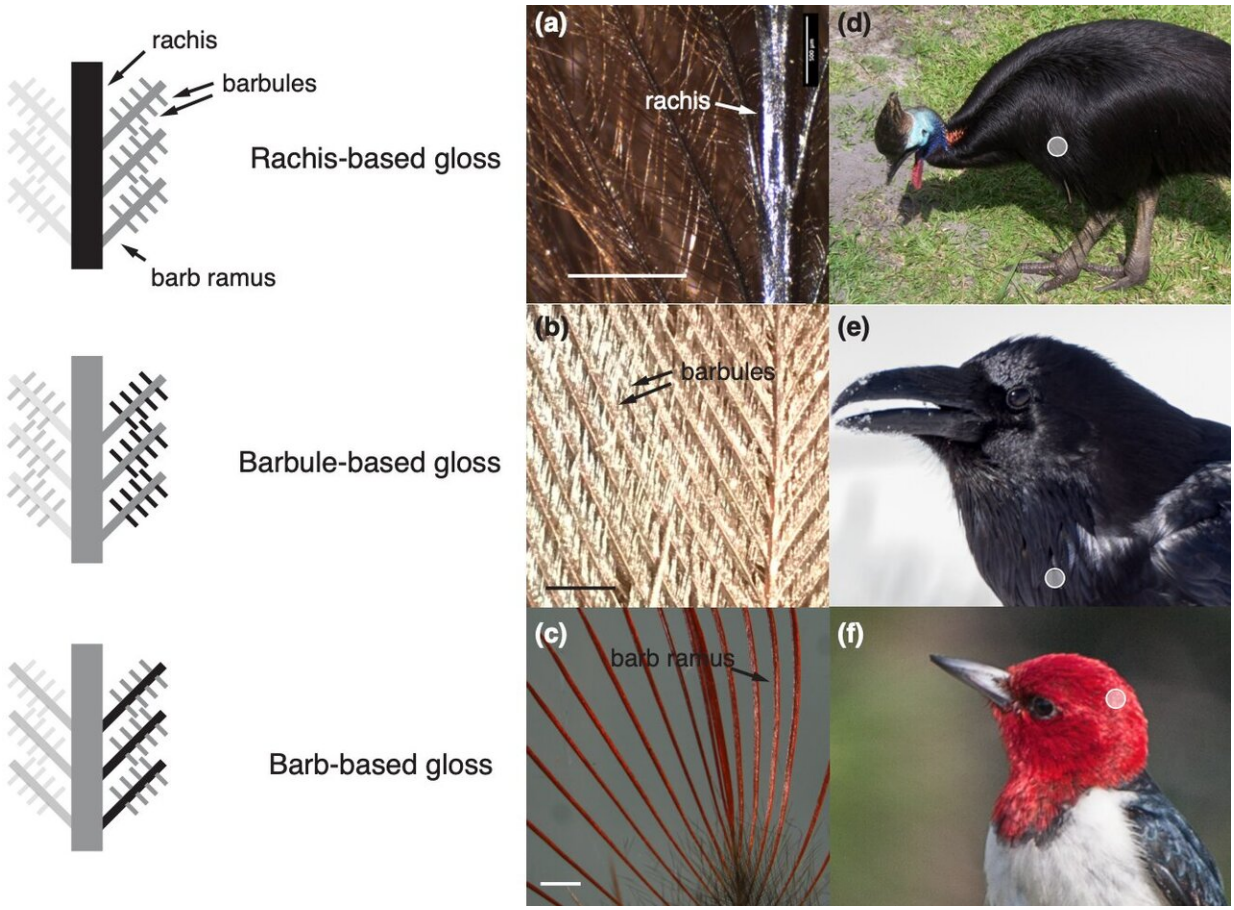
hummingbirds and the shiny, glossy black on crows, is due to the physical makeup of their feathers. The parts of their cells that produce pigment, called melanosomes, affect the feathers' color based on how light bounces off those melanosomes. Different shapes or arrays of melanosomes can create different structural colors, and so can the layers of keratin making up the birds' feathers. They can reflect a rainbow of light, and they can make the difference between dull, matte feathers and feathers with a glossy shine.


5 mm

Microscopic detail of a cassowary feather, showing the exposed rachises that allow for iridescence. Credit: Chad Eliason

Scientists had never found structural colors in the feathers of paleognaths like cassowaries and ostriches—only in the neognath group of birds like songbirds. But paleognaths can make structural colors: the blue skin on cassowaries' heads is due to structural color, and so is the shiny sheen on eggs laid by their cousins, the tinamous. Eliason and Clarke, who study structural colors in birds and dinosaurs, wanted to see if structural color was also present in paleognath feathers.

A bird's feather is structured a little like a tree. The long trunk running through the middle is called the rachis, and it has branches called barbs. The barbs are covered with tiny structures called barbules, akin to the leaves on tree branches. In other shiny birds, glossiness is produced by the shape of the barbs and layers of melanosomes in barbules. Eliason and Clarke didn't find that in cassowary feathers, though. Instead, they discovered that the shiny black color came from the rachis running down the middle of the feathers. Since the fluffy barbules on cassowary feathers are pretty sparse, the rachis gets more exposure to light than in "thick-feathered" birds, giving it a chance to literally shine.



A comparison of the feather structures and iridescent colors of different kinds of birds. Credit: Chad Eliason

In addition to finding structural color in cassowary feathers, Eliason and Clarke also explored the feathers of a cousin of the cassowary that lived 52 million years ago. The extinct bird *Calxavis grandei* lived in what's now Wyoming, and its incredibly well-preserved fossils include imprints of its feathers.

"You can look at a fossil slab and see an outline of where their feathers were, because you kind of see the black stain of melanin that's left over, even after you 50 million years or so," explains Eliason. "We peeled off

little flakes of the fossil from the dark spots of melanin, and then we used scanning electron microscopes to look for remnants of preserved melanosomes."

By examining these feather imprints on a microscopic level, the researchers were able to see the shape of the pigment-producing melanosomes in the leaf-like barbules of the feathers. The melanosomes were long, skinny, and green bean-shaped, which in modern birds is associated with iridescence.

Glossy plumage of a cassowary. Credit: Julia Clarke, University of Texas Austin. Photo of a northern cassowary specimen at the Naturalis Biodiversity Center in Leiden

Before this study, scientists had never found evidence of structural color in paleognath feathers—now, they've got two different examples. The researchers aren't sure why cassowaries and the fossil birds evolved two different ways to build shiny feathers—why reinvent the wheel? Eliason suspects that flightlessness might have given cassowaries more room to experiment with their feathers. In flighted birds, including the fossil birds in this study, the number one priority for feather structure is being aerodynamic. Since cassowaries don't need to worry about flying, they had more evolutionary leeway to develop their oddly-shaped, thick-spined feathers. "Needing to be able to fly is a very strong stabilizing force on wing shape," says Eliason. "Losing that constraint, that need to fly, might result in new feather morphologies that produce gloss in a way that a flying bird might not."

In addition to the questions this study poses about why these birds' feathers evolved so differently, Eliason and Clarke note that it gives us a better overall understanding of life on Earth. "It gives us a glimpse into the time when dinosaurs were going extinct and the birds were rising," says Eliason. "Studying these paleognaths gives us a better understanding of what was happening there, because you can't just study neognaths; you need to study both sister clades to understand their ancestors."

More information: C.M. Eliason el al., "Cassowary gloss and a novel form of structural color in birds," *Science Advances* (2020). advances.sciencemag.org/content/6/20/eaba0187

Provided by Field Museum