Toucan Beaks Inspire Lightweight Materials

Toucans may hold the key to developing materials for future aircraft and vehicle components in their long, lightweight beaks, according to researchers at the University of California at San Diego's (UCSD) Jacobs School of Engineering (Figure 1a).

Bird beaks are typically either short and thick or long and thin, but the toucan’s beak is both long and thick and used for a variety of purposes from gathering fruit to self-defense. Researchers chose to study the toucan’s unusual beak for its strength and light weight but found that it was also useful for absorbing impact.

The toucan’s beak, researchers discovered, is made of an unusual biocomposite. The beak’s interior is a highly organized matrix of stiff cancellous bone fibers interconnected by drum-like membranes. The result is a solid foam of air-tight cells that give the beak additional rigidity (Figure 1b).

“The beak is mostly air,” said Marc A. Meyers, materials scientist and professor of mechanical and aerospace engineering at UCSD. “While the inner part of human bone also contains cancellous bone, we don’t have the foam interconnections, which produce a much stronger structure with very little additional weight.”

A hollow region extends about half the length of the upper and lower beaks, where the mechanical stresses are insignificant (Figure 1c).

“This is why I jokingly tell my students that toucans have a deep knowledge of mechanics,” said Meyers. “They don’t bother adding structural support in a part of the beak that doesn’t really need it.

The beak’s outer layer is made up of keratin, the protein that makes up fingernails, hair, and horn. The keratin is arranged in overlapping tiles, each about 50 micrometers in diameter and 1 micrometer thick, that are glued together to produce sheets (Figure 1d).

Meyers says that the bio-composite structure of the toucan’s beak could inspire the design of synthetic metal and polymer foams for use in ultra-light aircraft and vehicle components. Because the toucan’s beak also behaves as a high-energy impact-absorption system, panels mimicking their structure could offer better protection to motorists in car crashes as well.

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