Biomechanical traits of a turtle shell in response to stress

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Abstract

The boney outer structure of a turtle's skeleton serves as its armor against a variety of threats. It is a shield for the ventral and dorsal parts of the turtle. The shell is composed of modified boney ribs and vertebrae overlaid by keratinous scutes. The rib bone is formed of dense cortical bone sandwiching an inner trabecular layer. Cortical bone has high resistance to bending and torsion, allowing it to withstand external tension. Trabecular bone is considerably more spongy and porous, allowing it to be more flexible and absorb energy. In non-marine turtles, the sandwiched architecture of the carapace is known to impact how the bone responds to loads. We are investigating the structure-function relationship of sea turtle shells by mechanically testing shell samples to understand how they respond to load. We are also using micro-computed tomography to quantify bone variables (e.g., porosity and trabecular separation) and relate the small-scale structure to the mechanical behavior. Our initial data indicate that trabecular and cortical bone structure varies between species of sea turtle. Flexible, energy absorbing shells are more porous than stiffer, stronger shells. A better understanding of how turtle shells have been successful for millions of years can provide novel insights for bio-inspired designs that require resiliency.