Mechanical behavior and structure of a Toco toucan beak

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Research objectives

- Examine the structure of the beak
- Identify the mechanical properties of a Toco toucan beak.
- Attempt to model mechanical properties as function of structure

Exterior of beak (SEM)

Figure (a) shows the exterior shell consisting of multiple layers of keratin scales. The thickness of each keratin scale is about 2–10 μm and the diameter is approximately 30–60 μm (Fig. (b)). The keratin scales are hexagonal and overlap each other. Although this was not investigated, they seem to be joined by a glue. The total shell thickness varies between approximately 0.5 and 0.75 mm

Interior of the beak (SEM)

Figure (a) shows the inside of the beak. It is clearly a foam structure. Most of the cells in the toucan foam are sealed off by membranes with thickness of 2–25 μm. Thus, it can be considered a closed-cell system. The cell sizes vary and the closed-cell network is comprised of struts with the thickness of 70–200 μm with edge connectivity of three or four (Fig. (b) and (c)).

Experimental techniques

- SEM for Structural Analysis
- Mechanical Properties
  - Tensile testing
  - Compression testing

Strain rate dependant of fracture mode (keratin)

The yield stress and UTS are plotted as a function of the strain rate. The yield stress is sensitive to the strain rate and associated with the viscoplasticity of the interscale glue. When the yield stress approaches (or exceeds) the UTS, fracture of the scales is preffered. The viscoplastic deformation of the glue

Finite Element Analysis

FEM simulation of beak shell under compression testing

Fracture patterns of foam

Viscous deformation of toucan foam

Finite Element Analysis

FEM simulation of beak foam under compression testing