

Structure and Mechanical Properties of Pangolin Scales as Flexible Dermal Armor

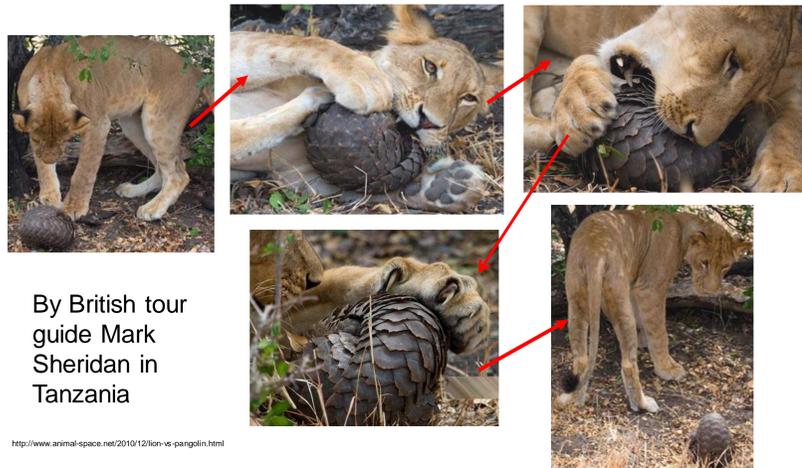
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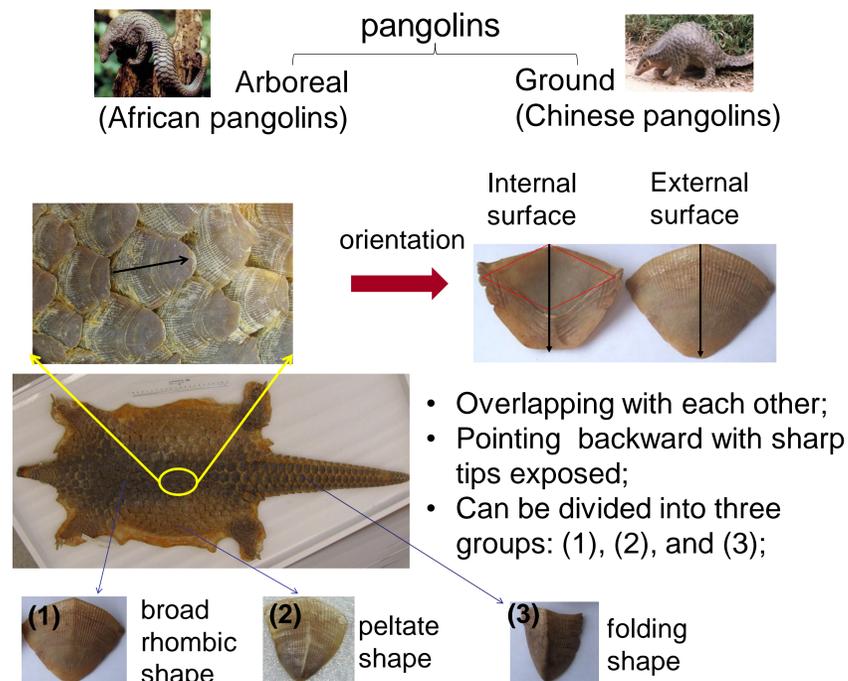
Background

Keratin is an important structural protein in the protective covering of animals, and it is among the toughest biological materials in nature. Pangolin scales are typical keratinized materials, and they have distinguished and effective defense to resist external attack and pray. The knowledge of structure-property relationship of pangolin scales to figure out how they defense against external force will help scientists develop new functional dermal armor materials.

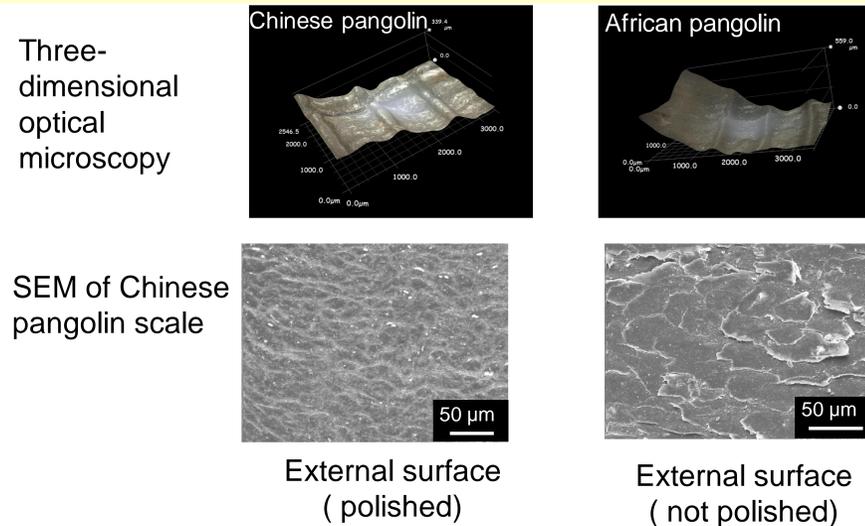
Function of pangolin scales as armor in real life:



Scales organization

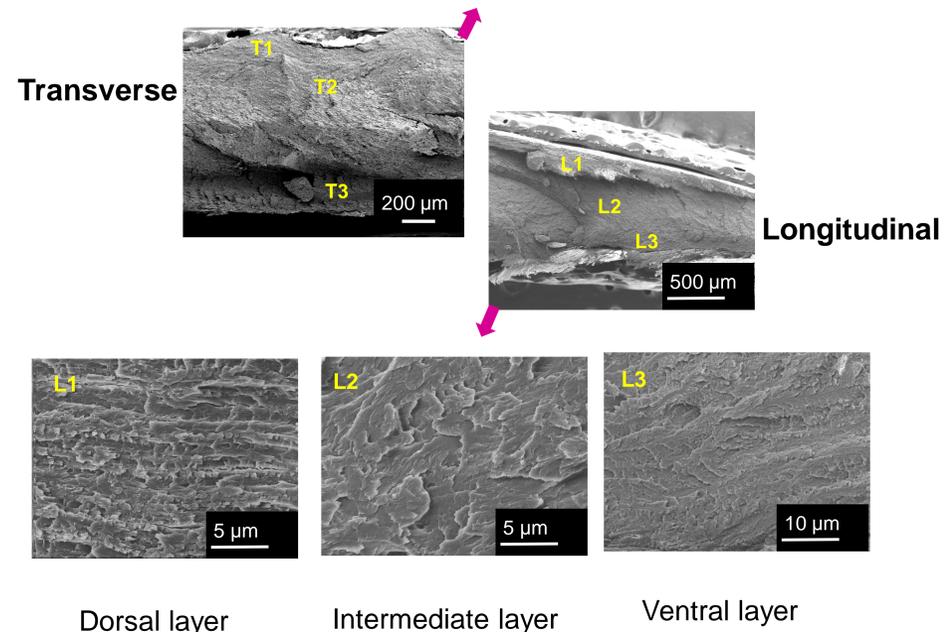
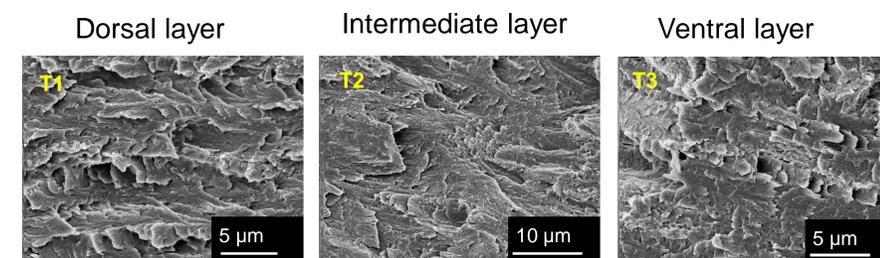


Scale morphology & structure



Cross-section of the scales: three-layered structure

Preparation: scales were fractured, fixed in 2.5% glutaraldehyde for 3h, and then immersed in 30%, 50%, 75%, 80%, 95%, 100% and 100% alcohol solutions, each for 15min.



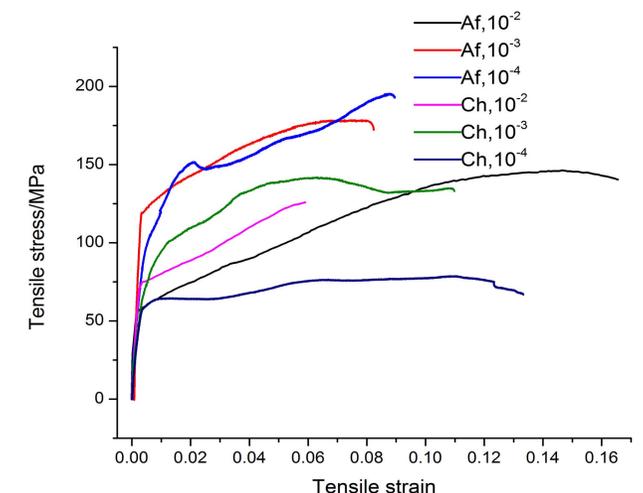
Tensile tests

Experiments: tensile samples were laser cut and polished, then tested under different strain rates, at $10^{-2} s^{-1}$, $10^{-3} s^{-1}$, $10^{-4} s^{-1}$;
Dimensions of samples: thickness: $\sim 0.5mm$, width: $\sim 1.65mm$, gauge length: $\sim 7.5mm$



African pangolin scale sample

Chinese pangolin scale sample



Conclusions & future work

- Protection mechanism of pangolin scales:
Macro: Overlapping \rightarrow "sharp-edge" ball;
Micro: a) Scales on surface;
b) Lamellae in different orientations;
- Property comparison:
African pangolin scale is higher than Chinese ones;
- Future work:
Compression, bending, nanoscratch and nanoindentation.