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Maturation experiments reveal bias in the fossil record of feathers

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The evolutionary history of birds and feathers is a major focus in palaeobiology and evolutionary biology. Diverse exceptionally preserved birds and feathered dinosaurs from Jurassic and Cretaceous biotas in China have provided pivotal evidence of early feathers and feather-like integumentary features, but the true nature of many of these fossil soft tissues is still debated. Interpretations of feathers at intermediate developmental stages (i.e. Stages II, III and IV) and of simple quill-like (Stage I) feathers are particularly controversial. This reflects key uncertainties relating to the preservation potential of feathers at different evolutionary-developmental stages, and to the relative preservation potential of diagnostic features of Stage I feathers and hair. To resolve these issues, we used high pressure-high temperature autoclave experiments to simulate the effects of burial on modern feathers from the Black Coucal (Centropus grilii) and Common Starling (Sturnus vulgaris), and on human hair. Our results reveal profound differences in the recalcitrance of feathers of different types during maturation: Stage I and Stage V feathers retain diagnostic morphological and ultrastructural details following maturation, whereas other feather types do not. Further, the morphology and arrangement of certain ultrastructural features diagnostic of Stages III and IV, e.g. barbules, are preferentially lost during maturation. These results indicate a pervasive bias in the fossil record of feathers, whereby preservation of feathers at Stages I and V is favored. Critical stages in the evolution of feathers, i.e. Stages II, III and IV, are less likely to be preserved and more likely to be misinterpreted as feathers at earlier developmental stages. Our discovery has major implications for our understanding of the fidelity of the fossil record of feathers and provides a framework for testing the significance of putative examples of fossil feathers at different developmental stages.