

Symposium 06 Macroscopic and microscopic evolutionary perspectives on feathers

Introduction

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Feathers receive little attention from most ornithologists, yet a few of us have studied them for a long time. In my experience, the first feather symposium at an International Ornithological Congress was that organized by Alan Brush at the 1974 meeting in Canberra. Since then, reports on feathers have been presented at three Congresses in symposia, lectures, and posters. The subject of most interest at these meetings has been plumage color, i.e., the mechanisms by which it is produced and the functions that it serves. Other continuing themes have been the synthesis and structure of feather keratin, the structure and functions of feathers, and the evolution of feather proteins, feathers, and flight.

There have also been reports on feather development and on bacterial degradation of feathers. Several of those subjects are included again in this symposium. Yet here new ideas and findings about the origin, evolution, and ecology of feathers are presented as well. Such subjects are far beyond what we could have imagined in 1974.

Despite these advances, we still have much to learn about feathers. Here are just a few unanswered questions for future study:

- How did the feather follicle and feather muscles originate in ancestral reptiles?
- Do the different structural types of feathers differ in their keratin? If so, what do these differences suggest as to the ancestral structure of feather keratin and the feathers that it formed?
- The molecular structure and properties of keratin vary in different parts of a feather. Are these variations related to the functioning of the feather and how?
- How do barbules work? In particular, what keeps downy barbules from getting entangled? Our understanding of barbule mechanics is still based on Sick's excellent study, but that was 65 years ago. To my knowledge, little has been done to advance our understanding of barbule mechanics using scanning electron microscopy.
- How did filoplumes evolve? What is their phylogenetic relationship to other kinds of feathers?
- How is the morphology of feather muscles related to the operation of feathers for flight, temperature regulation, display, and other functions?
- What holds a feather in its follicle? Constriction of feather muscles around the follicle may not be the whole answer. Tissue sections sometimes show what appear to be connections between the follicular lining and the outside of the calamus.
- The arrangement of feather tracts on the body differs widely among groups of birds and has been used as a taxonomic character. Do these differences in pterylosis have any functional significance, such as facilitation of heat radiation from the skin or movement of body parts or feathers?
- What is the function of uropygial gland secretion? Experiments are needed to determine whether it keeps keratin supple, contributes directly to waterproofing, and/or has antibacterial properties?
- The chemical composition of uropygial gland secretion differs among groups of birds. Is there any functional significance to these differences?
- The feathers of many birds, especially herons and pigeons, produce a fine powder. Its role has been debated, but never tested. Does it waterproof feathers, clean them, or have a visual effect?
- In a few birds, certain feathers appear to secrete a greasy or waxy substance. What is the purpose of this secretion? More fundamentally, how is keratin synthesis in these feathers transformed to produce this greasy material?
- How is the structure of each and every feather on a bird genetically encoded, bearing in mind that feathers vary over the body and that their constitution ranges in scale from overall macro-shape and -size to the ultramicroscopic and molecular?
- As if that were not complex enough, many follicles produce feathers of different form and color in suc-

cessive molts, and may take up to seven years to produce the definitive adult feather. How are these changes and the timing encoded?

- Lastly, how are genetic instructions carried out in the follicle as a feather grows? Since this question addresses a fundamental problem in cellular differentiation, it should be of interest to all develop-

mental biologists. Here the study of feathers finds application beyond ornithology.

These are just some of the questions about feathers that I believe should be investigated. Already some of the answers are forthcoming in this symposium; as for the rest, we can look forward to them at future meetings and in future publications.