# THE STRUCTURE AND PIGMENTATION OF THE FEATHER TIPS OF THE SCALED CUCKOO (*LEPIDOGRAMMUS CUMINGI*)

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NUMEROUS publications have dealt with the study of the structure and function of feathers, their modifications in various groups, and their use as a taxonomic tool (Chandler, 1916). Feather pigments and structural color have received much attention because of their attractiveness and the challenging developmental, biochemical, physical, and functional problems involved (for reviews see Frank, 1939; Fox, 1953; Völker, 1960).

Terminal structures on the tips of feathers have rarely been studied. Such structures are conspicuous on the secondary remiges of members of the genus *Bombycilla*, the waxwings. The morphological relations of the pigment and the feather, as well as the nature of the pigment itself, have recently been described by Brush and Allen (1963) for the Cedar Waxwing (*B. cedrorum*). The morphology of the feather tip of the closely related Bohemian Waxwing (*B. garrulus*) has also been investigated (Stieda, 1872), and Chandler (1916) concluded that among birds this structure is unique in *Bombycilla*. However, superficially similar structure may be found in other birds, such as the Paradisaeidae, the birds of paradise. Danforth (1958) reported a feather structure in the male Gray Jungle Fowl (*Gallus sonneratii*) which resembles that of the waxwing.

This study considers the Scaled Cuckoo, *Lepidogrammus cumingi*, a species confined to the islands of Luzon and Marinduque in the Philippines. Its plumage is not unusual except for the presence of numerous white feathers tipped with black "spangles" which occur on the pterylae of the head and neck. These feathers are the subject of this study.

## METHODS AND RESULTS

*Structure.*—Entire feather tips from various sections of the head and neck were prepared as dry mounts and examined microscopically. The tips were also embedded in gelatin, sectioned on a freezing microtome, and mounted in Farrant's solution. Tips were observed both after partial chemical disruption but with internal structure and pigment intact, and as whole tips with the pigment chemically bleached.

In feathers with incompletely developed tips, pigment is limited to the rachis and, toward the tips, to several large barbs (Figure 1, A and B). In fully developed tips (Figure 1, C) pigment granules (to the resolution of the light microscope) are, without exception, confined to the tip. Partial bleaching of the pigment revealed that the internal structure of the tip consists of closely packed fibrous tissue, oriented parallel to the long axis.

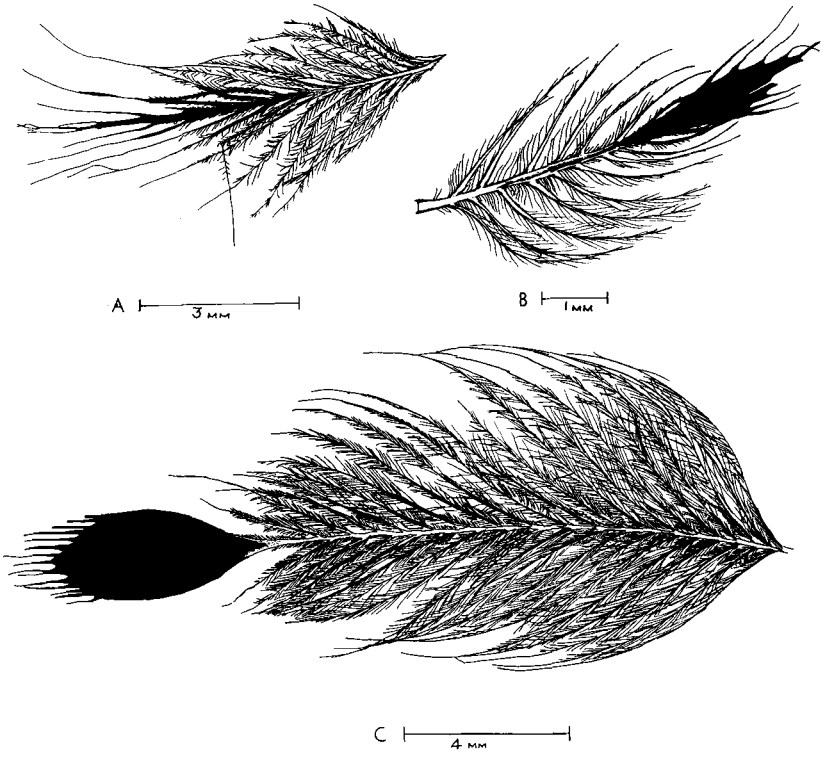


Figure 1. Selected feathers from *Lepidogrammus cumingi*, which show various degrees of tip structure and pigment distribution. A and B, feathers with incompletely developed tips; C, feather with fully developed tip.

The pigment is contained within these fibers, which resemble barbs both visually and dimensionally. The fibers are so closely packed as to exclude the existence of any significant amount of matrix.

In cross section (Figure 2, A) the tips appear to have the pigment heavily concentrated in the center with regular extensions toward both surfaces.

High magnification (Figure 2, B) indicates that there are structural supports which determine the pigment distribution. This support is provided by the fibrous structure visible in gross, bleached mounts and exposed through partial destruction of the structure. No separate external cuticle is apparent. The superficial nonpigmented layers are composed of the outer keratin walls of the individual, closely packed fibers. The structure and pigment distribution described here explain the uniform surface characteristics of the tip (i.e., there is no differentiation into "bright" and "dull"

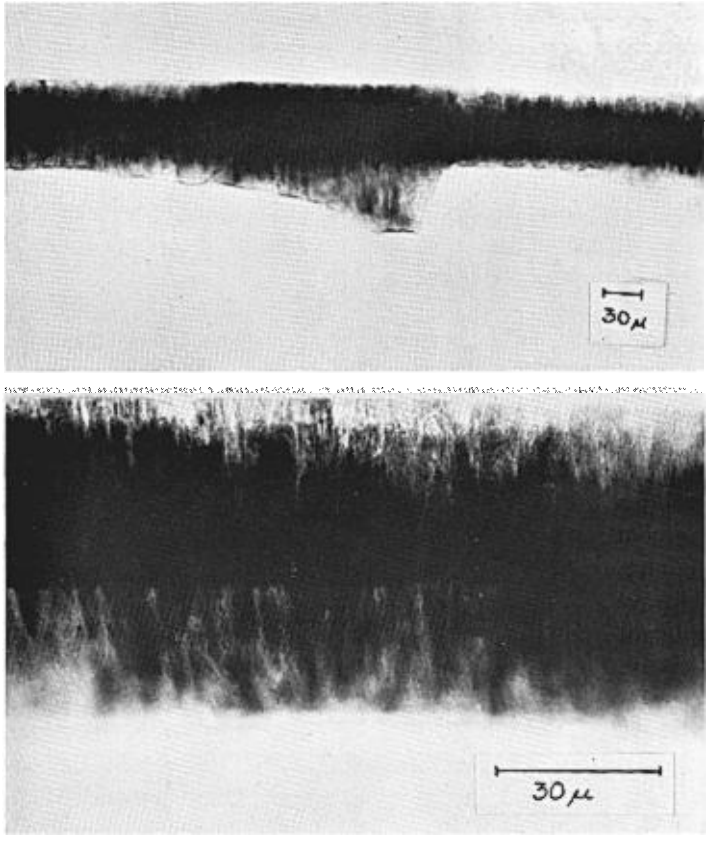


Figure 2. Cross section of the pigmented feather tips of the Scaled Cuckoo. Note concentration of pigment in central areas with regular extensions towards both surfaces.

surfaces). This is a result of the approximately equally thick layers of transparent keratin on both surfaces and of the heavy central and reduced peripheral concentration of pigment.

*Chemistry.*—The pigmented tips of *Lepidogrammus cumingi* were not affected by cold ether, N, N-dimethylformamide, or pyridine. This is due to the impervious nature of the keratin structure. The pigment was extracted in hot (90°C) alkaline methanol. The degree of destruction of fibrous structure can be controlled by this treatment, especially if it is followed under low magnification. Hence, it was possible to expose the internal structure.

Complete destruction of structure separated pigment and structural support. The pigment, which occurs as small insoluble, black particles was

recovered as a colloidal dispersion. These physical properties suggested that the pigment was melanin. The pigment was easily bleached by treatment with either 10 per cent hydrogen peroxide or 40 per cent peracetic acid. Both oxidation reactions occurred spontaneously. At least 48 hours were required to bleach untreated feather tips. Solutions of ammoniacal silver nitrate were reduced to metallic silver by the pigment dispersion. This is considered a more specific test for melanins (Pearse, 1960). On the basis of the oxidation and reduction reactions of this pigment, I conclude that the pigment present is melanin.

## DISCUSSION

The combination of melanins and highly modified feather tip structure as exhibited by the Scaled Cuckoo is unusual and of interest.

Fraser (1839: 112) described the feathers on the type specimen as: "expanded at their extremities into laminae, which may be compared to the shavings of whalebone. . . . The external edge of this expanded portion is minutely pectinated."

Shelly (1891: 405), who apparently worked with the same specimen, reported: "All the feathers of the forehead and a broad central band through the crown to the nape ornamented with glossy black horny appendages, and having the subterminal portion of each feather white; a broad band of similarly horny-tipped feathers extending down the centre of the throat." Except for Mayaud's statement (1950: 37) that these tips are similar to those in the waxwings, and a brief mention by Delacour and Mayr (1946: 110), I know of no other extensive descriptions of these feather tips.

Both in their chemistry and microscopic anatomy, the feather tips of the Scaled Cuckoo are strikingly different from those of *Bombycilla cedrorum*. A preliminary investigation of the "spangles" reported by Danforth (1958) in *Gallus sonneratii* indicated that the structure of the tips in this jungle fowl is more similar to that of *Lepidogrammus* than to the waxwing. The pigment in the feather structure of the junglefowl is red-orange, but chemically appears to be a melanin. Another bird that merits investigation is the Curl-crested Aracari, *Pteroglossus beauharnaesii*.

*Developmental sequence.*—Because neither live specimens nor any information on the molt of the Scaled Cuckoo are available, it is impossible to describe the development of an individual tipped feather. However, feathers with various degrees of tip formation may be found on one individual. These stages are shown in Figure 1. In the frontal, loral, and malar regions the small and incomplete tips are most common. The larger, more fully developed feathers occur on the coronal, occipital, and submalar tracts. A few isolated tipped feathers were also found on the ventral cervi-

cal region. The existence of a variety of tips on feathers of an individual may indicate that, in the peripheral areas, where incomplete tips occur, these feathers have been arrested at various stages in their development and therefore represent stages similar to those preceding complete development. The reasons for this presumably arrested growth are not known. It is significant, however, that these small, poorly developed feathers are inevitably found at the periphery of the feather tracts. Evidence from these peripheral feathers may be used to reconstruct the growth of the tipped feathers.

The following mechanism may be proposed: the production of melanin by melanophores occurs normally in the developing shaft, barbs, and pulp of the feather. During early development, barbs from each vane-half fold toward the mid-line of the rachis (for details, see Rawles, 1960: 203). Since the barbs are formed from the collar simultaneously with shaft formation, fusion of rachis and terminal barbs is mechanically and topographically possible. This fusion produces the tip. In certain peripheral sites in the feather tracts fusion is incomplete, which results in tips similar to those shown in Figure 1, A and B.

This mechanism of tip formation is considerably different from that proposed for the waxwings. In these birds, the tip is considered to be the expanded terminal portion of the rachis.

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## SUMMARY

The pigment in the tips of the feathers on the head and neck of the Scaled Cuckoo, *Lepidogrammus cumingi*, was determined to be melanin. It is deposited in a structure considered to represent the fusion of numerous pigment-containing barbs. The structure and pigment of these tips is quite different from that on the secondary feathers of the Cedar Waxwing (*Bombycilla cedrorum*), where the carotenoid pigment is contained in the expanded terminal portion of the rachis.

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