A NEW METHOD TO SEPARATE IMMATURE AND ADULT HUMMINGBIRDS

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IMMATURE and adult hummingbirds have usually been separated on the basis of plumage criteria. These are readily applied to some South American species such as *Patagona gigas, Oreotrochilus estella, Colibri coruscans* and *Acestrura mulsant*, in which a clear age specific distinction in color is present. In species occurring north of Mexico plumage criteria are much more difficult to use because immatures closely resemble adult females.

Because hummingbirds do not develop the double-layered skull shown by adult passerines, use of skull pneumatization to estimate age proves only partly satisfactory; adults are reported to have thicker skulls than immatures (Stiles, 1972), but variation within each age group is so wide that the criterion cannot be used in many specimens (Scheible, pers. comm.). Moreover, most museum skins are prepared with no regard for skull condition. Another character that has received some attention is culmen length, shorter in immatures than in adults (Zimmer, 1952), but large series are required for accurate comparison and measurement; these conditions can hardly be fulfilled in field studies or in all but a few museum collections.

In an effort to find a reliable and practical age distinction I studied a series of 11 skins of the Giant Hummingbird, *Patagona gigas peruviana*, recently collected in Ecuador. While measuring the bills of two immature specimens, I noticed that the lateral surfaces of the culmen were ridged by minute oblique corrugations. These extended from the top of the culmen distally, reaching its edge at an angle of about 30°. The lateral surfaces of the culmen of the nine birds with adult coloration had no such corrugations, being smooth and glossy (Figure 1).

As the large size of *Patagona* is exceptional among hummers, I was not surprised that I had failed to detect this difference in series of other species. However the bills of smaller hummingbirds showed similar patterns under a 10× dissecting scope. I concluded that separation of broad age groups is feasible on this basis and probably can be applied to all species of trochilids. Support for this claim is given in Table 1, where 104 specimens of 14 North and South American species, including 50 skins labeled as immatures or juveniles and 54 as adult males, are compared. Adults were limited to males to minimize inconsistencies from misidentification of immatures as adult females. As the sex of immatures is often difficult to determine from gonad condition, no effort was made

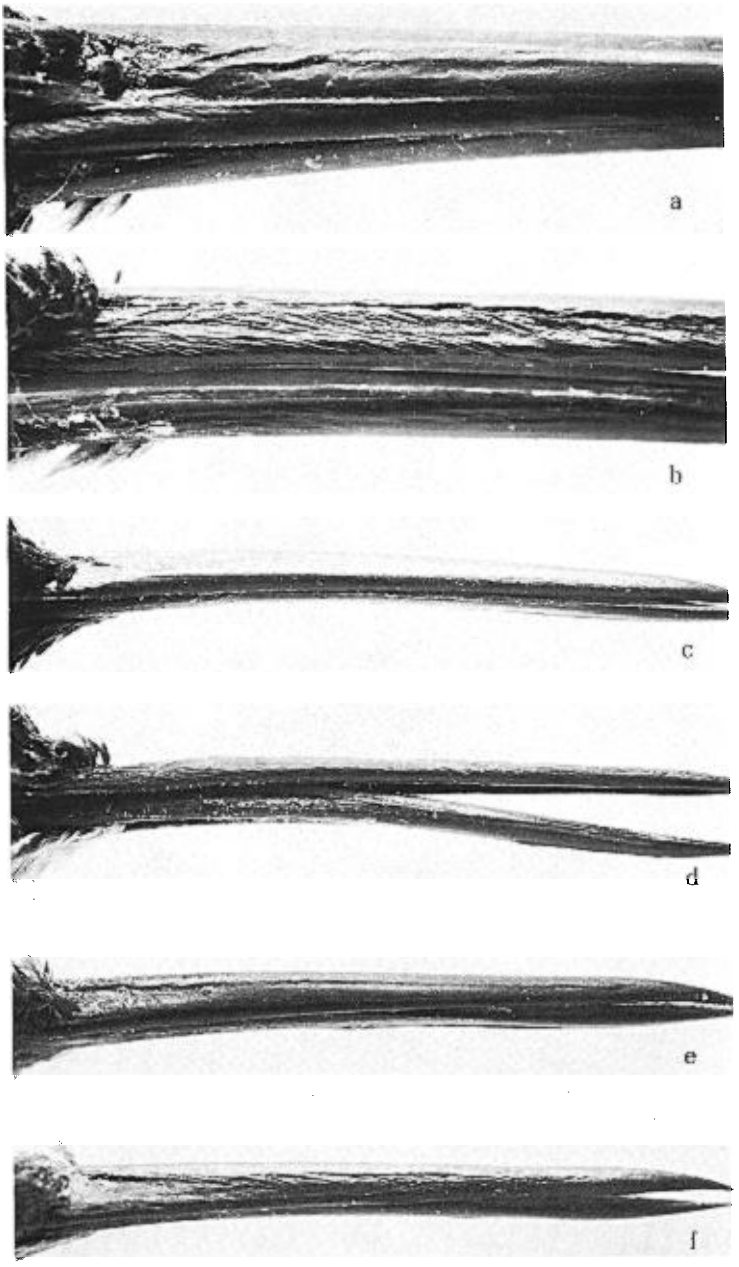

Figure 1. Bills of adult male (a, c, e) and immature (b, d, f) hummingbirds showing age specific differences in culmen texture; (a, b) *Patagona gigas peruviana*; (c, d) *Calypte costae*; (e, f) *Selasphorus rufus*. (Photos of museum specimens by A. A. Blaker).

TABLE 1
COMPARISON OF LATERAL CULMEN TEXTURE BETWEEN ADULT MALES AND IMMATURES OF 14 SPECIES OF HUMMINGBIRDS

Species	Adult males			Immatures	
	N	Smooth	Corrugated	Smooth	Corrugated
Colibri coruscans coruscans	2	1	0	0	1
Hylocharis xantusii	8	4	0	0	4
Oreotrochilus estella estella	4	2	0	0	2
Oreotrochilus estella jamesoni	6	3	0	1	2
Patagona gigas peruviana	8	6	0	0	2
Lesbia victoriae aequatorialis	2	1	0	0	1
Archilochus colubris	8	4	0	1	3
Archilochus alexandri	10	5	0	1	4
Calypte anna	10	5	0	0	5
Calypte costae	10	5	0	0	5
Stellula calliope	10	5	0	0	5
Myrtis fanny	6	3	0	0	3
Acestrura mulsant	2	1	0	0	1
Selasphorus rufus	8	4	0	0	4
Selasphorus sasin sasin	10	5	0	0	5
Totals	104	54	0	3	47

to include equal numbers of birds of both sexes in the immature group. Specimens with damaged bills were rejected, and the sample size for each species was determined by availability. Most specimens were selected from series at the Museum of Vertebrate Zoology (MVZ), but a few recently collected in South America were also included.

The results (Table 1) indicate that only 3 of the 50 birds identified as immatures had smooth bills, and that all 54 adult males lacked corrugations. In Figure 1 the bills of six museum specimens, an immature and an adult male of each of three species, illustrate this difference. Preliminary efforts to find intermediates in age suggested that at least one of the three exceptional "immatures," a Ruby-throated Hummingbird, *Archilochus colubris* (MVZ No. 145585), could be a misidentified adult female, but that the other two could have attained the smooth bill condition without having completed postjuvenile molt. Even if these are valid exceptions, bill texture appears to be a reliable character for aging hummingbirds; specimens having corrugated bills are probably less than a year old, while birds with smooth bills are probably older. Birds with highly ridged bills are almost certainly juvenile.

This conclusion is strengthened by data gathered on Rufous Hummingbirds, *Selasphorus rufus*, in the MVZ, comprising the largest series

TABLE 2
COMPARISON OF LATERAL CULMEN TEXTURE BETWEEN SELECTED GROUPS OF *SELASPHORUS RUFUS* HUMMINGBIRDS

Group	N	Corrugations[1]		
		Absent	Medium	Extreme
Adult females	8	6	1	1
Immature males	32	4	9	19
Immature females	12	0	4	8
Unsexed immatures	2	0	0	2
Females	48	22	11	15
Undetermined	16	3	1	12

[1] For criteria see text.

in its trochilid collection. It includes over 200 skins, which, in addition to providing ample representation, have the advantage of being identifiable as to their probable age and sex by entries on original labels and also by means of a complex key based on plumage recently developed by Stiles (1972). Thus the presence of individuals of misidentified or undetermined age can be minimized by checks independent of bill texture.

I first examined the bills of 50 specimens showing plumage characters of and labeled "adult males." None of these was found to have a corrugated culmen. Then I turned to the skins recorded as adult females, immatures of each sex, females with no record of age, immatures with no record of sex, and specimens of doubtful or unknown age and sex. In order to examine them I defined three categories for culmen corrugation: extreme, medium, and absent. I placed in the first category birds with creases along nearly the entire length of the culmen, in the second those in which a corrugated area was present but did not reach the distal fourth of the culmen, and in the third those having a smooth culmen. Birds in the first category usually had rather narrow, deep creases extending to the culmen's edge; specimens in the second had wider, shallower, more rounded corrugations resembling folds and confined to a longitudinal band at the nares level above smooth edges.

The results of the comparison, given in Table 2, are broadly consistent with expected age specific distinctions. In the group of 8 "adult females" are 6 with smooth bills. Among 46 "immatures," comprising sexed and unsexed specimens, all but 4 exhibit medium or extreme culmen corrugation. Of the remaining 64 specimens, 22 of 48 "females" and 3 of 16 birds lacking labeled age and sex prove to have smooth bills.

Ignoring notations on labels or lack thereof, the *rufus* series contains 28 adult females that conform to criteria defined by Stiles. These provide ample support for bill texture as an indicator of age, because all exhibit

the smooth bill that characterizes adults. Significantly, these include all 6 of the "adult females" that have normal bills, 19 of the 22 "females" that show the adult bill condition, 1 of the 4 "immature males" that are exceptional, and 2 of the 3 birds of unspecified age and sex that show no corrugations in my sample.

Among the "immatures" examined for bill texture only four were found to have a smooth bill. As was stated, one of these can be independently dismissed as a misidentified adult female (MVZ No. 102006). In addition a second "immature male" can be questioned from plumage considerations (MVZ No. 42174), but the remaining two specimens (MVZ Nos. 32984 and 32993) cannot be dismissed similarly. Although their throats lack an extensive iridescent patch, their tails resemble closely those of adult males and have no white-tipped rectrices as in females and typical immatures. They were taken in Pasadena on 21 March 1896 and 17 April 1897, respectively, which suggests that they fledged not in the year of collection but in the preceding one. Clearly their smooth bills, along with their tail characters and collecting data, identify them as older individuals, most likely spring migrants between 9 and 12 months old, collected in California as they moved northward to the breeding grounds. This in turn suggests that smoothing might take 9 months, at least in *rufus*.

Existing specimens have not allowed further separation of younger and older immatures (and thus a correlation between probable age and degree of bill corrugation) because of the time gaps in museum series. In *S. rufus* refined aging is hampered by the scarcity in collections of the older immatures that migrate outside the United States during the critical postjuvenile molt period.

In an attempt to overcome this difficulty I studied the MVZ series of Anna Hummingbirds, *Calypte anna*, a distinctive species largely confined to the United States throughout the year, which is reported to breed from late December to mid-August (Bent, 1940: 387). I found that extremes in bill corrugation can be associated with age variation; most immatures with highly corrugated bills were collected early (late March to late September), whereas most immatures with smooth or nearly smooth bills were collected later (October to mid-March). Birds with intermediate bills were also detected, and these could not be separated for more refined aging.

Part of the problem seems to be in the nature of the corrugations. The nestling bill is of course shorter than that of its parent. That the developmental process and its associated structural changes do not cease

at fledging is demonstrated by the fact that bill measurements have been used to separate age classes in postfledging Peruvian hummingbirds (Zimmer, 1952 and related papers). It is thus reasonable to expect that the corrugated culmen of immatures might result from a structural condition associated with bill growth.

Corrugations are evident not only in museum specimens but also in living hummingbirds. These include immatures of the genera *Selasphorus* (*fide* Stewart), *Phaethornis*, *Glaucis*, *Thalurania*, *Threnetes*, and *Amazilia* (*fide* Stiles). Even though I have not been able to follow individuals through time, I have examined living and freshly-killed immature *Calypte anna* and found corrugations present. Comparison of fresh and preserved material shows that postmortem desiccation may emphasize the effect of age, because the depth and extent of the corrugations increase soon after a specimen is left to dry. It is interesting to note that creases are not apparent in the yellow bills of very young nestlings, but are always conspicuous in the dark bills of older nestlings.

The bill is a composite of a core of bone and a keratinized sheath; the latter is deposited by cornification of epidermal cells that form an intermediate layer, also including dermal tissue, nerves, blood vessels, and collagenous fibrils (Witschi, 1956: 323–324). This process is rather direct, without the complications seen in the production of hair or feathers (Matoltsy, 1962: 4–5). Nevertheless it is poorly understood; classical embryology textbooks devote a few lines to its description (Lillie, 1908: 304), while most modern accounts neglect it altogether. Therefore, it is difficult to hypothesize what may be producing bill corrugation, and dissection fails to suggest a full explanation.

Removal of the bill's sheath in freshly killed birds and study of skeletal material reveals that immatures have soft bills, filled with abundant remains of preossified and prekeratinized cells, with short, thick, and spongy ossified regions, and a thin corneous covering. The bills of adults are harder and seem to lack a rich epidermal and dermal filling; their bones are longer, more slender, and more compact, and the sheath much thicker than in immatures.

Apparently as the bones lengthen and become more slender, crests project above the less ossified regions. The horny layer, thin in immatures, closely follows crests and depressions, apparently also acquiring folds as a result of normal mechanical deformation while foraging and preening. As the birds age bill elongation slows down, the bony core gradually loses its irregularities, keratin is added to the sheath filling depressions and rounding out crests, and the smooth surface typical of the adult culmen is eventually attained. At the same time the bill

hardens so that mechanical deformation caused by mandibular movement no longer produces folds in the sheath.

While the foregoing clearly points out information still lacking on the embryology of hummingbird bills, the new age criterion has an enormous advantage in that it can easily and quickly be applied to any hummer, living or dead, so long as its bill is not damaged. Investigations being conducted by Stiles in Costa Rica already suggest that schedules of smoothing may be feasible and give age estimates that compare favorably with those based on molt (pers. comm.). The criterion is far more convenient than skull thickness because dissection is not required. This means that a living specimen does not have to be killed or injured, and that curatorial objections do not have to be faced when working with prepared skins. Another major advantage is its applicability to many, probably all species of hummingbirds. Bill texture differences have been used successfully in 16 genera representing species from North, Central, and South America as discussed above. Thus complexities connected with plumage criteria may be eased or avoided by the use of a good hand lens or dissecting scope.

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LITERATURE CITED

BENT, A. C. 1940. Life histories of North American cuckoos, goatsuckers and their allies. U. S. Natl. Mus., Bull. 176.

LILLIE, F. R. 1908. The development of the chick. New York, Holt and Co.

MATOLTSY, A. G. 1962. Mechanism of keratinization. Pp. 1–25 *in* Fundamentals of keratinization (E. A. Butcher and R. F. Sognnaes, Ed.). Amer. Assoc. Advan. Sci., Publ. 70.

STILES, F. G. 1972. Age and sex determination in Rufous and Allen's Hummingbirds. Condor, 74, in press.

WITSCHI, E. 1956. Development of vertebrates. Philadelphia, W. B. Saunders and Co.

ZIMMER, J. T. 1952. Studies of Peruvian birds. Amer. Mus. Novitates, No. 1595.

Museum of Vertebrate Zoology, University of California, Berkeley, California 94720. *Accepted 27 October 1971.*