GROWTH BARS IN FEATHERS

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THE growth bars in feathers are those elusive, alternate light and dark, normal angular markings across the web of many feathers and have the appearance of watered silk without any sheen. They have been referred to as the "ribbing" by Mascha (1905), the "fundamental bars" by Whitman (1907: 13) and by Riddle (1907: 165), also "fault bars" by Riddle, as "subordinate bars" by Glegg (1945: 301), "watered barring" by Forbush (1929: 322), and called just "feather bars" by Michener and Michener (1938: 149). Since they are caused by the normal development and indicate the rate of growth of feathers, the more descriptive title of "growth bars" is recommended. Their special characteristics for a species are general uniformity, visibility, width, and angulation. Chandler (1916) did not mention these growth bars in his extensive investigation but stated (p. 281), "There are no considerable variations in the feather structure of different species of the same genus." Since these characteristics are so individualistic, definite, and descriptive, the growth bars deserve more consideration than has been accorded them by ornithologists.

These bars are most commonly seen in the wing and tail feathers, rarely in other tracts. While in most feathers they are not visible or only faintly, in some species they are very distinct in most feathers. In the feathers examined, they were as distinct in the juvenal as in the adult plumage. They are seen only by reflected light and best by tilting the feather. They are not discernible optically by transmitted light, although shadow-graphs may reveal them, nor are their outlines made more distinct by magnification or by exposure to X-rays, infra-red, ultra-violet light, phosphorescent, or polarized light. Photographs and shadow-graphs are not as clear as visual impressions.

The visibility of growth bars varies greatly among birds, from nothing to very marked. Its degree is constant for a genus. The visible bars do not occur in all species nor in all the feather tracts of any bird. Among the more than 80 species of eastern birds examined in this investigation, the growth bars were most easily seen in the: Purple Grackle, *Quiscalus q. quiscula;* Catbird, *Dumetella carolinensis;* Eastern Cardinal, *Richmondena c. cardinalis;* Eastern Robin, *Turdus m. migratorius;* and Brown Thrasher, *Toxostoma rufum.* Many other birds showed them less distinctly, but in some species the bars were so difficult to see that it became uncertain or impossible to measure their widths or angulation. They are seen in hummingbirds and in

eagles, and in many genera between. The Eastern Mourning Dove, *Zenaidura m. carolinensis*, was the only species examined which exhibited the growth bars in parctically all feather tracts and all having the same angulation. Growth bars were usually invisible in the body feathers of all the other birds.

The growth bars are found on the smooth web of any solid color, but only rarely on the soft, ciliated dorsum of owl feathers or the mirror of duck feathers. A variable pigmentation, as in mottled feathers, makes them invisible. When visible, they may be seen only on one or on both sides of a feather, only on the anterior or the posterior or on both surfaces of the remiges and/or rectrices, or on all surfaces of the involved feathers.

The growth bars develop as the growing barbs emerge from the calamus sheath; the undeveloped barbules within the sheath show no macroscopic or microscopic indication of a bar.

The broad color bands forming the patterns in feathers usually bear no relation to the growth bars, but in some species there is a developmental connection. In the House Wren, *Troglodytes a. aedon*, along the edges of the secondaries is a row of brown dots, each being the terminal ending of a dark diurnal growth bar, suggesting that each dark mark in the wren's plumage was diurnal in development. A similar arrangement is distinctly seen in the second rectrices of the Mockingbird, *Mimus p. polyglottos*, where black dots bordering the inner vane are the terminals of dark growth bars.

The difference between the light and dark growth bars is but a question of pigment, as Strong (1902) declared. This is seen readily under the microscope which shows the greater amount of lipochromic granules in the epithelial cells in the darker bars. Even white feathers show this difference in the form of pale yellowish granules. Riddle (1908) wrote, "Under poor nutritive conditions during nighttime the formation of barbule-forming cells is first checked," producing pale colored bars, an indication of the influence of diet upon the formation of the growth bars.

The rate of growth of a feather probably depends more upon the abundance of food ingested than upon the character of the food; other factors may of course be involved. While the Golden Eagle, *Aquila c. canadensis*, has very narrow growth bars, those in the Marsh Hawk, *Circus cyaneus*, vary from 4.5 to 5.9 millimeters for the pair of bars, several times broader than the eagle's bar of about one millimeter. A young Barn Owl, *Tyto alba*, from a nest containing many pellets with two to five mouse skulls in each, showed bars 1.9 mm. in width in the secondaries (no other feathers showed any bars); Great

Horned Owls, *Bubo v. virginianus*, had 2.3 mm. bars; and Screech Owls, *Otus a. naevius*, 3.1 mm. bars. Among ducks, the twin bars measured as follows: Wood Ducks, *Aix sponsa*, 3.6 mm.; Pintails, *Anas a. tzitzihoa*, 3.0; Mallards, *Anas p. platyrhynchos*, 2.0; and the American Merganser, *Mergus m. americanus*, 3.4 mm. for a pair of bars. A tame Mute Swan, *Sthenelides olor*, in a city park had 4.5 mm. growth bars in the wings. In birds of other diets we find Juncos, *Junco hyemalis*, giving a constant measurement of 3.3 mm., and Song Sparrows, *Melospiza m. melodia*, with a variable diet show measurements from 2.1 to 3.5 mm. The "gluttonous" Starling, *Sturnus vulgaris*, showed an average of 3.7, and the constantly eating Domestic Pigeon measured up to 7.6 mm. The varying rates of growth of feathers are shown definitely by the relative widths of the growth bars, and they suggest the abundance of food at the time of the development of the feathers.

Glegg (1945) observed that the rate of growth is greater in those feathers which are longest. This was shown in a museum specimen of the Forked-tail Flycatcher of Panama, *Muscivora tyrannus*, in the Pennsylvania State College collection. The central rectrices which are 8.5 inches long showed daily growth over twice that of the short lateral rectrices. The rate of growth in many birds is also much faster in flight feathers than in other tracts which are not so essential; it is faster in the remiges than in their coverts. In the Mourning Dove the secondaries showed a daily growth of 3.3 mm., their coverts only 2.1; a Robin's secondaries grew 2.6 daily, their coverts 2.1; American Merganser secondaries 3.4, tertials 2.6; Junco primaries 4.0, and rectrices 3.4 mm.

The width of a pair of growth bars is an important generic characteristic, varying with the species. The widths ranged from one millimeter in the eagle to seven millimeters in a Raven, *Corvus c. principalis*. Whitman (1907: 14) wrote, "The number of bars corresponds nearly to the number of days of growth." It definitely does in the birds in this investigation, after the emergence of the barbs from the calamus. Michener and Michener proved this point by measuring a developing feather for a number of days. To prove that the dark bars are diurnal in development and the light bars nocturnal, I plucked tail feathers. Song Sparrow, band No. 42-169085, had a rectrix plucked at 2 p. m.; 29 days later, the bird returned with a succeeding feather showing a dark tip of half the normal width, showing daytime growth. Song Sparrow No. 42-169087 had a tail feather removed at 5 p. m. and five days later entered the trap with a partially grown feather with a full-width tip of light bar, of wholly nocturnal development.

It has been stated that the difference in color between the dark and light bars may be due to a more rapid development of the barbules during the day, hence more of them in a given space. Comparisons with a calibrated microscope were made, using the same vane for both counts in several species of birds. Numerous counts of 13 species of birds gave the same average of 21 barbules in a space of 250 microns of each of the dark and light growth bars, the greatest divergences being in the Goldfinch, *Spinus t. tristis*, counting 37 in the light and 31 in the dark bar, and the Purple Grackle with 25 in the light and 30 in the dark bar. The distal barbules with hooklets averaged about two more barbules than the proximal barbules which have no hooklets.

In most birds examined, the diurnal and nocturnal bars were about equal in width, but in the Black Duck, *Anas rubripes*, and the Yellow-billed Cuckoo, *Coccyzus a. americanus*, the dark bar was three times the width of the nocturnal. The Robin's light bar was about two-thirds the width of the dark bar produced during the Robin's prolonged feeding period. The Screech Owl has a light bar twice as broad as the dark. The width of the bars has no relation to the size of the bird but doubtless indicates the amount of food ingested and the length of the feeding period, as the broader the dark bar the more lipochromic nutrient granules it contains.

The angulation of growth bars is that angle subtended by the bar to the proximal rachis. The angulations in the 400 feathers measured with a protractor varied from 45 to 90 degrees. The angle is definite and constant for a species; it varies with the species. In most species it is constant for all feathers showing bars, but in a few feathers it varies slightly with the tract, and sometimes the basal end of a feather has slightly more acute angles than does the central area. All feathers from a single tract have the same angle. Glegg (1945: 303) said the bars are more or less at right angles to the shaft; other writers used the expressions "transverse" or "across the web." Michener and Michener in their illustrated report on the House Finch, *Carpodacus m. frontalis*, in California, wrote that the angles are "somewhat less than 90 degrees."

The angulation is difficult to determine correctly in narrow vanes and is obscure in many indistinctly barred feathers. It is most readily measured in the wing and tail feathers. In a few birds there may be found variations between tracts, as in the Mourning Dove with secondaries showing 85 degrees, axillars 77, and upper tail-coverts 75.

The constancy of the angulation according to species, of an individual tract, is shown by the fact that 12 Starling remiges each measured 77 degrees; 20 Robin rectrices measured 74 each; Purple Grackle

rectrices, 75; remiges from 26 Purple Grackles, 63 each; 20 Junco rectrices about 71; 20 White-throated Sparrow, *Zonotrichia albicollis*, rectrices, 72 each; 44 Great Horned Owl remiges, about 62 each; and 10 Cardinal rectrices, 77 degrees. It was also shown by 32 varieties of prize chickens; each measured 72 degrees.

The angles in degrees in 850 measurements of 84 species of birds were mostly from the 60's to the low 80's. There is an apparent grouping within certain limits. As a general thing, the finches are between 85 and 95 degrees, and the warblers in the lower 80's. These are followed by the ducks ranging from 68 to 75 degrees and the hawks from 65 to 74 degrees. A notable group of individual birds gave the following measurements, all of rectrices: Kingbird, *Tyrannus tyrannus*, Crested Flycatcher, *Myiarchus c. boreus*, Phoebe, *Sayornis phoebe*, and Wood Pewee, *Contopus virens*, each measured exactly 70 degrees; Robin, 74; Wood Thrush, *Hylocichla mustelina*, 76; and Hermit Thrush, *Hylocichla g. faxoni*, 75; Crow, *Corvus b. brachyrhynchos*, and the Raven each measured 68; Flicker, *Colaptes a. luteus*, was 72; and the Downy Woodpecker, *Dendrocopos p. medianus*, measured 71 degrees. Some species placed close together in the A. O. U. Check-List showed interesting comparisons in angulation: Nighthawk, *Chordeiles m. minor*, 74 degrees, and the Chimney Swift, *Chaetura pelagica*, about 82; the Chickadee, *Parus a. atricapillus*, has 90 while the Tufted Titmouse, *Parus bicolor*, has 75 degrees; the White-breasted Nuthatch, *Sitta c. carolinensis*, was distinctly 89 degrees; the Mockingbird averaged about 77, with the Catbird, 79, and the Brown Thrasher, 82 degrees.

Growth bars, by their widths, indicate the rate of growth of feathers and the regularity of feeding with its relative consumption. Their angulation is generic and tends towards familial characters. An examination of growth bars will aid in the identification of individual feathers. The various aspects of growth bars at least deserve more attention than has been accorded them by ornithologists.

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