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BARS IN FLIGHT FEATHERS

WITH FIVE SETS OF ILLUSTRATIONS

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INTRODUCTION.—Probably our first attention to the significance of the more or less evenly spaced bars across the flight feathers of many birds was called forth by the late J. Eugene Law who told us of his experimental attempts to determine the rate of replacement of plucked feathers in the tails of banded towhees. These feathers showed distinctly fairly uniform bars across them. Mr. Law then suggested that each bar might represent a day's growth of feather but, so far as we know, he reached no definite conclusion in regard to this.

When we began a study of the molt of the House Finch (*Carpodacus mexicanus frontalis*) about three years ago we soon found that some flight feathers show bars and others do not, so we undertook to find out some facts about them. Now we are of the opinion that a paper on the bars and other markings of flight feathers, not including the feather patterns of birds that have such patterns, should be presented in advance of the one we contemplate on the molt of the house finch.

House finches have been our greatest source of information on this subject, but we have observed barred feathers also in every species of bird that we have handled in appreciable numbers.

METHOD OF STUDY.—In our study of the bars we plucked from many birds, mostly juvenals, as we trapped and banded them, the left ninth primary and the first and second right rectrices, selected, not because of intrinsic value greater than other flight feathers, but merely to establish a uniform practice. In this way the plucked feathers of approximately 1500 juvenal birds, predominately house finches, were preserved for comparison with the replacement feathers, many of which were studied without plucking and about 50 of which were collected for more detailed examination. Furthermore, after the study of the bars in feathers was begun, all the birds that were handled during our banding operations, some 3500 new birds annually and uncounted multitudes of repeats, were examined with this in mind.

DESCRIPTION OF BARS.—These bars consist of alternate apparently dark and light streaks lying approximately parallel across the webs of the feathers, the proximal angles between the bars and the rachis being somewhat less than 90 degrees on each web. For convenience we will speak of the apparently dark streaks as the bars. In the webs the bars resemble watermarks in paper. They are not equally visible in the corresponding feathers of all birds even of the same species, but grade from absent, at one extreme, to easily apparent, at the other.

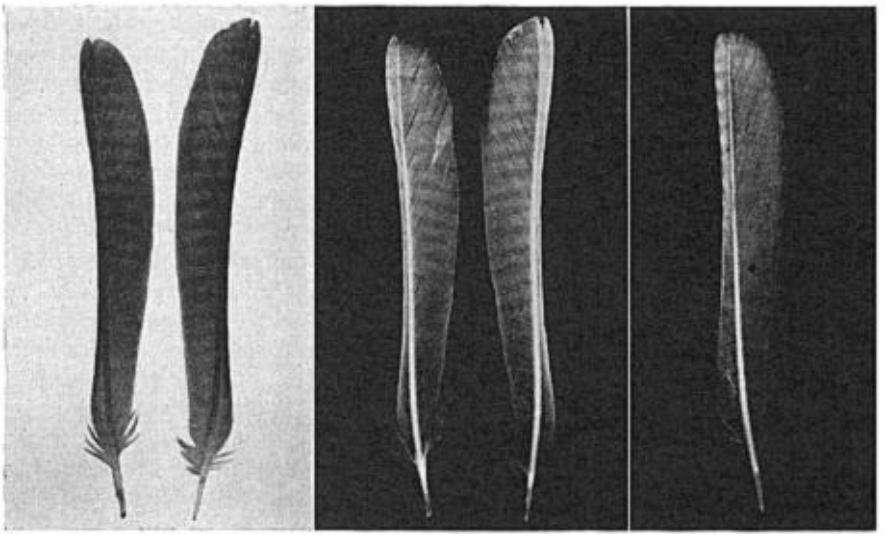
We speak of the bars as being *apparently* darker than the spaces between because we do not wish to be understood as saying that there is a color difference. This will be discussed later. However, we do know that the bars are less translucent than the spaces between them, as evidenced by the appearance of a black and white pattern when viewed through a barred feather, by the dark bars visible across the shadow of a well barred feather, and by the shadow prints made by placing the feather directly on

photographic paper. These prints, in the cases of many feathers, show the bars about as distinctly as they can be seen in the feathers themselves.

The most distinctly barred feathers show a structural difference between the bars and the intervening spaces, which accounts, at least in part, for the difference of appearance. The dorsal surface of the rachis is wavy in the dorso-ventral plane, especially in its proximal section, as can be observed by looking across the feather parallel to the plane of the vane. The dorsal surfaces of the webs are wavy, the crests of the waves matching the waves in the rachis and coinciding, approximately, with the center lines of the bars. This waviness can be seen by pointing the distal end of the feather toward the light and looking along the feather with a hand lens. When the waves can not be seen by this method they often are apparent in both rachis and webs by the bright streaks of specular reflection that ride over the bars as the feather is tilted lengthwise through a small angle. On the ventral surface the bars in the webs are slightly less apparent than on the dorsal side and they show little, if at all, on the rachis. This surface of the webs and the rachis seems to lack the waviness coincident with the bars, judging from the even sheen of specular reflection over the whole surface. There are a few exceptions in which a slight waviness is indicated. In these exceptions the crests of the waves on the ventral side are opposite those on the dorsal side. If these observations of waviness on one or both sides are correct, and we believe them to be, the webs and the rachis are thicker at the bars than between the bars.

When the vane of a well barred feather is only partly expanded, the bars of the proximal portion still held by the sheath can sometimes be seen through the sheath as dark transverse bands.

In addition to the bars that show in the webs and the rachises there are in the calami of feathers of all plumages transparent membranes which appear, from the outside, to be transverse partition walls dividing the calami into sections. (See figs. 38, 40, 41.)



a *b* *c* *d* *e*

Fig. 38. Barred tail feathers of House Finch. Photographs *a* and *b*, and shadow prints *c* and *d*, are of same pair of outer tail feathers, the most distinctly barred House Finch feathers we have seen, collected after the studies for this paper were completed. Shadow print *e* is of normally strongly barred House Finch tail feather.

Upon examining a longitudinal section of the calamus these membranes appear to form a row of capsules each with its ends pressed tightly against an end of the two adjacent capsules and with the side walls pressed against the walls of the calamus tube, often so closely as to be indistinguishable, with low magnification, from the main wall of the calamus. It is not uncommon, especially in the distal portion of the calamus, to find the capsules partially collapsed, apparently being forced away from one side of the calamus tube, with the end walls a more or less crumpled mass. In the proximal section of the calamus the capsules are short compared with their diameters, being, in fact, thin discs, while in the distal section they may be as long as several times their diameters. If a feather is plucked before it is entirely grown, it bleeds at the proximal tip and the calamus is left empty, or partially empty, of these membranous capsules, depending upon its degree of immaturity. (See feathers *a* and *c*, fig. 38, and *a*, fig. 41.)

In a large majority of barred feathers the spacing of the bars is remarkably regular for a given species, but irregularities of considerable magnitude are not uncommon. These variations in spacing may occur between feathers from different individuals of the species, between different feathers grown on the same individual at different times, between feathers grown from the same feather follicle at different times, and between different sections of the same feather. Although there are these variations, barred feathers grown simultaneously on the same bird are sure to have similar spacing of the bars; for example, if two or more remiges on one or both wings are dropped at the same time, either naturally or fortuitously, all the replacement feathers will be similarly barred. The same is true for the rectrices.

Number of Bars in Remiges.—It is only in a few of the most strongly barred feathers that the bars can be counted exactly and definitely the whole length of the vane, and even in these it is usually necessary to count the bars in the webs for part of the distance and in the rachis for the remainder. In our experience the bars in the rachis never can be counted for its entire length and the bars in the webs rarely can be counted for their entire lengths, the most uncertain parts being the distal and proximal extremes of the rachis and the proximal parts of the webs.

To determine the number of bars in the ninth primary of a house finch 11 such feathers, which had grown to replace plucked juvenal feathers, were selected because their bars could be counted the whole length of the webs with considerable accuracy. In only two was it necessary to estimate the number of bars for a small portion of the proximal end of the vane because they could not be seen either in the webs or the rachis. These 11 feathers averaged 17 bars in the vanes and varied from 15 to 20 for individual feathers. The vane lengths varied from 44 mm. to 51 mm., with an average of 47 mm. The spacing of the bars averaged 2.7 mm. for all 11 feathers, 3.4 mm. for the feather with the maximum spacing, and 2.2 mm. for the feather with the minimum spacing.

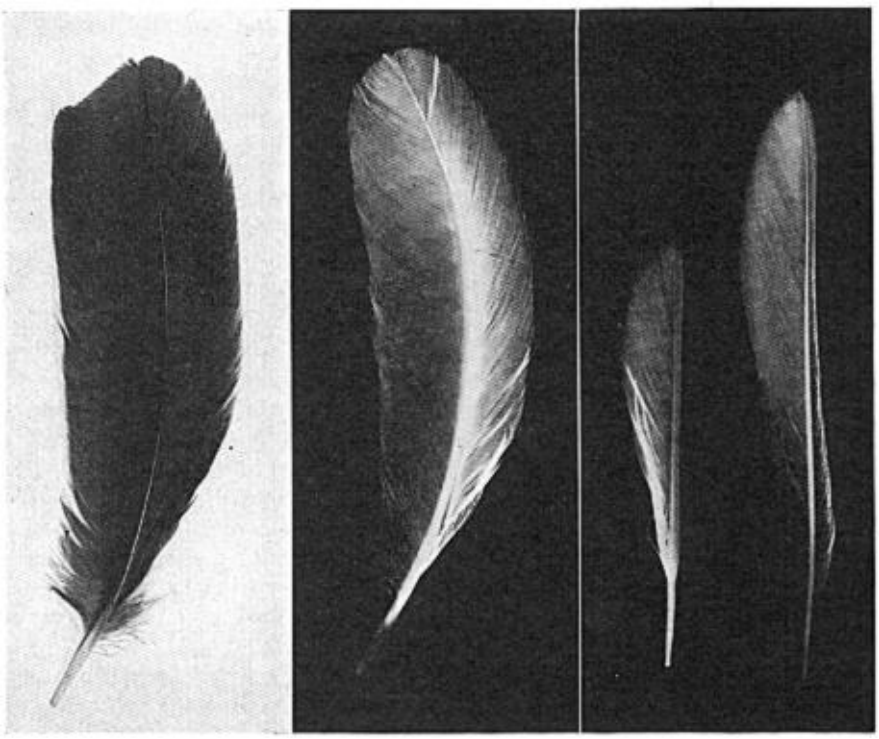
These 11 feathers are representative of all the postjuvenal or later primaries of the house finch, regardless of the age or sex. The bars have been counted in many more, and 16 or 17 are the usual numbers for the vanes.

Rate of Growth of Remiges.—The number of days required by a house finch for the replacement of a ninth primary averages 27, with a minimum of 21 and a maximum of 35, as found from 25 birds which gave reasonably accurate information on this point. Not all of these birds were in hand on the exact day that the feather reached its full length; but some of them were, including the ones that established the maximum and minimum limits. For most of those which were not in hand on the crucial day, the trends of their curves showing length of feather plotted against time in days since the preceding feather was plucked indicate that their feathers reached full length between these time limits. The method of measuring the lengths of these feathers was not suf-

ficiently accurate, nor did many of the birds come to us often enough to give entirely satisfactory rate-of-growth curves. However, these curves do show clearly that during the first 12 to 19 days after the preceding feathers were plucked the average rate of growth was considerably less than it was for all or nearly all of the remainder of their growths. During this early period, in which the tips of the primaries were growing out to the tips of the coverts above them, we made no measurements of these primaries because they were so easily injured when searching among the coverts to find them. Some of the curves show a diminution in the rate of growth for the last few days before full length is reached.

NUMBER OF BARS AND RATE OF GROWTH OF RECTRICES.—A similar study of the tail feathers gave an average of about 23 bars in the vane, 21 of which could be counted in the webs or rachis, with room for about 2 more bars where they could not be seen at the proximal end of the vane. The spacing of the bars averaged approximately 2.8 mm. The most distinctly barred house finch tail feathers we have seen were collected recently and are shown in figure 38, *a*, *b*, *c*, and *d*.

Growth curves for the first and second right rectrices replacing plucked juvenal feathers were plotted from the available data for 36 birds and the time for the growth of these feathers, measured from the plucking of the preceding feathers, was determined



a *b* *c* *d*

Fig. 39. *a*, *b*, Barred secondary of California Jay. In the feather the bars show plainly in both webs, but neither photograph (*a*) nor shadow print (*b*) show them in outer web, which is blue part of feather. *c*, *d*, Shadow print of tail feathers collected in November from adult Gambel Sparrow: *c*, late autumn replacement of postnuptial feather; *d*, normal postnuptial feather.

to be an average of 33 days, with a minimum of 28 and a maximum of 39. These rate-of-growth curves have the same characteristics as those plotted for the primaries. For the rectrices we have ample observations to justify the statement that it requires 6 or 7 days after plucking for the new rectrix to appear at the surface of the skin.

NUMBER OF CAPSULES IN CALAMUS.—We hesitate to suggest even remotely that one of the capsules in the calamus has any relationship to one day's growth of that part of the feather, because we know so little about the manner in which a feather is formed. However, it is a fact which should be recorded, that in house finch remiges and rectrices there is little deviation from the average of 11 in the number of capsules in each calamus. It is also a fact, the meaning of which we do not know, that 11 added to the average of 17 bars found in the vanes of the remiges gives 28, while 27 days was the average growing time found for these feathers. Similarly for the rectrices, 11 added to the average of 23 bars in the vanes gives 34, while 33 days was the average growing time found for these feathers. We would like to be able to say that this shows the number of bars in the vane plus the number of capsules in the calamus to be equal to the number of days consumed in the growth of the feather. We are very doubtful whether this can be true and attempt toward proof is beyond the scope of our present work.

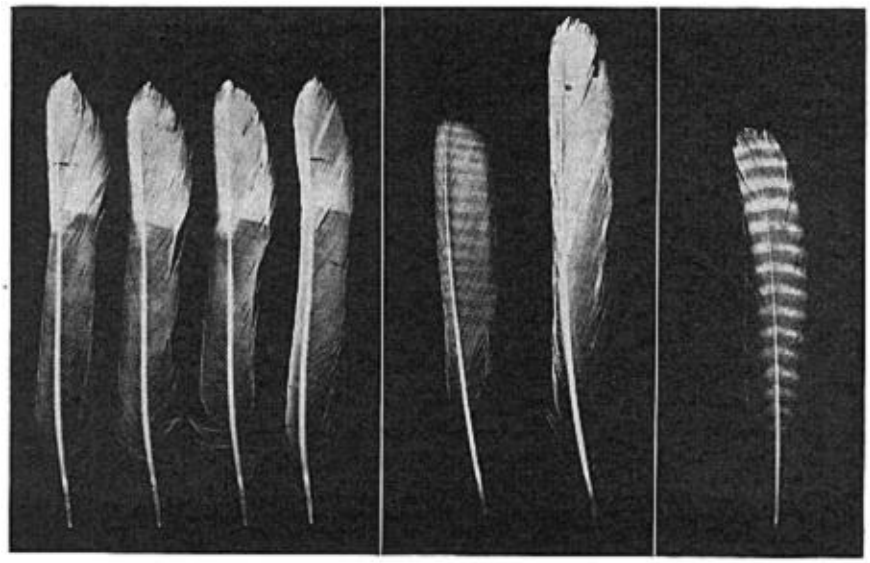
DANGER OF BASING CONCLUSIONS ON MEAGER DATA.—While speaking of the rate of growth of feathers we wish to digress slightly to point out the danger in drawing conclusions from insufficient data, even though these data appear to point definitely to those conclusions. After recording our observations for a summer and fall we undertook to determine the rate of growth of the tail feathers of a house finch. Records on 5 birds were found that seemed to be sufficiently complete to be worth while plotting as rate-of-growth curves. When plotted, the points lay remarkably close to two straight lines starting at zero length and at 6 and 7 days, respectively, and rising at the rate of one-eighth inch in length (3.2 mm.) for each additional day. We were elated with the definite answer and, with considerable confidence, developed the following formula for the rate of growth of house finch rectrices: 6 or 7 days after plucking until feathers show outside of the skin, then one-eighth inch per day until fully grown. But other gaps in our records caused us to continue our studies for another year, at the end of which time a sizable sample of the data on hand gave no such definite answer to the question, as has been indicated already in this paper.

SOME ADDITIONAL INSTANCES SHOWING THE PERIODICITY OF BARS.—At one time we kept in captivity for 31 days four house finches from which we had plucked half the tail feathers, the left primaries 8 and 9, and the left secondary number 1. At the end of this time the primaries were nearly full length and the tail somewhat short of full length. These new feathers were collected from all four birds. Those from one bird in particular are well barred, it being possible to count with accuracy the bars on the two primaries, the secondary and four tail feathers. The other two tail feathers were not preserved. Each one of these feathers, all of which we know to be the same age, have 17 bars. The bars on the wing feathers of the other three are too faint to count and the tail feathers are too much worn to show the bars well the entire length. However, enough can be counted so that we feel sure that the tail feathers from one have 17 bars, from another 16 bars, and from still another 19 bars. The calami of all tail feathers of the two sets having 17 bars show about the same stage of immaturity, and the sheaths are clasping a few of the barbs; those on the set with 16 bars are less mature and the sheaths are appreciably higher on the barbs; and those on the set with 19 bars appear to be mature, having become clearer, and the barbs are nearly free from the sheaths. In one case we are sure that the simultaneously grown primaries, secondary and rectrices have the same number of bars, 17. The remiges are practically normal in length for fully

grown feathers, but the rectrices are about 10 mm. shorter than normal. The variation between the different birds in the number of bars in the rectrices might be assumed to be due to the feathers on the different birds starting to grow at slightly different times although the previous feathers were all plucked at the same time, or it may be due to the sheaths being broken away to a lower point on some than on others. However, it seems probable that these differences in the number of bars indicate the same differences in maturity that exist in the calami, as stated above.

Of the many barred feathers whose lengths we have recorded from time to time as the birds have been in hand and then have plucked for preservation, those from a few birds only, permit of counting the bars over sections of the vanes having definitely known growing periods. In the case of one of these birds (house finch 37-9872) the two tail feathers grew from 27 mm. long to 46 mm. long between observations on June 13 and June 21, a period of 8 days. The sections of these feathers between points 27 mm. and 46 mm. from the distal tips each contain 8 bars. In the first 5 days of this period the ninth primary increased in length from 25 mm. to 41 mm., and this section, measured from the distal tip, contains 5 bars.

The first and second left tail feathers were plucked from an adult Gambel Sparrow (*Zonotrichia leucophrys gambelii*) on October 21, 1937. They showed no bars. On November 20 the two new feathers were growing in, were the same length, and were distinctly barred, no. 1 being plucked to preserve the record of the bars. Early on the morning of November 26, no. 2 was plucked in order to compare it with no. 1 as it was 6 days before. In neither case was the feather fully grown. Both authors, counting independently, one not knowing the interval of time, obtained a difference of 5 in the number of bars. The time of day of plucking no. 1 rectrix is not known. It is presumed



a *b* *c* *d* *e* *f* *g*

Fig. 40. *a*, *b*, *c*, *d*, Shadow print of four rectrices from hand-raised House Finch; distal portions normal and proximal portions lighter, latter due to hand feeding. *e*, *f*, Shadow print of right no. 2 and no. 3 rectrices, collected in May from adult San Diego Song Sparrow. No. 2 is partially grown feather, showing bars, replacing one which had been lost, and no. 3, showing no bars, is old postjuvenal or postnuptial feather. *g*, Shadow print of rectrix of San Diego Bewick Wren, showing color pattern which coincides with diurnal bars.

that both feathers had the same number of bars when no. 1 was collected on November 20 and hence that no. 2 added 5 bars in the following approximately 6 days. The amount of sheath that has broken away from a growing feather can easily make a difference of one in the number of bars visible. In the case of another Gambel sparrow, no. 2 rectrix had 22 bars and no. 1 rectrix had 19 bars when collected 33 and 30 days, respectively, after the previous feathers were plucked, a difference of 3 in both the number of bars and the days of growth. Other examples give equally definite relationships between the number of days of growth and the number of bars.

On May 28, 1937, an immature house finch (37-9876) was banded and its left ninth primary and right rectrices no. 1 and no. 2 were plucked. Because of the interest of this bird's record we here reproduce our notes from our daily journal except that we use the days of elapsed time since plucking instead of the days of the month. All lengths of the primary are measured from the tip of the covert above it and the lengths of the rectrices are measured from the flesh at the bases of those feathers.

19 days, "no. 9 primary quill just at covert edge. Tail 25 mm. long."
21 days, "no. 9 primary 5 mm. beyond covert. Tail 1 and 2 are 29 mm. long."
22 days, "no. 9 pri. 5 mm. beyond covert. New tail 32 mm. long. Very finely barred. Kept no. 2 tail."
24 days, "no. 9 primary 10 mm. long. Tail 35 mm. long."
25 days, "no. 9 pri. 13 mm. long. Tail no. 1, 35 mm. long. This feather came out." (Apparently not preserved.)
26 days, "no. 9 primary 16 mm. long."
27 days, "no. 9 pri. 19 mm. long. On this very short primary can count 12 bars. Cf. 37–9846 same date."
28 days, "no. 9 primary 21 mm. long. Removed to show narrow bars."

The journal notes for 37–9846, an immature house finch banded and plucked May 27, 1937, which was cited for comparison, are:

28 days, "Primary 9 is 2 mm. short of normal. Can count approximately 12 bars on this primary. Tail feather no. 1 is 8 mm. short of normal; no. 2 is 5 mm. short of normal." (These tail feathers were not collected.)

One of the authors, without knowing the above journal entries, measured the collected feathers and counted the bars in them, for the first bird, and converted the "short of normal" measurements for the feathers of the second bird to lengths from the proximal ends of the calami, the normal total length of no. 9 primary and rectrices nos. 1 and 2 being 54 mm. and 65 mm., respectively, as determined by the measurement of a large number of feathers. The results for the no. 9 primaries of these two birds were as follows: 28 days after plucking previous feathers, 37-9876, the bird with slow growing feathers, total length 38 mm., length of vane beyond sheath 22 mm., number of bars in vane 13, average spacing of bars 1.7 mm.; 37-9846, the bird with faster growing feathers, total length 52 mm., number of bars in vane as reported in journal approximately 12.

It should be noted that the first of these feathers has practically the same number of bars as the second although it is 14 mm. shorter (about three-fourths as long); also, that the first had 13 bars as plucked at 28 days and 12 bars as counted on the bird at 27 days.

When the data for the first feather are plotted as a rate-of-growth curve, it lies in a fairly straight line which, if projected, reaches normal full-grown feather length at 35 days. This is the time that our other rate-of-growth curves indicated as about the maximum for the growth of no. 9 primary for a house finch. The tail feathers of these birds do not admit of comparison, as indicated in the journal notes.

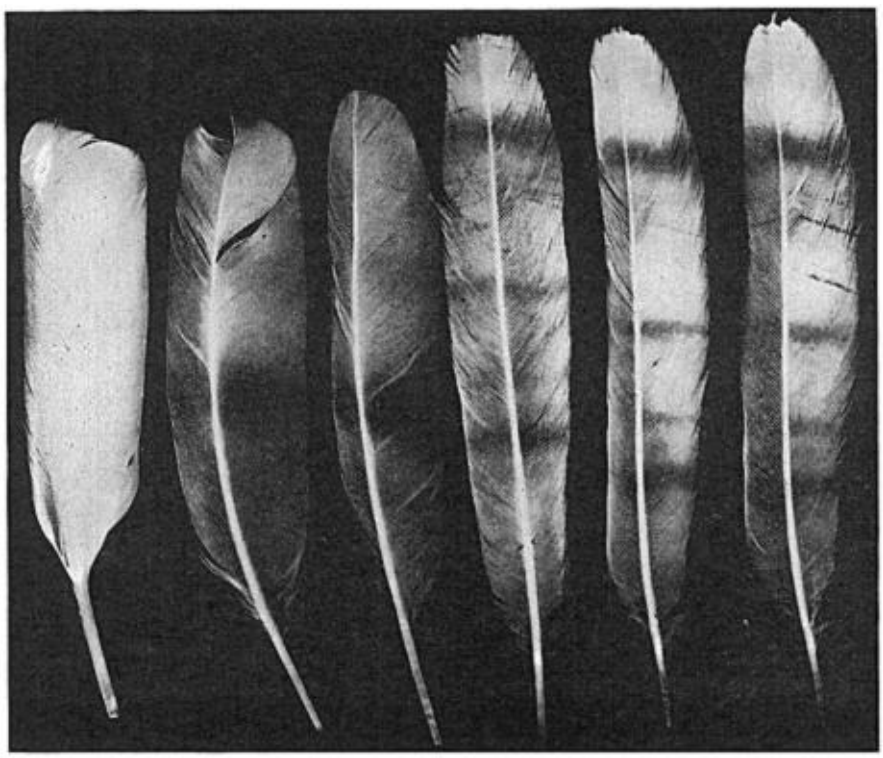
Summer Bars Less Distinct Than Winter Bars.—In the house finches that we have handled, flight feathers grown by birds of all ages in late fall and winter to replace those that have been lost show the bars much more distinctly than those grown in spring and summer.

Gambel sparrows arriving in the autumn show, in the tail and in the wings, no bars or only the faintest indication of bars; yet if a feather is lost after the bird's arrival the replacement feather shows bars more distinctly than the previous feather. (See fig. 39, *c* and *d*.) This is true of adults as well as immatures, and the contrast is greater than in the case of the house finches that live here all the year.

ARE THE BARS IN FACT DIURNAL?—Was Law correct in his surmise that the bars represent the daily increments of growth of the feathers? Are the dark streaks the parts formed in the day and the light streaks in the night, or vice versa?

It seems evident that the bars are due to some periodically recurring condition which affects the feather growth. The spacing of the bars is such that a little consideration leads easily to the suspicion that the frequency of the recurring condition corresponds with the day and night cycle. Both the number of bars in like feathers and the number of days required for such feathers to grow to full length have average values which most feathers quite closely approach.

If we assume that the number of days required for the vane of the feather to grow is the same as the number of bars in the vane, ninth primary averages 17 and first and second rectrices average 23 for house finches, the remainder of the average time required for each of these feathers to reach full growth, 10 days, does not seem to be too much



a *b* *c* *d* *e* *f*

Fig. 41. Shadow print of feathers of male Brewer Blackbird: *a*, postjuvenal primary; *b*, juvenal secondary; *c*, juvenal primary; *d*, *e*, and *f*, juvenal rectrices. All juvenal feathers show light bands (dark in figure). Postjuvenal feather is solid black of normal adult male, although it undoubtedly has replaced a juvenal feather having bands.

to be consumed in starting the growth of the feather after the previous feather is plucked and in the growth of the calamus.

Simultaneously grown flight feathers on the same bird have the same number of bars at any time previous to the full growth of the earliest developed vane, and on different birds this is true, with possibly a slight variation, even though the feathers on one bird may grow much more rapidly than on another.

Finally, by direct count, the number of bars added to a growing feather in a given number of days is equal to that number of days. For the above reasons we feel justified in concluding that these bars are formed diurnally. However, it probably is not the light of the day nor the lack of light of the night that acts directly on the bird or on its feathers for, if it were, the feathers of the juvenal also would be barred. The juvenal in the nest is inactive. It does little but convert food into growing tissue, the food usually being supplied by the parents in fairly even abundance from daylight to dark. When the bird is fledged and depending upon itself as a food gatherer much of its energy is spent during the daytime in physical activity. As the autumn and winter progress, the shorter days, lower temperatures and the lesser abundance of food make for greater consumption of energy during the shorter daylight period and for a greater contrast between the day and night conditions. We think Gambel sparrows illustrate this point most markedly. As previously stated they arrive here in the fall in postjuvenal or later plumages with flight feathers showing only faint bars if any at all. These feathers are grown while the birds are in the northern part of their range while the days are long and the nights are short. When we pluck these feathers in the fall or winter, here in latitude 34 degrees north, the new feathers are strongly barred and, on the comparatively few we have measured, show an average spacing of bars in the tail feathers of 3.2 mm., which is somewhat greater than that of the house finches.

KNOWN AND SURMISED EFFECTS OF CHANGES IN METABOLISM SHOWN IN FEATHERS.—That a change in food or some other cause influencing the metabolism of a bird does have a more or less profound effect upon the feathers that are growing at the time is illustrated, we think, in the bands that are often found, singly or in multiple, across the wings, the tail, and, in extreme cases, all the feathers of a juvenal plumage. In their usual form they are lighter in color than the remainder of the feathers. Sometimes there is a difference in texture or in some other quality, difficult to define, which causes a difference in appearance. They are always more translucent. Most young birds lack them but they are not rare and we have found them in practically every species we have handled.

It is only on birds in juvenal plumage, all the feathers of which grew at substantially the same time, that the bands are found to extend across all the flight feathers of wings or tail, with the possible exception of a bird of any age which has simultaneously lost and replaced all the feathers of a tail, for instance, and, during the growth of the replacement feathers, has experienced some condition which caused the bands to form. Any feathers of postjuvenal or later plumages may have these bands on individual feathers, but the bands will not line up as a band across several adjacent feathers unless those feathers grew simultaneously.

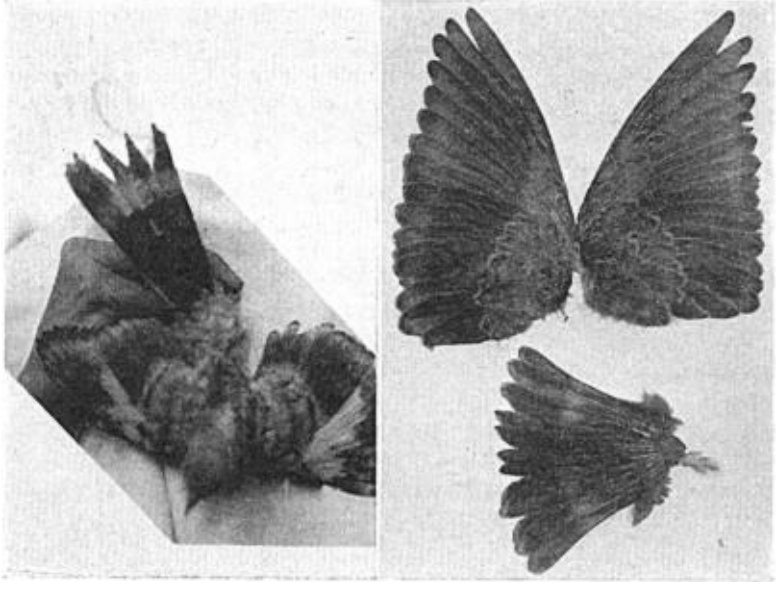
We think the bands are due to some experience in the bird's life which caused an abrupt change in the health of the bird—in the amount of energy available for feather growth, perhaps.

We have had two young house finches which were taken from their parents when very young. Both these birds had a definite dividing mark across the tail, the proximal sections of the feathers being lighter and more translucent than the distal sections. In the bird that was taken from its parents at the earlier age the distal edge of the band

was nearer the tip of the tail than in the other. A shadow print of four feathers from the one which was the older when transferred to hand feeding is shown in figure 40, *a*, *b*, *c*, and *d*. We think the division line dates for this bird a change in its metabolism, probably due to its change from parental to human care, and that whatever produced this change continued to influence these feathers during the remainder of their growth.

Another instance was that of a young house finch in normal juvenal plumage from which two tail feathers had been plucked. About two weeks after the feathers were plucked the bird sustained a broken wing and other serious injuries from an encounter with a cat. None of these injuries was in the region of the tail. The bird was put in a large cage with plenty of food and water and not disturbed for several days; then it was released. It soon was able to fly quite well. When the replacement tail feathers were nearly grown they were collected. There is an abrupt change in the appearance of these feathers about 5 mm. from the ends. This changed appearance is maintained for a distance of about 15 mm., and here the appearance becomes normal again. In this instance there are a few irregularly spaced light streaks interspersed with the bars in such a way that it is difficult to say whether the peculiar appearance is due to abnormal barring or to bands as we have defined them.

The cases cited, in which we know parts of the life histories of the birds which seem to explain the causes of the bands, are simple in band patterns and in probable causes compared with some of the band patterns we have observed and the multitude of events that might easily take place in a young bird's life and have an influence on its metabolism. Figure 41 shows a shadow print of tail feathers (*d*, *e*, and *f*), primary (*c*), and secondary (*b*) from the juvenal plumage of a male Brewer Blackbird (*Euphagus cyanocephalus*). The tail feathers in particular show three pronounced almost white bands



a *b*

Fig. 42. *a*, Photograph of Western Mockingbird in juvenal plumage, every feather of which is strikingly marked with light bands. *b*, photograph of wings and tail of Dwarf Cowbird showing light bands across rectrices, remiges and wing coverts.

and another not so pronounced. (Note that these shadow prints are negatives, white on the feather being black on the print.) If our conclusion as to the cause of these bands is correct, this bird had a number of variations in food supply, or in parasite attacks, or in something else that affected its metabolism. It might be thought that the light bands indicate partial albinism; but, if so, they should persist in the postjuvenal and later plumages, which they do not. Feather (*a*) in this figure is a postjuvenal primary taken from this bird. It is the normal shiny black of the adult male. Many young blackbirds marked similarly to this one have been trapped and recorded. They all molt into the normal postjuvenal plumage for male or female as the case may be.

Figure 42*a* is a photograph of the Western Mockingbird (*Mimus polyglottos leucopterus*) showing much banding in its juvenal plumage. We have not seen this bird again, but its postjuvenal plumage was probably that of a normal mockingbird.

Figure 42*b* is a photograph of the wings and tail of a juvenal Dwarf Cowbird (*Molothrus ater obscurus*) showing light bands across rectrices, remiges and wing coverts. A considerable portion of the young cowbirds captured have shown bands in their flight feathers. We are tempted to speculate upon what is the optimum food for a young cowbird. They evidently survive on a great variety of foods, judging from the great variety of known foster parents; but perhaps these bands indicate that their young lives are not all one continuous period of parasitic comfort with no pangs other than those due to overfilled stomachs.

Possible Relation of Bars to Color Pattern.—We have refrained from saying that the bars are in any sense a color pattern. The bars are particularly well marked in a Brewer Blackbird, yet it could not possibly be said that the blackbird feather shows a color pattern. Also the bars show distinctly in some white feathers. In the majority of the brown flight feathers of the house finch it has been difficult to decide whether the bars actually show a color difference, but occasionally there is one which seems to justify this distinction. This same is true of the California Jay (*Aphelocoma californica californica*), figure 39, *a* and *b*.

Judging from the relatively few Song Sparrows (*Melospiza melodia cooperi*) whose feathers we have examined, the juvenal flight feathers show bars faintly. The flight feathers of postjuvenal and later plumages show them much more plainly (fig. 40, *e* and *f*); the tail feathers, and particularly the two middle ones, sometimes show them so distinctly that we feel inclined to call them a color pattern.

In the tail of the San Diego Wren (*Thryomanes bewickii correctus*), figure 40*g*, there is an undoubted color pattern of bars; yet we believe, although the quantity of material examined is small, that these color bars are, in fact, the diurnal bars which we have been studying. With these suggestive observations we leave to our readers the question of how the wren's tail came to be barred.

CONCLUSIONS

1. Each of the bars in a flight feather, similar in appearance to a watermark in paper, represents a day's growth of the feather.

2. Most flight feathers of postjuvenal or later plumages show bars.

3. Juvenal flight feathers usually show no bars, though occasionally the bars are visible, especially in the tail.

4. Bands lighter than the normal color are not uncommon across the wings or the tail, or both, of a juvenal bird. In rare cases all the body feathers also show these bands. Bands probably are due to some metabolic deficiency resulting from some changed condition in the bird's life.

5. Bands may occur in postjuvenal or later plumages if a group of flight feathers is replaced simultaneously and if the bird, during the growth of these feathers, experiences conditions which will cause bands.

6. The presence of bands or the absence of bars justifies a strong suspicion that the feather is a juvenal feather.

7. The presence of bars justifies a strong suspicion that the feather is not a juvenal feather.

8. Feathers grown in late fall and winter have more pronounced bars than those grown in spring and summer.

9. The presence of a strongly barred feather in company with adjacent or corresponding feathers having no bars or but faint bars indicates that the strongly barred feather has replaced one lost from the normal plumage.

Pasadena, California, February 12, 1938.

NOTE.—As this paper is ready for publication, Dr. J. M. Linsdale cites to us "The Genesis of Fault-bars in Feathers and the Cause of Alternations of Light and Dark Fundamental Bars," by Oscar Riddle (Biological Bulletin, vol. 14, 1908, pp. 328-370). We recognize in Riddle's "fundamental bars" the bars described in our paper and in the results of his experimental work the information we have been wishing so much we had. However, our method of study and the results we present in addition to those presented by Riddle will justify, we hope, the presentation of this paper.—H. M. and J. R. M.

AN HOUR IN THE LIFE OF A BROAD-TAILED HUMMINGBIRD

WITH ONE ILLUSTRATION

By A. M. WOODBURY and JOHN W. SUGDEN

A small glade 80 feet in diameter in an opening in a natural forest of spruces and aspens formed the setting for the activities of a male Broad-tailed Hummingbird (*Selasphorus platycercus*). Here he displayed his incessant "feeding, fighting and flirting" as we observed him in the mating season on June 13, 1937, at the Utah Outdoor Camp in Big Cottonwood Canyon, Salt Lake County, Utah. The glade was densely studded with twinberry bushes (*Lonicera involucrata*) in bloom (about waist-high) interspersed with grasses and herbage of many kinds. The twinberry blossoms provided the food supply and, so far as we observed, he did not feed on anything else.

After fifteen minutes of preliminary observation, we began to make detailed notes of the bird's activities. A sketch of the area was made and the perching points most commonly occupied were numbered. The area was bounded on the north and northeast by heavy conifers (spruce and fir), into which the hummingbird seldom ventured. The west boundary was provided by a clump of aspens with an opening to the northwest providing an open passageway. To the south and southeast, the twinberry brush extended some distance beyond the scene of observation along the banks of two tiny streams that converged at this point. (See fig. 43.)

We found three adjoining birds apparently maintaining territory, one on each fork of the little stream where the twinberries were thick, as shown in the sketch, and the other to the northwest, downstream. The boundaries of the adjoining territories seem to have been definitely delimited; for two birds would perch close together on opposite sides of the "line" without showing hostility.

The bird under observation seemed to perch on twigs on the sides of either trees or bushes (never on top) where he could keep the entire area under observation. Favorite perches were located on the inner sides of trees around the border of the area, or else on bushes from which he could see the surrounding trees.

Occasionally a female entered the area and the male gave her a good deal of attention, sometimes dancing in the air with her, occasionally touching bills, but more often performing his characteristic dives, in which he would spiral up about as high as the tree tops and then dive rapidly toward the ground making a sweeping curve at the bottom and come up again on rapidly beating wings. The descent was generally marked by a peculiar rattling sound which gave way at the bottom to a decided cluck just as the sweep reversed and he started to rise.