MOLT AND VARIATIONS IN PLUMAGE PATTERN OF MOCKINGBIRDS AT PASADENA, CALIFORNIA

By JOSEPHINE R. MICHENER

As a part of studies of the behavior and local distribution of Mockingbirds (*Mimus polyglottos*) at Pasadena, California (see Michener, Condor, 53, 1951:276-283), records of molt and color pattern were kept for many banded individuals. It is the purpose of this paper to report the results of these observations.

The molt of Mockingbirds in Pasadena approximates that of House Finches (*Carpodacus mexicanus*) as described by us for the same area (Michener and Michener, Condor, 42, 1940:140-153). The record of the process is not so complete for Mockingbirds as for House Finches. No attempt to study molt *per se* was made, but notes about molt were recorded, if time permitted, when birds were trapped. Mockingbirds do not repeat as frequently as House Finches, and juveniles of the former move away sooner. Adults may come to the yard very frequently while feeding young, then rarely or not at all after late July.

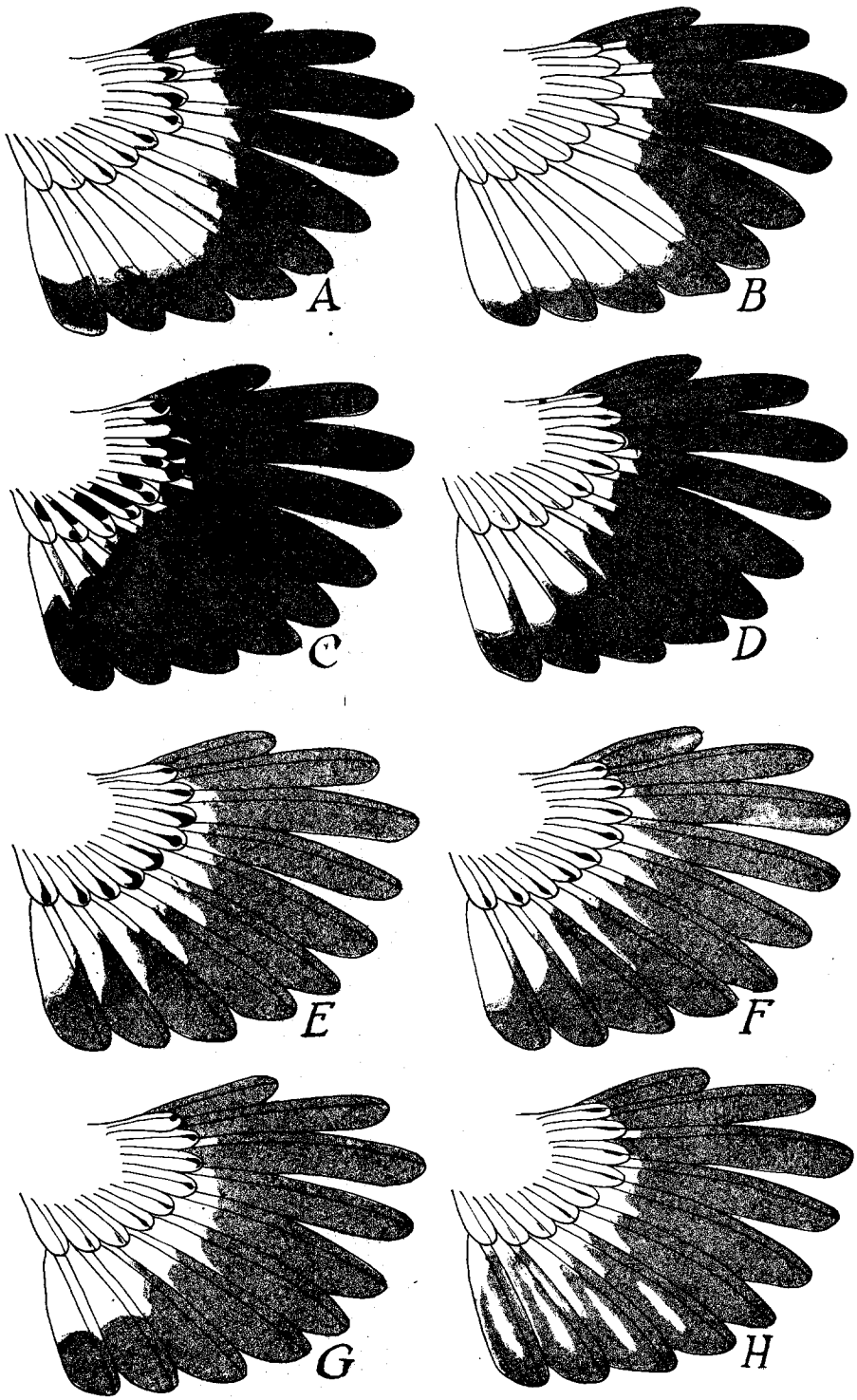
Adult Mockingbirds begin their molt in late summer from mid-July to early August and complete it by mid-October. There is no prenuptial molt. The juveniles begin to molt into their first winter plumage soon after leaving the care of their parents, and, like House Finches, show a varying degree of completeness in this molt.

The method followed was that used in the observation of the molt of House Finches. Notes on trapped birds or on free, color-banded birds were recorded. Juveniles, when banded, were marked for future study of molt by cutting small notches in the remiges and rectrices of the right side. If these birds were recaptured later and before their first postnuptial molt, it was possible to tell if any of these notched feathers of the juvenal plumage remained. The outermost (smallest) primary was not notched. In this paper the term "adult" is used for birds that have passed through a complete molt as well as those that have passed merely through the postjuvenal molt which may be incomplete.

The postjuvenal molt may involve all the feathers; however, some remiges and occasionally some rectrices may remain until the first postnuptial molt a year later. Rectrices seem less apt than remiges to be thus retained, but evidence from trapping may be obscured by the fact that these active and often obstreperous birds easily lose tail feathers in the traps. Notched rectrices on birds a year old were found but never all six and usually only one or two.

One of our best records to show retention of rectrices came from a bird banded after its postjuvenal molt. It had a pale, wide band across all primaries and across all tail feathers except 1 and 2 on the right and 5 and 6 on the left. Such a mark we have found across a wing and tail only in immature birds (Michener and Michener, Condor, 40, 1938:149-160). The conclusion was that the banded feathers belonged to the juvenal plumage and that the bird, trapped as an "adult," was one year old. The four unbanded tail feathers, not indicating symmetrical replacement as would be expected as the time of normal molt, probably were replacements following accident. They were distinctly newer, longer and stronger feathers than were the other rectrices.

In the following records of molt of remiges in immature mockingbirds (table 1), at one extreme the molt is complete or nearly so and at the other only a few feathers are molted. When a primary is molted the primary covert above it also drops as far as observed. In the postjuvenal molt of House Finches, on the other hand, the middle section of the row of flight feathers is frequently replaced, with some birds showing an extension of replaced feathers distally and some medially. The present report, however, is


A
B
C
D
E
F
G
H

based on far less material than was used in the study of House Finches, and hence general tendencies in the postjuvenal molt of Mockingbirds do not emerge so clearly against the variation in extent and pattern of the molt.

Our main interest in the postjuvenal molt was to determine whether there is a feather pattern for juveniles distinguishing them from adults. If such occurs, it is clear from table 1 that in some birds there will be a combination of both adult and immature feathers. Separation of the two age groups may be difficult to establish if the markings are similar.

Table 1

Postjuvenal Molt of Remiges in Mockingbirds

Bird	Date of notching	Date of retrapping	Feathers replaced on date of retrapping																
			Primaries*									Secondaries							
			9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9
38.100363	May 31, 1938	Aug. 9, 1938																7	8	9
38.100382	June 3, 1938	Oct. 27, 1938	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9
A240817	June 8, 1938	Apr. 29, 1939				6				2	1	1						7	8	9
138.104930	June 18, 1938	May 16, 1939									1						6	7	8	9
138.104383	June 22, 1938	Oct. 7, 1938	9	8	7	6	5	4	3	2	1	1	2		4	5	6	7	8	9
138.104980	June 22, 1938	Apr. 15, 1939								2	1	1						7	8	9
138.104983	June 22, 1938	Apr. 18, 1939									1							7	8	9
138.104998	June 24, 1938	Oct. 3, 1938									1	1		3	4	5	6	7	8	9
138.105069	July 10, 1938	May 20, 1939															6	7	8	9
138.105095	July 27, 1938	Apr. 15, 1939																7	8	9

* The last (outermost) primary is small and was omitted from this study.

WING PATTERN

The white spot conspicuous in flight or in the lifted wing and almost concealed when the bird is on the ground or perched spreads over primaries and their greater coverts. This account of the wing pattern is based on drawings made when the birds were trapped. At first, sketches of these feathers were made; but later mimeographed outlines were used and the patterns of primaries and primary coverts entered on them in pencil. Examples of these are shown in figures 1 and 2. Patterns of 243 juveniles and 139 adults were drawn in this way. All were drawn on the same outline and no claim is made that they were exact. But that they show the patterns with some degree of accuracy is attested by occasional inadvertent preparation of two diagrams of the same plumage of the same bird, and in such instances it is easily recognized that both represent the same wing.

As with rectrices, there is a characteristic range of pattern for each primary. Each feather contributes to the amount of white in the wing spot, the size of which might be roughly predicted by knowing how many of the outermost primaries fail to show any white, or show only a little on the narrow, outer web.

Primaries.—In the wing of a juvenal Mockingbird (fig. 1A) primary 10 appears to have no white; but beneath the coverts it can be seen that while the outer web is dark, there is white on the broad, inner web, and that the margin of this white area

Fig. 1. Color patterns of primaries and their greater coverts in Mockingbirds. *A*, juvenile used as basis for description in text; *B*, known male with a large white area on primaries and white coverts; *C*, juvenile with reduced white area and heavy spotting of coverts; *D*, known female with medium-sized white area and moderately developed spotting of coverts; *E*, probable female examined in April, 1935, showing jagged patterns of white area and fairly heavy spotting of coverts; *F*, same as *E*, examined in May, 1936, when spotting of coverts was lighter; *G*, juvenile examined in July, 1935; *H*, same as *G*, examined in adult plumage in which patterning of primaries is unusual and which was of normal type in later years.

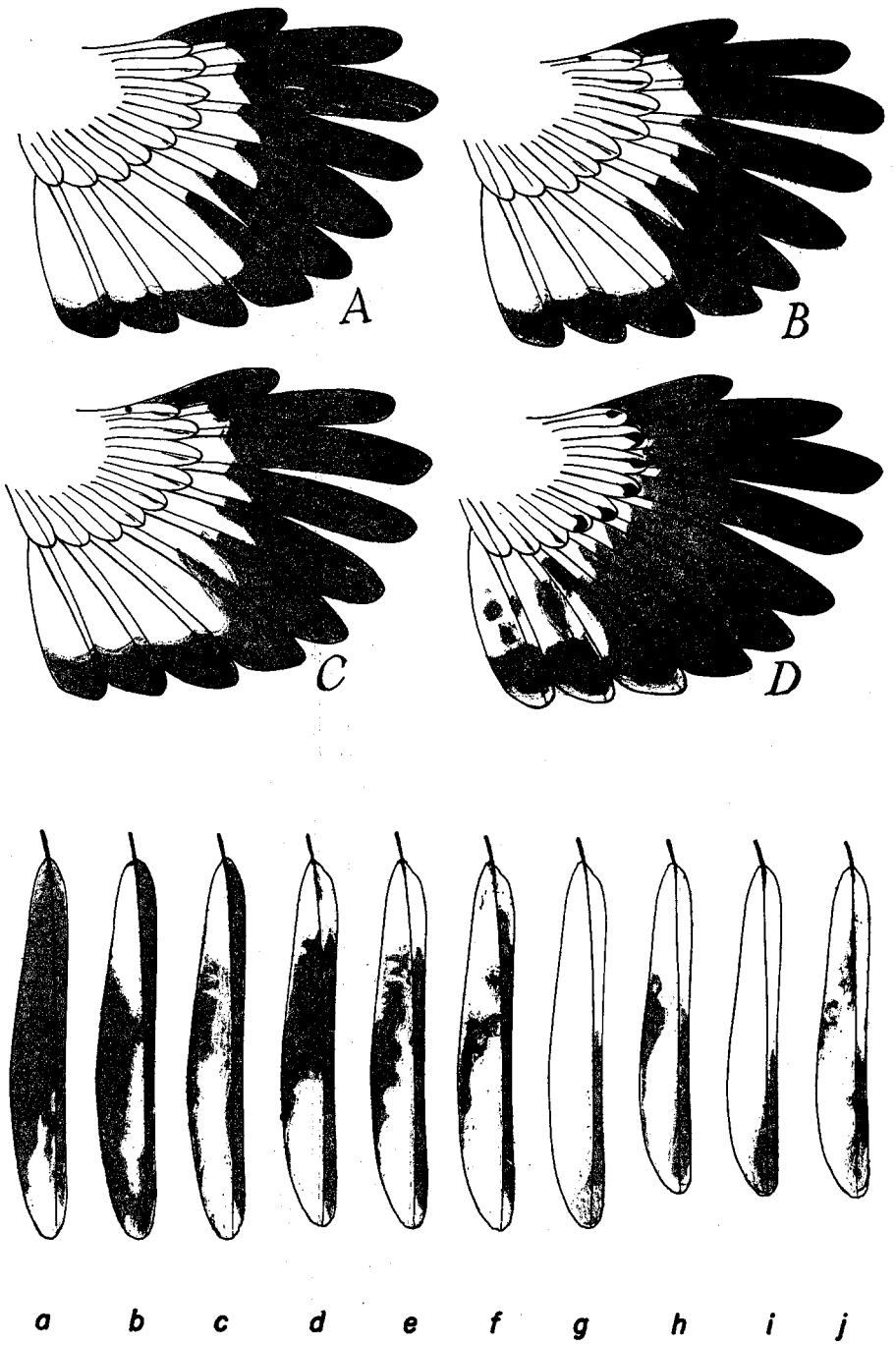


Fig. 2. *A, B,* and *C,* same adult examined in May, 1936, May, 1935, and July, 1934, showing an unchanging pattern; *D,* juvenile with an irregular patterning on primaries and a common type of coverts. *a-j,* patterns shown by juvenal rectrices, with successive reduction of dark color. Arbitrary classes: *a* and *d,* class 2; *b,* class 2 or 3; *c, e, f,* and *h,* class 3; *g, i,* and *j,* class 4.

slants rather sharply from quill to edge, terminating at the tip of the covert above it. The exposed pattern begins on primary 9. On this feather white extends slightly beyond the covert on the outer web, and on the inner web it extends distally at a sharp angle. This feather can be duplicated in other birds by primaries 8, 7 or even 6 and, rarely, this slanted pattern is repeated across the rest of the primaries (fig. 1, E and F). The latter pattern does not fit the basic one here described. In the juvenile, shown in figure 1A, primaries 8, 7 and 6 carry the white pattern rapidly outward on the wing by three repetitions of the design of primary 9, each, in turn, starting at the level where the white of the preceding feather ended. On primary 5 the beginning of a tendency for the slope to level off appears. In primary 4 the slope is almost suppressed and only a narrow trace of dark on the edge of the narrow web represents it.

The change in angle of this pattern line correlates with the area of the white spot. If the slope is relatively steep, the white extends, as in this bird, distally toward the tips of the inner primaries. If the slope is gradual or begins on the 8th or 7th primary, the line across primaries 4, 3, 2 and 1 will be more medial and will cross only, if at all, the innermost one or two primaries at a right angle to the quill (fig. 1C).

Greater coverts.—The greater coverts form a second set of patterned feathers. For consistency, the pattern of this row of feathers is described as are those for primaries and rectrices, that is, as an encroachment of white on dark. In an occasional individual, these feathers are extensively dark-patterned, but in the vast majority, they are white, sometimes entirely so, more usually showing with a row of dark spots. The last covert is almost invariably pure white. If patterning occurs, it occupies larger areas on the outermost coverts than medially.

In the juvenile used to exemplify pattern of primaries covert 10 is marked by a circular spot about 4 mm. in diameter (fig. 1A). This has a slight notch proximally on the inner web. This slight indentation marks the beginning of a very common type of covert pattern for, as the white increases, the dark spot is reduced to a hook-shaped spot (figs. 1E, 2D), the hook invariably being open to the side of the inner web. If reduced along its proximal edge, the dark spot may form a truncated circle, a half circle, a crescent and finally a mere rim of dark. Or reduction of this spot may occur by lateral compression producing elongated ovals, tending to be broadest at their distal ends, or the pattern may be wedge shaped or even linear, thick at the tip and fading to pure white in more medial coverts. These patterns are usually mixed in a wing.

Changes in wing pattern.—Does so complex a pattern change from plumage to plumage in the individual? We have records of successive adult plumages for 27 individuals, and of the juvenal and following adult plumage for 19 individuals. For five adults there are records of three successive plumages for each. These drawings are now compared to ascertain whether or not there are significant differences in pattern in the succession of plumages in any one individual.

Attention is called again to the method used to record the year-to-year changes in pattern. The drawings were prepared when birds were trapped and the plumage might be wet or dry, clean and new or soiled and old. The observer was often pressed for time and under necessity of releasing the bird in a matter of minutes. It is not wished to represent the drawings as more accurate than they are. Drawings from one individual were prepared months apart, and no reference was made to an earlier drawing when a later one was made. Three drawings for A284549 (fig. 2, A, B, and C) representing primaries and coverts in three succeeding years show three plumages for this bird. Here no change occurred in pattern of primaries and their coverts.

For 19 individuals mentioned above, patterns of juvenal primaries were compared with those of adult primaries, with the following results: Ten showed no change recog-

nizable by our methods. Eight showed slight but real differences. These differences consisted of (a) a change in the size of the wing spot due to a change in the curve of the line separating light and dark in the innermost primaries, and (b) a change from blotchy or shaded boundaries between light and dark to sharper and cleaner ones.

In one bird, the change was so great that the new primaries presented an entirely different pattern and, in fact, a pattern unlike any ever seen before or since in our experience (fig. 1, G and H). This curious pattern was repeated on the rectrices and even extended to a usually unpatterned rectrix. It could only be regarded as representing some abnormal or unusual condition persisting during a large part of its molting period. This plumage was known to be that of a singing male distinguished as the darkest male handled for drawing purposes. That the pattern was abnormal was apparent because the bird was color-banded and was known to us at window shelves in succeeding years when it had a normal plumage.

In the 27 records of successive adult plumages, primaries showed the following changes: Twenty-four could not be considered different from the preceding plumages. Three showed changes: one showed spots or blotches of dark invading the parts of primaries 2 and 1 that were white in the earlier plumage; and two showed a moderate increase in the size of the white area.

It is concluded, therefore, that the pattern of primaries is one of considerable stability, fixed in extent in the juvenal plumage and ordinarily subject only to minor changes.

The examination of the covert pattern for these same birds gives a somewhat different picture of the possible change from plumage to plumage.

For each of the 19 individuals first studied as juveniles, comparison of patterns of coverts gave the following results: Eight showed no change in pattern. Eleven showed changes. Of these, ten showed a reduction in the extent of dark color—a lighter design, while one reversed this and showed a heavier pattern.

From coverts of the 27 adults studied, the following results were obtained: Nineteen showed no change. Eight showed changes. Of these, three showed a reduction of dark patterning, while one, a known female, showed an increase. The remaining four records are provided by two known females sketched in 1933, 1935 and 1936. Both showed a distinctly heavier covert pattern in 1935 than in 1933, and in both it was lighter in 1936.

We have here five changes in known females, and in them the covert pattern varied considerably. The results suggest that the pattern of coverts changes more than that of primaries and that in juveniles pattern changes occur in roughly half of the individuals, tending to become reduced. In five adult females marked changes and even reversals in pattern were recorded. There is in addition a drawing of a partly molted female with a note stating that the new coverts appear lighter than the old.

From 243 drawings of juvenal wings, it is possible to say that no primary pattern and no covert pattern can be considered characteristic of juveniles. But the majority of juveniles have dark coverts. On the other hand, in adults, light or pure white coverts are the general rule. Age differences in pattern of primaries do not stand out with any clarity.

Sexual differences in wing pattern.—The sex of banded Mockingbirds was known to us only by their actions as we watched them through the year (Michener and Michener, Condor, 37, 1935:97-140). Some known males were large birds and some known females were small but many were at neither extreme. The extremes were so noted when trapped. For other reasons, determination of sex by external characters is difficult. Some juveniles do not have a complete wing molt in assuming their first winter plumage. Also, a juvenile may have a large wing spot and pure white coverts rather than the more char-

acteristic dark ones. Hence, it seemed desirable to use every bird of known sex to test for differences between sexes in wing patterning.

Color-banded birds holding territories and watched in the breeding seasons were identified as to sex. Disregarding the singing of juveniles we called any other bird singing in spring and summer a male; the mates of any of these birds were then listed as females. In addition, sex identification was based on habits of high perching in summer, especially vigorous defense of territories in summer, and actions during the mating season. To these records were added a few noted at time of banding when extremeness in size permitted tentative identification of sex. In all, we have records of 27 known males, 18 almost certainly males, 11 known females, and 17 probably females.

Wing spots were classified simply as large, medium or small. The drawing for each bird was assigned to one of these three classes. Only the white on the primaries was considered; coverts were ignored. The largest and smallest white spots were easily selected; indecision placed an individual in the middle class. An effort was made to review the drawings several times rather than to spend much time in trying to decide each dubious case by long consideration. Totals in successive tabulations varied only by one or two (table 2).

Table 2

Sexual Differences in Size of Wing Spot

Area of wing spot	Males			Females		
	Known	Probable	Total	Known	Probable	Total
	27	18	45	11	17	28
Small	1	1	2	6	10	16
Medium	4	6	10	5	6	11
Large	22	11	33	0	1	1

From table 2 it appears that a bird with a large wing spot is probably a male and one with a small one a female. The proportion of birds that cannot be assigned to either sex at sight is large.

If the size and shape of the wing spot in the primaries is fixed in the juvenal plumage, the percentage of large, medium and small wing spots must be the same for both juveniles and adults. With this in mind the drawings were examined. For this purpose, the older drawings made without the use of the mimeographed outline were not used because in them the chief attention had been given to the covert pattern. Comparison

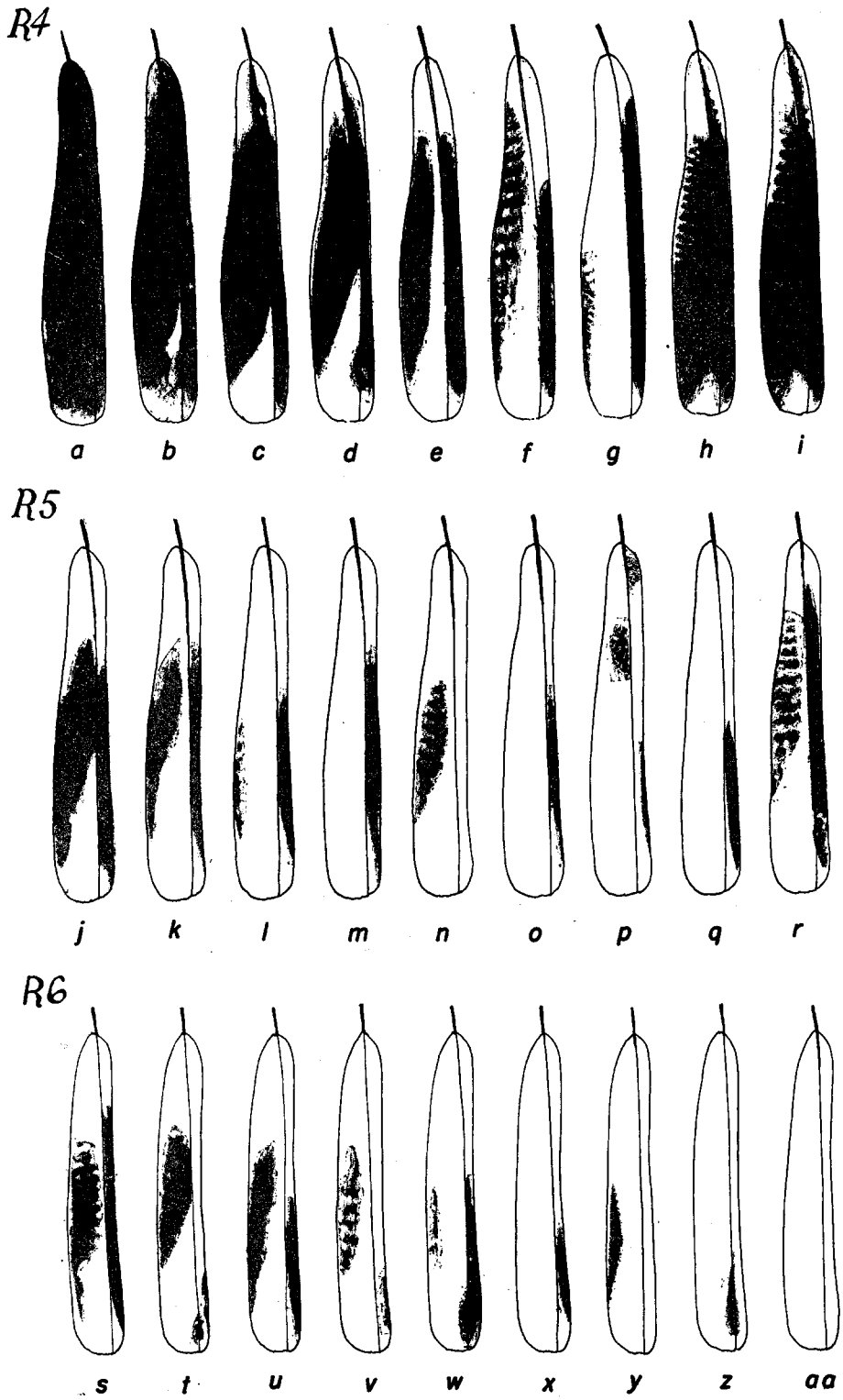
Table 3

Comparison of Wing Spots of Juveniles and Adults

Size of wing spot in primaries	133 juveniles		127 adults	
	Number	Per cent	Number	Per cent
Small	38	28.6	32	25.2
Medium	65	48.9	67	52.9
Large	30	22.6	28	22.0

is based on 133 juveniles and 127 adults, as shown in table 3. Considering the complexity of the outline and the fact that these white areas were judged by eye, it is felt these percentages do show that the primary pattern of juveniles and adults is almost the same. The only real difference is the tendency for some juveniles to show indefinite or blurred separation of dark and light areas.

Returning to the drawings of coverts, it was decided to classify these into three categories and to separate juveniles and adults. The three groups of coverts were arbitrarily


R4
a
b
c
d
e
f
g
h
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R5
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R6
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v
w
x
y
z
aa

defined as follows: (1) pure white or with no more pattern than a black line; (2) a black line heavy at the tip (an exclamation mark), or a narrow oval or wedge-shape mark, or a lightly outlined hook or crescent edge; and (3) all heavy patterns regardless of shape. All drawings were used for study of the covert pattern. There were 243 juveniles and 139 adults. The frequency of the three patterns, called light, medium and dark, is given in table 4.

Table 4

Frequency of Pattern Types on Greater Primary Coverts

	Juveniles		Adults	
Covert pattern	Number	Per cent	Number	Per cent
Light	83	34.1	86	61.9
Medium	113	46.5	38	27.3
Dark	47	19.3	15	10.8
Totals	243		139	

From table 4 it appears that the condition shown by the 19 birds examined in both juvenal and adult plumages is usual and that adults, as a group, have lighter-colored coverts than juveniles.

The 45 males and 28 females used to study pattern of primaries were now placed into the same classes of covert pattern, as shown in table 5.

It seems clear that males do have pure white or almost white coverts more often than females. The latter may tend to have the coverts with a lighter pattern as they grow older. The overlap between males and females and again between juveniles and adults make any assignment as to sex by these patterns difficult. But the fact remains that both wing spot and pattern of coverts is partly correlated with sex, and some birds can be sexed with a fair degree of confidence.

Table 5

Sexual Differences in Pattern of Coverts

Covert pattern	Males	Females
Light	26	3
Medium	14	16
Dark	5	9
Totals	45	28

RECTRICES

In this paper the rectrices are numbered from the central pairs outwardly, 1 to 6. They vary in color from blackish brown to white. Drawings of R4, R5 and R6 from various birds are shown in figures 2 and 3. Differences in outlines indicate differences in size of adult and juvenal rectrices. Numerous rectrices were plucked or saved from any available dead bird as records of patterns.

The pattern of the rectrices, although variable, has well-fixed characteristics. R1, R2 and R3 are plain, dark feathers but R4, R5 and R6 are always patterned, and each bird shows a progressive increase in white areas from R4 to R6, the last often being entirely white. R3 may occasionally show a faint beginning of pattern as a light area at the proximal end and another at the distal end, the latter on the broad, inner web

←■ Fig. 3. Patterns shown by three outer rectrices (R4, R5, and R6) of adults. Arbitrary classes: *a, b, h,* and *i,* class 1; *c, d,* and *j,* class 2; *e, f, g, k, l, r, s,t, u, v, w,* class 3; *m, n, o, p, q, x,* and *y,* class 4; *z,* class 5; *aa,* class 6.

where it is a light, ill-defined spot. This spot approaches white in only one of the feathers examined and usually it is not present at all.

Successive degrees of increased white are shown in figure 3. If not entirely dark, R3 is of type *a*. R4 may vary from *a* through *f*, and a few are of type *g*. R5 varies among types *j* through *q*. Patterns *c* through *g* appear in both the first row showing variants of R4 and the second showing variants of R5. R5 takes up the R4 pattern at *c* and carries it beyond any variant of R4. In any individual bird, then, R5 will contain more white than R4. But following an R4 of type *a*, R5 may almost duplicate pattern *c*, but usually R5 is more white. In the row of R5 patterns (*j* through *r*), all patterns are duplicated in either the first or the third row.

Patterns observed in R6 are shown in figure 3 as types *s* through *z* and *aa*.

Quills also show a progression from black to white. The black of the quill may show reduction along with that of the pigment of the feather vane, but this is not consistent, and the black of the quill may be the only pigment left in an otherwise pure white feather.

The preceding account shows how pattern of rectrices progresses from a dark to a white feather. These patterns have been separated into six arbitrary classes in order to determine what patterns were typical for each rectrix. Unusual feather patterns are classified solely according to amount of white.

Class 1.—Feather all dark, or with slight beginning of pattern corresponding to *a, b, h,* or *i* (fig. 3).

Class 2.—Feathers with patterns *c, d,* and *j*. This is a very common pattern. In the juveniles, as will be seen, feathers approaching this pattern are difficult to classify because of blurred pattern edges. Juvenal feathers in this class may resemble *c, d,* or *j* in figure 2, or they may be of types *a* or *d* in figure 2.

Class 3.—Patterns with white running the full length of the broad web along the quill, as in *e, f, g, k, s, u, v,* and *w* of figure 3, and *c, e, f,* and *h* of figure 2.

Class 4.—These feathers show a spot on the narrow web only or on the broad web only. In most the spot is on the narrow web. There are rather few feathers on which a spot is on the broad web. In two successive plumages, the spot on the narrow web may disappear or, more rarely, it may be replaced by one on the broad web. In view of this the amount of pigment seemed more important than its exact location. Some feathers with the merest fleck of color on the broad web but with a distinct spot on the narrow web were hence put in this class rather than in the preceding one. Class 4 consists of rectrices 5 and 6. It is exemplified by *m, n, o, q, x,* and *y* in figure 3. Type *p* is aberrant and arbitrarily put in this class. From figure 2, types *g, i,* and *j* are also arbitrarily assigned to class 4.

Class 5.—This class includes all feathers that are white except for either a black quill or a small blur of terminal discoloration. These feathers are essentially white, and the reason for separating them at all is that they are so prevalent among juveniles. An example is type *z* in figure 3.

Class 6.—Feathers are pure white (type *aa*, fig. 3).

Juvenal rectrices.—It has been pointed out that the patterns described for adults can be found in some juveniles and that the juvenal pattern may carry over to some adults. But in the main, patterns of juvenal and adult rectrices are dissimilar. It is necessary to remember that the postjuvenal molt may be incomplete. Hence some juvenal feathers may persist into the second year after hatching. Unless age is known, or unless distinguished by characteristics of form or pattern, some juvenile rectrices can only be called adult. In addition, juveniles hatched early in a season molt completely, and their rectrices are like those of adults. Finally, adventitiously replaced rectrices fall between adult or juvenal types, especially if this occurs when the bird is still young.

Juvenal rectrices are narrower and weaker than those of adults (compare figs. 2 and 3). Their patterns are strongly inclined to be irregular and spotty. All available rectrices and drawings were classed three separate times to test for error resulting from intermediates difficult to place. Considering the total number of records, the results

were similar enough that it was decided to ignore the few doubtful assignments. The results are summarized in table 6.

For adults, table 6 shows that for each rectrix there is a prevalent pattern: class 2 for rectrix 4, class 3 for rectrix 5, and classes 5 and 6 for rectrix 6. For juveniles, table 6 shows that pattern of rectrix coloration is more variable and usually darker than that of adults.

Table 6

Frequency of Pattern-types in Adult and Juvenal Rectrices

Pattern	Adults			Juveniles		
	Rectrix 4	Rectrix 5	Rectrix 6	Rectrix 4	Rectrix 5	Rectrix 6
Class 1	88 (28.4%)			105 (46.5%)		
Class 2	171 (55.2%)	60 (20.3%)	2 (0.7%)	95 (42.0%)	64 (27.4%)	8 (3.2%)
Class 3	51 (16.5%)	172 (58.3%)	28 (9.0%)	25 (11.1%)	98 (41.9%)	34 (13.4%)
Class 4		63 (21.4%)	68 (21.9%)	1 (0.5%)	72 (30.8%)	82 (32.3%)
Class 5			135 (43.6%)			96 (37.8%)
Class 6			77 (24.8%)			34 (13.4%)
Total number of feathers	310	295	293	226	234	254

R4 of juveniles is easily darker than that of adults. Juvenal R5 lies midway between dark and light in pattern and the broken up, intermediate patterns of this feather are occasionally difficult to classify. The juvenal R5's were gone over more than the usual three times because of the surprising percentage in class 4 (table 6). With the tendency of the juvenile to be a little darker than the adult it seemed odd to find more of this pattern in the juveniles than in the adults. No regrouping altered this result. However, rectrix 5 cannot be considered lighter than that of the adult on this evidence. The fact is that pattern at this point in the progressive series of pattern types is highly variable, and the broad inner web is the place where the pattern fluctuates most. It shows a spot, barred in one plumage, solid in another, or spread out in an indefinite bordered area or even gone entirely. The narrow web does not show so much variation. It seems apparent that the indefinite dark areas on this feather may increase in size and clarity at the postjuvenal molt, throwing the feather into adult class 3, although such a change is in the opposite direction from the general trend. The occurrence of this is known from records before and after the postjuvenal molt.

Stability of the rectrix pattern in the individual Mockingbird.—The foregoing descriptions have shown that for each feather there is a range of available patterns and that the succeeding feather in the rectrix row will carry a feather with an increased amount of white. A bird with rectrix 4 in class 1 may have a rectrix 5 in class 2 and rectrix 6 in class 3; or the arrangement may be any R5 pattern followed by any R6 pattern. There is therefore a very wide variety of combinations found, and the question arose as to how permanent the pattern became after molt into adult plumage.

Fifty-eight birds were represented by two or more sets of feathers from different plumages. These were separated into two groups: (1) replacements made after removal and before normal molt, and (2) replacements with one or two normal molts since removal. An examination of these feathers at first seemed confusing. Some were different from the ones removed. This is not to say, for example, a rectrix in class 1 was replaced by one in class 3. Some did change from one class to the next. Some did less than that, but showed a difference within the class limits that was quite apparent.

There were 28 sets of feathers that represented plumages in two different years. In one bird four plumages were so represented. Here juvenal plumages are excluded. Of

the 28, fifteen showed almost identically corresponding patterns in two or three years. Of the thirteen birds that did not show close adherence to the first pattern, six showed two feathers resembling the first set and one differing. Two birds had juvenile-type patterns in the first set, and both on the bases of banding records could have been birds in their second season and hence carrying juvenal feathers. In the ninth case, the new set was so stained it had to be disregarded. In the tenth, all three new feathers were different in the second plumage. The three remaining birds showed adherence to the original pattern except for the addition of a spot of pigment on the broad inner web of either R5 or R6. The instability of this area in pattern has already been discussed. The spot on the narrow outer web is more persistent, but it can disappear and the next plumage then shows a spot on the broad web. This was true of these three birds. The conclusion from these 28 records of successive plumages is that a pattern is peculiar to each individual, but it may be modified by special conditions in a given season.

In 22 sets of three outer rectrices removed in spring, replacements show white areas larger in the new than in the old feathers. This may not be true of all three feathers, which under these circumstances grow at the same time, but it often is. Two sets showed an increased amount of pigment in R6 although the increased amount of white in R4 and R5 justified classification of the set as a whole as lighter. The maximum increase of whiteness might move a feather from one class to the next lighter one, but not necessarily. In a replacement for a feather in class 4, for example, a long, narrow dark spot might still be present on the outer web, but it could be shorter.

The significance of these small changes would seem slight in one bird, but with all 22 showing the same trend it seemed of some import. In House Finches (Michener and Michener, Condor, 33, 1931:12-19), we removed red rump feathers and they were never replaced with equally red ones until the next normal molt. These small feathers could be grown several times in a year, each time with less red. With long rectrices and the long time required for renewal, this point could not be tested so satisfactorily; but the change in the direction of less pigment was suggestive. However, for four sets of outer rectrices removed in August, the replacements grew at the normal time of molt and resembled the original feathers. One bird deserves special mention: Number 37.151903 had feathers removed on April 3, 1938, and again on May 20, 1938. The last set is lighter and is included among the 22 discussed above. In a set removed from the same bird on April 10, 1940, the patterns of R4 and R5 are replicas of the corresponding feathers removed on April 3, 1938. On this date, R6 was missing.

Rectrix feathers as sex indicators.—The only pattern distinction between male and female mockingbirds that seemed to have any validity was the tendency to more whiteness in the male plumage. This was thought to be generally true, but it was known that in some females R6 was all white while in some males it was patterned. In this, as in every characteristic discussed, there is no sharp and fast line between males and females, nor between adults and juveniles. But the distinctions do apply on an average basis, as shown for the tail by the following data.

For 73 of the birds providing data on pattern of rectrices, sex was known. The group consists of 46 males and 27 females. Although the ratio of males to females is unequal, the percentages as presented in table 7 indicate that R4 is almost the same in the two sexes. In R5 the tendency of the male to have this feather lighter is evident, and many more males than females have R6 in classes 5 or 6, either of which appears white to the observer.

These differences between the sexes, as also those between juveniles and adults, are of little practical use to an observer. They are, however, indicators of divergence in pattern between sexes and between juveniles and adults. The differentiation can be de-

fined as a tendency to greater whiteness in the adult than in the juvenile, and in the male than in the female. Amount of whiteness increases in successive feathers so that a bird with spread wings and tail then exposes the most conspicuous part of the pattern at the greatest possible distance from the body or at least from the antero-posterior axis.

Table 7

Rectrix Patterns of Male and Female Mockingbirds

	Rectrix 4		Rectrix 5		Rectrix 6	
	Male	Female	Male	Female	Male	Female
Class 1	20	12				
	43.5%	44.4%				
Class 2	21	14	2	11		
	45.7%	57.9%	4.3%	40.7%		
Class 3	5	1	22	12	2	4
	10.9%	3.7%	47.8%	44.4%	4.3%	14.8%
Class 4			22	4	9	12
			47.8%	14.8%	19.6%	44.4%
Class 5					2	6
					4.3%	22.2%
Class 6					33	5
					71.7%	18.5%

Barred patterns on rectrices.—Color of rectrix spots may be barred rather than solid. In the earlier analysis, such spots were combined with those of solid color to avoid confusion and because it is known that a barred area can replace a similar area of solid color, or vice versa.

In barred areas, the direction of the bars as also their width and position indicates a relationship to diurnal growth bars, that is, with the differences in conditions of feather growth between day and night. Such bars occur on the broad, inner web of R4, R5 and R6 but, in general, they are absent from the outer webs. On the broad web, the pattern is most striking and there it varies most. The influence of position of the feather in the rectrix row on pattern has already been discussed. Pattern is also influenced by rate of feather growth and by season. Evidently the relationship between color and diurnal bars in mockingbirds is not a fixed and invariable one but subject to expression or arrest depending probably mainly on factors of nutrition and on inherent potentialities of expression of varying pattern.

Records were obtained for the time required by replacement feathers to grow to nearly the length of the removed ones. Those recently replaced, but of full length, were not used because it was not known when growth stopped. If replacements were a little short of full length, it was assumed the elapsed time and the length would give the average rate of growth per day. Although it is known from other measurements that the length does vary somewhat in different plumages of an individual, this is slight. The feathers concerned here all represent spring growth, hence not growth at normal time of molt. Measurements were taken from rectrix 4. The results are as follows:

Bird	Length of feather	Time in days	Average growth per day
37.152131	11.3 cm.	44	2.56 mm.
37.137513	11.4	41	2.78
36.145875	11.0	42	2.61
35.128273	11.1	59	1.89
A284536	10.6	40	2.65
36.150059	10.5	34	3.08
35.117937	12.4	43	2.88
38.100255	10.4	37	2.80
36.143707	12.0	49	2.44
37.151903	11.7	47	2.48

There is little possibility these records record extremes, and they are introduced as evidence that growth rate does vary among individuals because there are patterns that reflect varying rates of growth. The barred feathers are the ones that show this most strikingly.

One bird, 37.125552, is represented by feathers taken on March 23, 1938, and on May 15, 1939. Both sets are fully grown. The proximal, unworn and unstained ends of these feathers are useful. Both R4 feathers show a narrow white edge on the broad web and the dark pattern shows a scalloped edge. Each scallop is the width of a clearly discernible diurnal growth bar. It is plainly evident that the width of the bars in the part of the feather with the scalloped edged pattern is different in the two feathers. In corresponding one-inch lengths, the March feather has six bars and the May feather a little less than eight. This indicates that the March feather in at least one section of its length grew more rapidly than the May feather. The pattern is of slightly different aspect because of this but the two feathers should be classed as almost identical. They are shown as types *h* and *i* in figure 3 in which row of R4 feathers they are labeled as R4*h* and R4*i*. Much more striking are some of the Mockingbird rectrices with barred patterns in feathers lighter than these. Occasionally a bird shows such strong barring that a single rectrix by itself seems hardly to belong to this species.

From the above data it seems safe to conclude that the variability in bars per inch is due to variability in growth rate of the feathers, since the bars correspond to growth in 24-hour periods.

A barred spot occurs more frequently on R5 than on R4 or R6. For information on the frequency of such patterns the rectrices of 276 birds were examined. Sixty-seven feathers showed barred spots. For twelve, the spots were present on R4, for 41 on R5, for 12 or R6. Examples are shown in figure 3, *h*, *i*, and *v*.

DISCUSSION

Mockingbirds have been pictured as showing not only a range of possible plumage patterns but an overlap of these patterns between sexes and also age groups. An exception is the streaked breast of the juvenile, which is lost early. Eye color is more strongly an indicator of age than any other easily recognized character. Juveniles commonly have a blue-gray iris, while that of adults is yellow, often a deep amber that almost suggests yellow glass in some individuals known to be males. But this difference is not infallible. We have a record of an adult female with gray eyes, and another of a juvenile still wearing the streaked breast with yellow eyes. The change to the yellow eye does not usually occur until late summer or even autumn, and the changing eye color was used to identify some birds caught in August and September as juveniles.

These characteristics of mockingbirds separate them very sharply from species that can always be assigned in age and sex at sight. Brewer Blackbirds, for example, offer no difficulty in such placement. Each one as soon as it leaves the nest is known by size and eye color as to sex and almost immediately they begin to replace primaries so that the adult difference of color between the sexes is apparent when they are very young. No mockingbird can be so assigned.

The chief conclusion of this study is that even within a single population of Mockingbirds (those of an area in Pasadena, California), there is wide variability not only in color pattern of feathers but in time and sequence of molt. There is evidence that pattern may be modified by some unknown environmental factor and later may return to the pattern stable to some degree for the individual. It seems worth suggesting that this variability should be compared with that of other Mockingbird populations and also that the variability of this highly territorial species be compared with that of

wide ranging, migratory or flocking species whose territories, if such are manifest, are at most temporary affairs. Since Mockingbird territories are more or less permanent and since the one-year old individuals appear to have a strong partiality for the vicinity where they were reared, it seems possible that most matings are between more or less closely related individuals. Inbreeding of this sort might well help to promote detectable degrees of differention between geographically adjacent groups of interbreeding individuals.

That local inbreeding occurs is suggested by selected records of juveniles banded in 1933. These young Mockingbirds were reared on territories kept under close observation and were banded before the flood of dispersing young of midsummer. All of them returned to the vicinity of their original home territories when they were adults.

C.103272, banded May 12, 1933; in records till 1939.
C.103325, banded May 20, 1933; in records till 1939.
C.103361, banded June 8, 1933; in records till 1938.
C.103371, banded June 12, 1933; in records till 1937.
C.103372, banded June 12, 1933; in records till 1937.

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SUMMARY

Records of molt show that mockingbirds may retain some juvenal wing and tail feathers until the second fall molt.

Color pattern of primaries, coverts and rectrices are described. Pattern changes from juvenal to adult plumage and the difference between male and female are studied in banded birds from drawings of wings and rectrices and from collected rectrices. The final pattern for each feather tract is due to a more or less regular increase in amount of white from feather to feather in a given row. The large range of possible patterns for each feather allows the initial amount of white to be so variable that there are overlapping patterns between the sex and age groups to such a degree that they are not of value in age or sex determination and can be described only as average differences. Males show more white than females, and adults show more than juveniles.

Occasional barred patterns on rectrices are discussed in relationship to diurnal growth bars. Growth records for replaced rectrices are given. The possible effect of variation in growth rate on pattern is suggested with illustrations from two plumages of one bird.

Banding records show the probability of local inbreeding in this strongly territorial species, and a possible effect of this on pattern is suggested.

Pasadena, California, May 15, 1951.