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INCOMPLETE FIRST PREBASIC MOLT OF MASSACHUSETTS HOUSE FINCHES

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After introduction into the New York City area in 1940 (Elliott and Arbib 1953, Aldrich and Weske 1978), the House Finch (*Carpodacus mexicanus*) rapidly increased its range, and is now a common breeding and wintering bird in many eastern states (Bock and Lepthien 1976, Mundinger and Hope 1982). Indigenous to the western United States, the eastern population is believed to be founded from southwestern California stock (Elliott and Arbib 1953, Aldrich and Weske 1978). Eastern birds have been exposed to climatic conditions different from those in their native range. Populations in the Boston area have been subject to decreased sunshine, decreased solar radiation, higher maximum summer temperatures, lower minimum winter temperatures, higher total precipitation, higher snowfall, and higher humidity than ancestral populations in southwestern California (Environmental Data Service 1968).

Introduction of a bird into an environment climatically different from that in which it originated may bring about rapid evolutionary change. Calhoun (1947) and Johnston and Selander (1964) documented morphological differentiation of House Sparrows (*Passer domesticus*) following introduction into North America from Europe, and Packard (1967) recorded conspicuous adaptive radiation in color and size in this same species. Previous research on eastern House Finches indicates that these birds have developed slightly shorter wings and tails, markedly shorter tarsi and toes, and significantly larger bills than ancestral stock (Aldrich 1982). Aldrich and Weske (1978) found eastern birds to differ in color from western birds.

I investigated the first prebasic molt of eastern birds to determine if there has been deviation from western birds. A study of molt of House Finches from the Pasadena region, California, allows comparison with ancestral stock (Michener and Michener 1940). Juvenile House Finches were maintained in holding cages to allow systematic documentation of molt progression in individual birds. Primary attention was given to sequence, variability, duration, and rate of molt.

METHODS

Juvenile House Finches were captured with traps and mist nets in eastern Massachusetts (Essex, Plymouth, and Barnstable counties) during August 1980 and June–August 1982. Age of first-year birds was determined by buff-colored feather edgings and incomplete skull ossification (Trevor L. Lloyd-Evans, pers. comm.).

Captive House Finches were held in 3 m × 1.5 m × 2 m outdoor cages exposed to prevailing weather, and were fed sunflower and mixed bird seed, vegetable greens, fruit, and mealworms. Each bird was color banded for individual identification. Molt information was recorded on British Trust for Ornithology molt cards (Snow 1967) on the day of capture and at approximately weekly intervals thereafter. Numbering sequences and definitions are those of Snow. Using the system of Evans (1966) and Newton (1966), flight feathers were scored 0 for an old feather, 1 a feather missing or in pin, 2 a feather up to ⅓ grown, 3 a feather up to ⅔ grown, 4 an incomplete feather more than ⅔ grown, and 5 a completely new feather. Primary 10 was excluded from calculations due to its extremely small size; thus, a House Finch with fully molted primaries (9 each wing) would have a score of 90. For comparative purposes, juvenal primaries retained on birds exhibiting incomplete molt were scored 5. Thus, a bird which began molt with primary 6 had an initial primary score of 50 (5 × number of primaries retained). Molt of contour feathers was summarized for lesser and median coverts, underwing, upperparts, underparts, and head.

Twenty-six birds were monitored in 1980 and 36 in 1982. Of these, 12 (5 in 1980, 7 in 1982) exhibited some degree of primary molt.

RESULTS

Sequence of molt.—Figure 1 illustrates the sequence of molt of the various feather tracts relative to primary score. A score of 50 was chosen as the starting point because most birds in the sample had begun remex molt with primary 4 or 5. Sequence of feather replacement within individual tracts was variable, and warrants more detailed discussion.

In both years, primary molt began between 13 August and 3 September. Molt of these feathers began with loss of primary 4, 5, 6, or 7. After this beginning, molt progressed symmetrically on both wings. At the beginning and ending stages of molt, the normal number of primaries growing simultaneously on one wing was 2. At the middle stage, 3 feathers were most frequently growing. In isolated cases where 4 feathers were being replaced, at least 1 was in the latter stages of growth. The rudimentary primary 10 did not molt in sequence, but dropped at the time of loss of primary 6 or 7.

Rectrix molt began approximately 7 days before primary molt was initiated. Although the number of feathers molted varied greatly, molt was generally symmetrical. Tail molt proceeded centrifugally, although adjacent feathers frequently dropped simultaneously. Individuals that molted all rectrices frequently had all 12 feathers simultaneously at some stage of regrowth. Rectrix molt was usually completed within 7 days of primary molt.

Tertial molt generally began simultaneously with primary molt. In

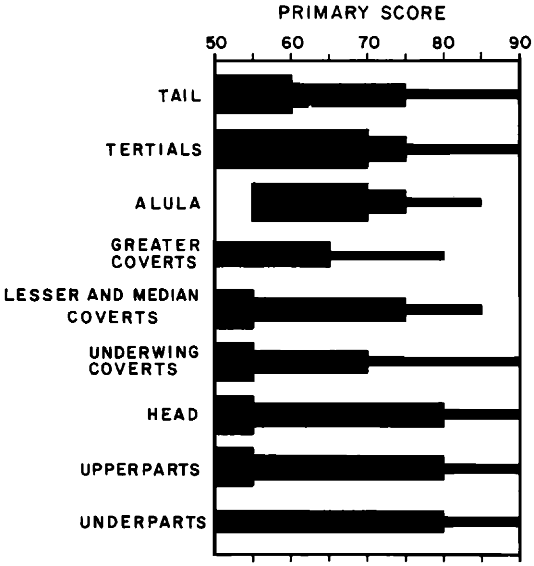

FIGURE 1. Sequence of molt of the various feather tracts relative to primary molt score. Thick line represents beginning of molt, medium line middle stage of molt, and thin line ending stage of molt.

half of the birds (n = 10) tertial molt ended within a few days of completion of primary molt, but in the remainder, growth continued for up to 21 days. Tertial molt progressed in an orderly fashion, with the middle tertial (secondary 8) dropping first, followed by the proximal (secondary 9), and finally the distal (secondary 7) tertial. Symmetry between wings was the general rule, although occasionally growth of a tertial on one wing would be ahead of its homologue on the opposite wing. Two tertial feathers on 1 wing were usually growing simultaneously; when 3 were involved the middle tertial was nearly full grown.

Molt of the alula began approximately 14 days after primary molt was initiated. Replacement was completed in an average of 20 days. Molt of these feathers was generally simultaneous, with all feathers on both wings dropping at once. In every case, replacement was complete. All individuals replaced all alula feathers.

Greater primary coverts molted immediately before or simultaneously with the primaries. Molt occurred with either all feathers dropping at the same time, or in a rough progression from the proximal to the distal feather. Replacement was complete and lasted approximately 28 days. All individuals replaced greater primary coverts.

Molt of the lesser and median coverts, underwing coverts, and feather tracts of the head, upperparts, and underparts began immediately before primary molt. Molt of the contour feathers typically began with the upperparts and underparts, followed by the remaining tracts. Replacement continued in the ending stages for several weeks after primary molt ended.

Extent and variability of molt.—Juvenile House Finches were extremely variable in extent of flight feather molt. Of 62 birds examined, 12 (19%) exhibited some primary molt, 47 (76%) molted some rectrices, and 43 (70%) molted some tertials. All birds molted contour feathers. None was observed to undergo a complete primary molt. Only 2 individuals (3%) molted secondaries. One of these, captured in September 1980, had replaced secondaries 1 and 2, and numbers 3 and 4 were in an intermediate stage of growth. Molt of the remaining secondaries progressed centrifugally and was symmetrical between wings. Due to wear on the primaries, it was difficult to determine where primary molt began. At the time of capture, primary 6 was new, primary 7 was in the latter stage of growth, and number 8 was in sheath. Primaries 1–5 showed equal wear, suggesting that replacement may have begun with primary 6. The second bird, captured in July 1982, initiated primary molt on 27 August by dropping primary 6. At the same time this bird began secondary molt by replacing secondary 1, the beginning feather in the normal sequence (Michener and Michener 1940). Although primary molt in this bird continued in normal fashion, secondary molt continued only as far as secondary 2, the second feather in the molting sequence.

The remaining birds can be placed into 4 categories based on extent of molt:

(1) Twelve juveniles molted all rectrices and tertials but failed to molt all primaries and any secondaries. Of those observed, 2 began molt with primary 4, 6 with primary 5, 3 with primary 6, and 1 with primary 7.
(2) Six juveniles molted all rectrices and tertials but failed to molt any primaries and secondaries.
(3) Nine juveniles molted all tertials, but failed to molt all rectrices and any primaries or secondaries. Individuals differed in the extent of tail molt, although all birds replaced the inner and outermost pair. Asymmetrical rectrix molt was recorded in two cases. This is probably the result of accidental feather loss.
(4) Thirty-two juveniles (51%) molted some rectrices and tertials, but no primaries or secondaries. In those individuals having incomplete tertial molt, the distal feather (secondary 7) was most often retained. Molt of the rectrices was extremely variable, with numerous combinations replaced. In each case rectrix molt was symmetrical. The inner and outermost rectrices were replaced in all but one individual.

One juvenile did not fit into the above categories. This bird molted all tertials, primaries 7–9, and rectrices 1-1, 4-4, 5-5, and 6-6. This was the only bird to exhibit some primary molt without complete molt of rectrices.

Duration and rate of molt.—During the prebasic molt all but a few body

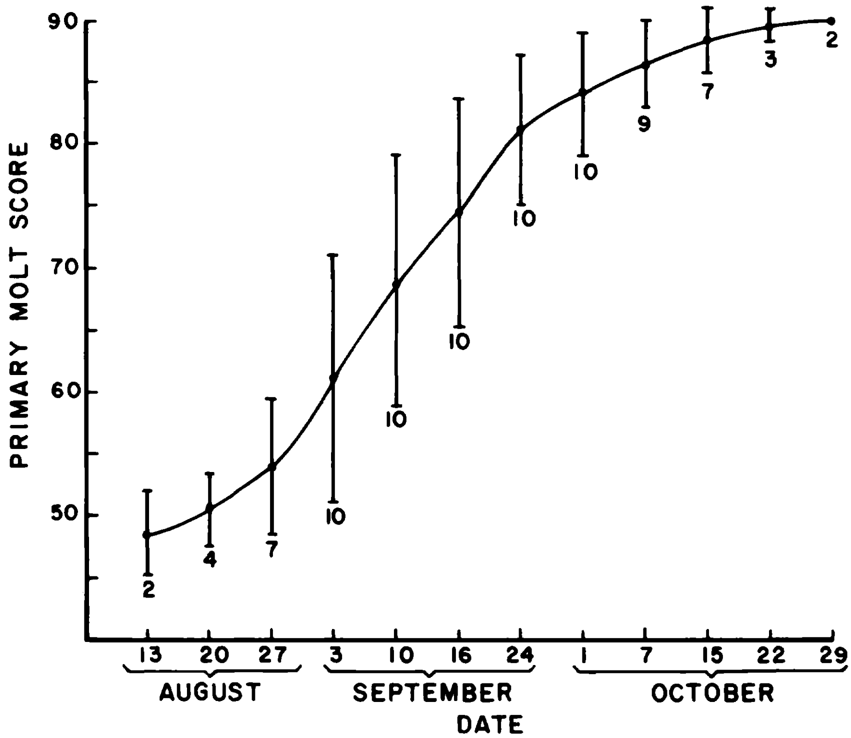

FIGURE 2. Mean primary molt score plotted against date. Vertical bars represent standard deviation. Sample sizes below bars.

feathers are replaced within the time required for primary molt. Overall duration of molt can therefore be estimated from duration of primary molt. Duration for 1982 birds is estimated by counting days between initiation and completion of primary molt. Birds which began replacement with primary 5, 6, or 7 had an average molt period of 51, 63, and 35 days. In 1980, the 5 molting birds had already dropped the initial primary at time of capture. By observing growth of primaries in other birds, I determined that it took an average of 7 and 10 days for a primary to grow to a score of 3 or 4, the point to which these birds had progressed at time of capture. By adding this period to the known span for the remainder of molt, duration is estimated. Using this method, birds which began molt with primary 4 or 5 had a molt period of 53 and 59 days. Comparison of primary scores between years and between sexes indicated that means are not significantly different (Student's *t*-test).

Linear regression of individual scores against time (Fig. 2) gives the line $y = 47.68 + .68x$, $r = .86$. A plot of the residuals indicates, however, that a linear regression does not accurately describe the relationship between molt score and time, and a curvilinear relationship should be considered.

Molt increased most rapidly in the middle stages (Fig. 2). This is probably because at this time 3 primaries were usually growing simultaneously on each wing. In the beginning and ending stages, usually only 1or 2 feathers were growing simultaneously. Slow progress in the ending stage was also the result of a linear decrease in the growth rate of individual primaries as molt progressed distally. Primary 5 completed growth in an average of 14 days, while primary 9 averaged 28 days. Longer development times of distal primaries was due to slowed rate in the latter stage of growth. Primary 9 averaged 13 days to progress from a growth stage of 4 to 5, while primary 5 required an average of 4 days. A similar pattern of slowed growth was found in the tertials, although no pattern was apparent in the rectrices.

Previous estimates of duration from banded birds have been calculated using linear regression (Evans 1966, Newton 1966, Bancroft and Woolfenden 1982, Lloyd-Evans 1983). Newton (1966) and Bancroft and Woolfenden (1982) acknowledge that molt may better fit a sigmoid curve, but found that the curved ends of the sigmoid were short in comparison with the linear portion. In the present study, however, the combined curved segments of the sigmoid are as long as the linear segment. Because molt progresses more slowly in the beginning and ending stages, linear regression may in some cases result in inaccurate duration estimates.

DISCUSSION

Duration of molt of adult House Finches in southwestern California (Pasadena region) is between 95 and 120 days, with an average of 105 days (Michener and Michener 1940). Juveniles in my study which began molt with primary 4, 5, 6, or 7 had a molt period of 52, 50, 42, and 70 days shorter than adults. Michener and Michener (1940) also found duration was shorter in juveniles which retained primary feathers. Juveniles in the Pasadena region which began molt with primary 3 or 4 had a molt period of 31 and 46 days shorter than adults. My study and that of Michener and Michener indicate that retention of primary feathers can substantially reduce duration of molt.

The striking difference between juvenile House Finches in Massachusetts and those in the Pasadena region is the greatly reduced molt of eastern birds. The Micheners (1940) found that each year some early hatched birds underwent a complete molt similar to that of adults. In 2 years of observation, I did not witness complete molt of a single juvenile from eastern Massachusetts. The Micheners found that most juveniles molted all rectrices and tertials and varying numbers of primaries and secondaries. In my study only 20% of juveniles molted some primaries and only 3% molted some secondaries. Finally, the Micheners noted only a small number of late hatched birds forego molt of the primaries. In my study, nearly 80% of the observed juveniles failed to molt any primaries. How can these differences be explained?

In adult birds, duration of molt decreases with an increase in latitude or altitude (Pitelka 1945, Evans 1966, Mewaldt and King 1978). This is an adaptation to progressively shorter summer seasons (Mewaldt and King 1978). The reduced molt of juvenile House Finches may represent a similar adaptation.

The Massachusetts study site is at a higher latitude (42°30′N) than the Pasadena site (34°30′N), and climatic conditions are harsher for the northeastern populations. Banding data (Russell T. Norris, pers. comm.) indicate that most Massachusetts juveniles fledge in early June, about 7 weeks later than do birds of the Pasadena region (Michener and Michener 1940). Results from my study indicate that juveniles in Massachusetts complete molt by the second week in October, a month before Pasadena birds (Michener and Michener 1940). Therefore, the reduced molt of Massachusetts juveniles may reflect an adaptation to a shorter summer.

Miller (1933) and Selander and Giller (1960) suggest that retention of feathers is an energy saving adaptation. If juvenile birds hatched late in the summer were to undergo a complete molt, they would be replacing feathers well into the winter. It is possible that energy requirements of molt, coupled with the foraging and climatic hardships of winter, would so stress juveniles that it might reduce survivorship. By replacing only those feathers most susceptible to wear, juvenile birds ensure fresh feathers for flight and insulation, but avoid the metabolic cost of renewing late developing and well protected feathers.

I conclude that the reduced first prebasic molt of Massachusetts House Finches is an adaptation to a more severe climate. Rapid colonization of this species in the east will permit additional tests of the hypothesis that feather retention is an energy saving adaptation. For instance, I predict that newly established breeding populations in the southeast would exhibit molt patterns similar to those of ancestral California stock. Studies of western populations at high latitudes and altitudes are also needed to elucidate the correlation between completeness of molt and climatic condition.

SUMMARY

Juvenile House Finches from eastern Massachusetts were held in outdoor cages to allow systematic check of the first prebasic molt. Approximately 80% of 62 individuals examined in 1980 and 1982 did not undergo primary molt. The remaining 20% molted varying numbers of primaries, initiating molt with primary 4, 5, 6, or 7. The effect of retaining juvenal feathers was to reduce duration by 52, 50, 42, and 70 days. Reduced duration of molt in eastern birds compared to ancestral stock in southwestern California may be an adaptation to a shortened summer season.

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