THE MOLT OF HOUSE FINCHES OF THE PASADENA REGION, CALIFORNIA

WITH ONE CHART

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Dwight (1900) describes the molts of many passerine birds and states the general pattern followed by these birds. However, for anyone with an abundance of material, Dwight's reports of variations between species and between individuals of the same species are sufficient to stir the curiosity and the desire to verify and to extend his findings. He worked with many individuals, mostly skins, each of which he observed at only one stage of molt.

Mr. and Mrs. McCabe (1928), utilizing their banded Pine Siskins (*Spinus pinus*) with practically no repeats, relate the molting of the wing coverts, secondaries, and rectrices to that of the primaries without any reference to calendar time. Magee (1930 and 1936), with banded Purple Finches (*Carpodacus p. purpureus*), has based his studies on the progress of the molt in individual birds as they have repeated in his traps during the molting season. Miller (1928), working with 377 skins of the Loggerhead Shrike (*Lanius ludovicianus*), has given the progress of the molt in the various feather tracts and has related this progress in other tracts to that of the primaries.

Miller (1933), working with 247 skins of the Phainopepla (*Phainopepla nitens*), 175 of which were males and 43 of these first-year males collected subsequent to the postjuvenal molt, found that the postjuvenal plumages of male Phainopeplas are often complex, consisting of varied combinations of juvenal feathers and postjuvenal feathers having varying amounts of black pigmentation. He gives evidence supporting his conclusion that the extent of the retention of juvenal feathers and lack of melanin in the postjuvenal feathers are inversely proportional to length of time available for the postjuvenal molt and to the age, vigor and gonadal development of the bird at the time of this molt. In many respects our findings with the House Finches parallel closely his findings with the Phainopeplas, although geographic variation must be eliminated as one of the causative factors in our case.

The present study on the molt of the House Finch (*Carpodacus mexicanus grinnelli*) parallels that of Magee in the use of banded birds, many of which were recaptured frequently. Its object was to obtain an understanding of the autumnal, and only, molt of this bird. It was carried out by observations over a period of four years on the birds handled in the banding operations of a station banding from 2000 to 2500 House Finches per year and having many times that many repeat captures. House Finches lend themselves well to such a study because they are excellent repeaters.

In this work the primaries are numbered with no. 1 as the proximal primary, and the secondaries, including the three proximal ones sometimes called the tertiaries, are numbered from 1 to 9 beginning with the most distal. This is a change from our previous system (Michener and Michener, 1938) in which we followed Dwight and others in the numbering of the primaries. Study of the papers of Boulton (1927), Burt (1929), and Miller (1928) has led to the use of the present method.

We disclaim any effort to establish new names for the feathers of any regions on the bird, but where we have felt the need of naming them we have done the best we could with the works on pterylography at hand which, we have felt, lack completeness and agreement in regard to some of the smaller regions.

Some bilateral unbalance between the molting wings or the two halves of the tail has been found, but birds showing this to a marked degree have not been used, particularly ones that seem to indicate extreme departures from the usual order of molt, because of the danger that the unbalance resulted from fortuitous loss of feathers.

We do not assume to say that the findings for our House Finches at Pasadena, California, would hold true for House Finches throughout the range of the species. On the contrary we are inclined to the belief that in some respects they would not. For this reason the scope of this paper is limited to the House Finches of the Pasadena region.

THE MOLT OF ADULTS

Although the molt of the adult House Finch follows a quite definite general order of dropping and replacing feathers within each tract and in the tracts relative to each other, observations made on many birds reveal numerous deviations from this order. In fact, the variations are so numerous and so great that any statement of the "usual" sequence of the molt should be made and received with the understanding that it might not fit exactly any particular bird. Nevertheless, there is a "usual" sequence. The difficulty is in making a statement that is sufficiently elastic and yet one that will not give the impression that there is no order.

Duration of the molt.—The molt was studied in all adult House Finches captured from May 1 to late November. With slight exceptions, the first and last indications of the molt were found to be the dropping of primary 1 and the completion of the growth of secondary 6, respectively. The time between these two events, then, is considered the duration of the molt, and to determine the length of this interval the records of a great many birds have been used as follows:

1. Where almost the entire molt histories of the individuals are available, they were either used as they stand, or they were pieced out at one or both ends by using the information previously obtained in regard to the rate of growth of remiges (Michener and Michener, 1938).

2. Where a bird that had been watched from the beginning of its molt ceased coming, its record was superimposed on the record of a bird which first came after the molt had begun and which was watched until its molt was completed, provided the two records contained corresponding points in the molt at which they could be joined. This method is not to be regarded as completely reliable but was used merely to give additional evidence.

By these methods we have concluded that the molt of adult House Finches lasts about three and one-half months (105 days), and that it may vary between 90 and 120 days. A few typical records, giving the first and last entries only, are:

35-14875, female, June 26, 1937, primary 1 gone. October 18, secondaries 5 and 6 still short. This is an observed time of 114 days to which a few days should be added for the completion of the secondaries. This is the bird that led to the conclusion that the duration of the molt may be as much as 120 days. An observation on October 27 showed the molt to have been completed. Thus it is known that the molt duration was not more than 123 days for this bird.

B-8171, male, July 28, 1937, primary 1 gone on each side. October 26, primary 9 and secondaries 5 and 6 still a trace short. This is an observed period of 90 days. A few days must be added for the completion of the growth of these feathers.

36-30697, male, July 24, 1937, primary 1 a quill. October 16, molt completed. This is an observed time of 84 days. The molt began a few days before the first date and may have been completed a few days before the last date. This is the bird that led to the conclusion that the molt may extend over as little as 90 days.

Additional evidence of the approximate duration of the molt is given by the dates of the earliest and the latest observed beginnings and endings of the molt, as follows:

Earliest date of observed beginning of molt (a female), May 15; earliest date of observed completion of molt (a male), September 20, a time difference of 128 days.

Latest date of observation detecting molt not begun (a female), August 11; latest date of observed completion of molt (a female), November 10, a time difference of 91 days.

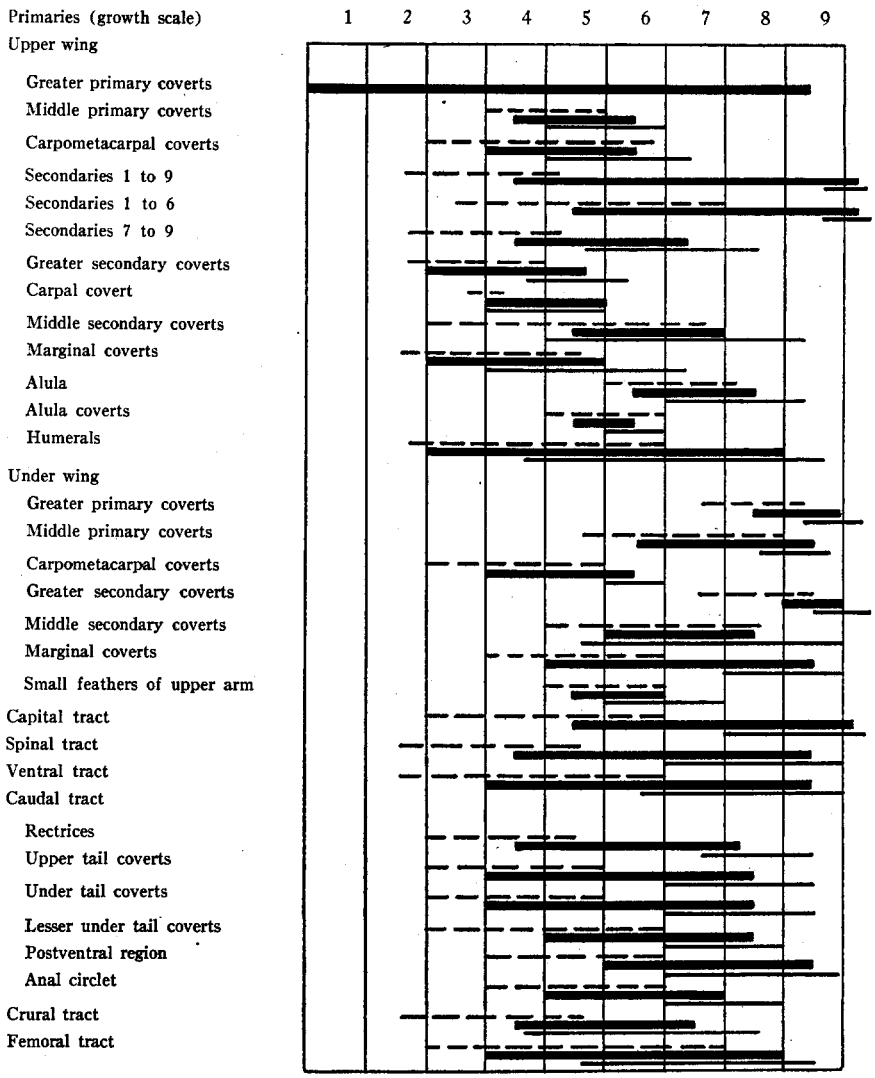

Fig. 43. Sequence of molt of the various feather tracts of adult House Finches relative to the growth of the new primaries. Dotted lines represent the range on the primary growth scale of observed beginnings of molt; light solid lines, the range of observed endings of the molt; heavy solid lines, the range in which the molt will usually be found.

Sequence of the molt.—In this work, as in that of several other writers, the molts of the feathers of the various tracts have been correlated in time relationship to the molt of the primaries. The graph (fig. 43) is an adaptation from Miller (1928, p. 411).

No thought of calendar time should be connected with this graph. The horizontal distance allotted to each primary represents the period of growth of that primary, from the time the old one falls (the extreme left) until the new one is fully grown (the extreme right). The light dotted line after the name of each feather tract indicates the range over the progress of the primary molt of the observed beginnings of the molt in that tract. Likewise the light solid line indicates the range of the observed completions of the molt of that tract relative to the progress of the primary molt. The heavy solid line indicates that usually the molt will take place in this tract while the primary molt is within the extremes marked by the ends of the line.

The positions of these lines were determined by plotting, for each feather tract, on a primary scale the same as the one at the top of this graph, the beginnings or endings (for a few individuals both) of the molt of this tract for a considerable number of birds. The earliest and the latest beginnings fixed the two ends of the light dotted line and the earliest and the latest endings fixed the ends of the light solid line for that tract. The ends of the heavy solid line were not fixed by a rigid mathematical treatment of the observed beginnings and endings, chiefly because most of the observations were not made at the moment the first old feather dropped or the last new feather reached full length and hence required a small adjustment. Giving weight to these adjustments this line was located by visual inspection of the chart sheet so that its length included most of the beginnings and most of the endings, leaving out only the unusually early beginnings and the unusually late endings of the molt. Further, this location was checked against the general impression gained by the examination of many birds during four molt seasons. For emphasis it is repeated that the heavy solid lines indicate for each tract that the molt of that tract usually will take place while the progress of the primary molt is between the two extremes of this line. For example, reading from this graph, the fall of the first rectrix has been observed to occur at many points in the primary molt between the falling of primary 3 and "primary 5 one-half grown"; the completion of growth of the last rectrix has been observed to occur at many points in the primary molt between "primary 7 two-thirds grown" and "primary 9 one-half grown"; and the rectrices usually molt while the progress of the molt of the primaries is between "primary 4 one-half grown" and "primary 8 one-fourth grown."

Primaries.—This graph, showing the time relationship between the molts of the primaries and of the other feather tracts, does not completely represent the molt of the various tracts. The primaries in particular should be discussed further. The molt begins with the loss of primary 1, the proximal primary, or with 1 and 2 at the same time. Sometimes 1, 2, and 3, and seldom 1, 2, 3, and 4 are gone at the same time. In one bird 1, 2, 3, 4, and 5 must have fallen at the same time, for they were found to be the same length when primary 6 was gone. Exceptions to the primaries being the first to fall are, occasionally, the loss of some or all of the upper greater secondary coverts and extremely rarely the loss of some or all of the upper greater primary coverts before any primaries are lost. After this beginning, the molt progresses through the primaries in a rather orderly sequence. It is unusual to find more than four primaries on one wing molting at the same time, six being the greatest number recorded, and when four or more are involved, more than half of them usually are nearly full-grown new feathers. The most common condition, about half the total, is that of two primaries involved at the same time. Of 389 adult birds studied for this purpose by plotting the condition of the primaries at the time of trapping, 2 had 6 primaries involved in the molt, 2 had 5, 19 had 4, 58 had 3, 200 had 2, 102 had 1, and 6 had none, that is, all nine primaries were present and fully grown, the proximal ones being new and the distal ones old.

At this point it seems pertinent to discuss the number of the primaries. Although we have not dissected or determined the attachment of the feathers, there is in the House Finch an extremely small feather, shorter than, and concealed under, the small upper ninth primary covert, which we regard as the rudimentary tenth primary. Its length averages approximately 6.3 mm. and that of the small overlying covert about 7.9 mm. We can find no tenth covert. This seems to be exactly the condition Miller (1928) found in the Loggerhead Shrike which, however, has one more primary than the House Finch.

Upper greater primary coverts.—This row of feathers is usually extremely regular in its relation to the primary molt. As the primaries begin to fall, each upper greater primary covert drops with the corresponding primary and is replaced at once, being fully grown when the primary is still short. Extremely rare exceptions are the few where all primary coverts dropped before the primary molt began. However, the statement that each falls with the corresponding primary needs modification as the distal end of the row is approached. The small ninth feather of this tract is, in all cases observed, dropped before the ninth primary. It falls when the seventh, or more often when the eighth, primary is gone and the small rudimentary tenth primary falls just after the renewal of this small ninth covert so that these two small feathers are, in all adults observed, replaced before primary nine falls. Associated with this departure from the rule, a lag is noted in the falling of the eighth, and sometimes of the seventh, upper greater primary coverts, these falling distinctly after the primaries beneath them. This is especially true of the eighth.

Because of the synchrony of the molt of these coverts with that of the primaries, no lines of observed beginnings and endings are shown on the graph.

Upper middle primary coverts.—These small feathers molt so nearly all at the same time that the order of molt within the tract seems of little moment. In at least some of the observed cases, the molt progresses from the proximal to the distal end and follows closely that of the carpometacarpal coverts.

Upper carpometacarpal coverts.—This small group of feathers, lying at and near the edge of the upper surface of the wing distal to the alula, molts just preceding, or occasionally with, the upper middle primary coverts. These also do not progress in orderly fashion but in most cases the new feathers seem to appear at one time. The first pinfeathers, however, are at the proximal end of the tract. We are not sure of the proper name for this group of feathers. Boulton (1927, p. 397) and Dwight (1900, p. 92) include these with the corresponding feathers on the under side of the wing in the carpometacarpal coverts. Miller (1931, p. 127) marks these as marginal coverts. If they are to be called marginal coverts, it should be stated that they molt a little later than the marginal coverts of the patagium.

Secondaries.—The graph, in addition to showing the whole secondary tract, numbers 1 to 9, also shows separately the two groups, numbers 1 to 6, inclusive, and 7 to 9, inclusive, because the latter group is sometimes called the tertials. Number 1 is the distal and 9 is the proximal feather. The molt in this tract begins with the fall of secondary 8, or rarely 8 and 9 fall at the same time, commonly about the time that primary 4 is half grown. Number 7 is considerably delayed, often being missing when primary 6 is lost. About this same time, relative to the primary molt, secondary 1 is dropped and from this point the secondary molt usually proceeds in a consecutive, orderly manner, but sometimes two or even three adjacent feathers may drop almost together and the rest be delayed for some time. Occasionally, even more irregularity than this occurs and number 6 falls and is replaced at the same time as 7, and in one instance 6, 5, and 4 fell when 7 fell and grew to full length before 1 fell.

Upper greater secondary coverts.—This tract is usually in molt between the falling of primary 3 and the stage when primary 5 is two-thirds grown; sometimes it shows an orderly gradation from new, full-length feathers proximally to pinfeathers at the distal end of the row, but much more often all drop at almost the same time. They are replaced rapidly.

Carpal covert.—The one carpal covert falls and is replaced as if it were a member of the upper greater secondary covert row, almost always after, but in a few cases before, the most distal feather of that row.

Upper middle secondary coverts.—These are distinctly later in molt than the upper greater secondary coverts, usually beginning about the time that primary 5 is one-half grown. They fall and are replaced rapidly with little order in their sequence. However, there is a tendency for the feathers to be younger distally in at least some of the cases observed.

Upper marginal coverts.—This tract is one of the first to show that the molt is extending beyond the primaries and upper greater primary coverts. These coverts are here limited to the upper surface of the patagium, the region between the alula and the humerals. The rows of new quills do not first appear at the border but below it, and the progression is downward, sometimes almost the entire area being in pinfeathers at one time. The rows nearest the border are always the last to be renewed.

Alula.—The alula, in almost every case, is found to drop and replace its feathers as the upper middle secondary covert molt reaches the distal end of the row and after the replacement of the alula coverts. The molt progresses distad.

Alula coverts.—The replacement of these follows immediately the completion of that of the upper marginal coverts.

Humerals.—The molt of the humerals progresses from anterior to posterior. This group often shows new quills at the anterior end when new ones first appear in the upper marginal coverts.

Under greater primary coverts, under middle primary coverts, under greater secondary coverts, and under middle secondary coverts.—With all of the coverts of the under wing it is difficult to time the molt exactly, for the feathers are small and those of each row are renewed almost at the same time. The new feathers look so like the old ones that it is difficult to be sure that the molt of the row is completed unless an individual bird can be examined frequently during the process. In spite of this it has been determined that in these four rows the molt progresses from the proximal to the distal end as shown on the graph. Perhaps it should be said that the first pinfeathers of each row appear proximally, and then the entire row appears to develop at the same time.

Under carpometacarpal coverts.—These are replaced almost simultaneously with the corresponding upper coverts and are the first of the under coverts to be molted. The molt progresses distad.

Under marginal coverts.—The progress of the molt in these feathers is proximad, with the long ones closest to the body being replaced last but before the completion of the under greater secondary coverts. There is considerable variation in the completion of the molt of these border feathers. Sometimes the entire row is of the new, full-grown, short feathers with the alternating long ones gone but growing out later. In other cases the long ones seem to keep pace in development with the short ones. The last to grow are always the most proximal long ones.

Scattered feathers of the under surface of the upper arm.—It is only in Dwight (1900, p. 92) that we find mention of these feathers. They are small, few in number, easy to find, and are usually molted between the time that primary 5 is one-half grown and the time that primary 7 is lost.

Capital tract.—Birds differ greatly in the appearance of the head during the molting period. Usually pinfeathers show first in the frontal region and from this point the molt extends back through the coronal region. The entire top of the head may be thick with new feathers at one time or, on another bird, the feathers may grow only a few at a time, thus keeping the head rough in appearance over a long period. In any case, the occipital region is long delayed and may fail to show new feathers when the appearance of the bird suggests that the molt is almost completed. The malar, loral, ocular, and auricular regions will be found a mass of young feathers as the molt of the primaries is practically completed. The feathers of the eyelids molt about the time that primaries 6 and 7 are molting and the molt progresses anteriorly.

Spinal tract.—This tract shows quills first in the interscapular region. The molt progresses caudad and sometimes seems to unite with molt radiating from another center in the pelvic region. The entire back and rump are often full of pinfeathers at one time. In other birds the molt seems to progress from the interscapular center of origin over the entire tract in more orderly fashion. This is a large tract and much time is required to complete its molt but it is uniformly ahead of the ventral tract in completion. The cervical region of this tract is late in developing new feathers.

Ventral tract.—The molt in this large tract requires a long time for completion (about two months), during the greater part of which all stages of feather growth can be found in the breast where the molt of the tract is first observed as a single row of pinfeathers on each side. The extension of the molt of this tract with reference to the primary molt is more variable than in any other tract. The axillar region is late in molting and the interramal and submalar regions are a mass of young feathers as the primary molt is practically completed.

Rectrices.—The first tail feathers to fall are the middle pair. Apparently the normal procedure is for pairs to drop in regular succession thus giving in the early stages of the molt a forked tail, then a wedge-shaped tail, a rounded tail, and a normal tail as the molt progresses to completion. However, it is not unusual to observe two or even three of the inner pairs missing at the same time. The young growing tail feathers are easily injured and lost and replaced. Many peculiar tail shapes result from such losses.

Upper, under and lesser under tail coverts.—Whatever variation there is in the time of beginning the molt of the rectrices will be almost exactly duplicated in the beginnings of the molts of the upper and the under tail coverts. These begin to fall at the time the middle rectrices fall, or sometimes even before. The molt of the upper tail coverts is usually ahead of that of the lower by a small margin. The sequences of molts within these rows appear to have considerable irregularity, probably at least partly because of the ease with which the partly-grown feathers are fortuitously lost. However, the normal sequence in each row seems to be from the middle pair outward, as with the rectrices. Although these are short feathers, they do not appear to be fully developed until near the completion of the outer rectrices.

The molt of the lesser under tail coverts (Miller, 1931, p. 128) is slightly later than that of the upper and under tail coverts. All feathers of this row seem to molt at the same time.

Postventral region.—The molt of this small region is late, following that of the anal circlet. It precedes the completion of the molt of the ventral tract.

Anal circlet.—The feathers of this region are rapidly renewed, apparently all at the same time, before the completion of the molt of the ventral tract.

Crural tract.—The molt of this tract is not easily described as progressing either distally or proximally. A great many new quills appear almost simultaneously in the

fleshy region of the leg. The appearance of additional new feathers progresses both distally and proximally. Often the most proximal are the last to be developed.

Femoral tract.—The molt of this tract starts uniformly later than that of the humeral tract and, like the humeral tract, the appearance of new feathers progresses posteriorly.

Exceptionally late molting adults.—As stated in a previous section, the duration of the molt of an adult House Finch is from 90 to 120 days. However, a few have been observed which have begun the molt so late and in which the portion of the molt observed has developed so rapidly that we are led to think that their total molt period might be appreciably less than 90 days. In the birds beginning to molt before midsummer there is a considerable time when only the primaries and the upper greater primary coverts (except in rare cases) are involved. In exceptionally late-molting adults this delay in starting the molt in other tracts is partly or entirely eliminated. Two examples are given.

An adult female captured on August 15, 1939, had primaries 1, 2, and 3 all short. It also had pinfeathers in upper marginal coverts, carpometacarpals, humerals, ventral tract, crural tract, femorals, tail coverts, and head. All the upper greater secondary coverts except one were gone. The molt might have been completed in less than 90 days. This bird was banded as an immature in July, 1935, hence was four years old.

For comparison the following records typical of the more usual molt are offered.

34-87930. Primary 1 gone on July 16. Retaken August 16 with primary 3 gone. No evidence of molt in any other tracts except upper greater primary coverts.

36-30336. Taken June 16 with primary 1 gone. August 1, primary 4 gone. No other tracts involved except upper greater primary coverts.

Another extremely late-molting bird was at least seven years old. It showed no sign of molt on August 11, 1939, had one primary gone on August 15, and on October 11 had primaries 1, 2, 3, 4, 5, and 6 new and full length, 7 one-half length, and 8 and 9 old. Secondary 1 was new and full length, 2 a short quill, 3, 4, 5, and 6 old, 7, 8 and 9 new. Molt of rectrices was complete except that the two outer pairs were still short. Molt was in progress in practically all the other feather tracts, whereas normally it would have been completed in several of them at this stage of the primary molt. The new colored feathers were yellow, the old ones red. This is our first observation of an adult male changing from red to yellow in the normal molt, although we knew that old males sometimes do this. Yellow adult males are not rare but we know many of them are first-year birds that were hatched late the previous breeding season. We think there may be some causative connection between old age, late molting, and the yellow color. Most of the adult birds leave us by mid-autumn, presumably to join in the large flocks in the open fields. Extensive collecting from these flocks might reveal a larger proportion than we have found of unusually late molting adults.

For convenience we are using in this paper the words red, yellow, or dull yellowish to indicate the general colors without attempting to give the exact nomenclature. In two of our previous papers (Michener and Michener, 1931 and 1932) these colors have been extensively discussed.

THE MOLT OF IMMATURES

Method of study.—The molt of the immature House Finches is more difficult to follow than that of the adults because relatively few young remain long enough for observations on the entire process and because many molt patterns are found in them. To get evidence of the process in many birds, over 2000 young were marked when first captured by snipping a few barbs in each primary, secondary, and rectrix on the right

side, thus leaving these feathers marked by a small notch until they were replaced. Some of these birds remained in the vicinity and repeated often for observation but great numbers of them apparently went away and returned at greater intervals during the time prior to their first postnuptial molt. They have shown us how extraordinarily variable is the molt of the immature House Finch. Feather notching was begun in 1935 on relatively few birds and was continued through 1936 and 1937, over 1500 being so marked in 1937.

Breeding season, and the age of immatures.—In discussing the molt of the immatures the breeding season of the House Finch is, of necessity, the first topic. The first young birds are captured in late April and the latest date on which an immature still showing natal down has been caught is September 16. Throughout this study a bird with natal down has been regarded as very young, for in the many handled repeatedly none has retained it more than a few days after the first capture. All immatures early in the season are, of course, of approximately known age. Later, the ones with natal down can be separated as younger and this has been our criterion of age although, as the season advances, the older young show fading and wear of the tawny-olive feather edgings and molt earlier than the late-hatched broods. By late August an immature with no molt in progress is quite certainly a late-hatched bird, but even at this season we have had enough young with natal down to lead to the conclusions we have drawn in this paper.

Extent and sequence of the immature molt.—The most striking feature of the molt of immatures is the great variability between different individuals in the extent of the molt in the wings and the tail. This variability is definitely correlated with the time of hatching for the various birds, but the time of hatching is evidently not the only factor influencing these variations since all young of the same age do not follow the same molt pattern. The general type of variation is that of refraining to molt increasing numbers of wing and tail feathers as the time of hatching advances. For convenience of presentation the birds will be divided into groups based on types of molt pattern rather than on dates of hatching.

There is sometimes irregularity between the two wings. For example, carefully watched birds were known to molt one more primary on one side than on the other, and this was true of secondaries and occasionally of greater primary coverts.

Immatures following molt pattern of adults.—Each year some of the first hatched young are banded in the latter part of April and repeat in our traps at frequent intervals throughout the summer and fall, thus allowing the entire molt to be observed. Their molt begins later than that of the first adults to molt, but in many of them the extent and sequence of the molt is the same as that of the adults. One typical of the group was banded on April 21. On July 18 primaries 1, 2, 3, and 4 were growing in. It repeated frequently for observation and the record of a complete molt ends on October 22 when secondary 6 was still a little short. Our evidence is that only the early-hatched young, and not all of them, molt in this way. The males of this group show the colored areas as red in the postjuvenal plumage.

Immatures that molt all rectrices and secondaries 7, 8 and 9 but fail to molt some or all primaries and secondaries 1 to 6.—This is a numerous group with many possible combinations of old and new feathers in the primaries and secondaries 1 to 6 after the postjuvenal molt period is completed. Old and new feathers in all cases mean notched or unnotched, hence juvenal and postjuvenal, feathers, respectively. Although the list of observed combinations fills several pages, it is probable that we have not found all that are possible.

In the birds of this group the first sign of the molt usually is not found in the primary tract, but the molt may begin almost simultaneously in many tracts. The upper marginal coverts, ventral, dorsal, crural and humeral tracts may show pinfeathers before the primaries begin to drop. A few begin the primary molt with no. 1 and retain some juvenal secondaries, and a few begin the secondary molt with no. 1, but the great majority fail to molt a few of the proximal primaries and a few of the distal secondaries until a year later at the first postnuptial molt. The entire process is compressed in addition to the omission of the renewal of a number of primaries and secondaries, the degree of compression and omission being proportional to and depending largely upon the lateness of hatching. Instead of the upper greater secondary coverts preceding in molt the upper middle secondary coverts, they both molt together. In the most compressed cases almost all tracts show molt at the same time. The upper greater primary coverts are not molted unless the corresponding primaries below them are molted. Aside from the unmolted secondaries, primaries and the upper greater primary coverts, the molt seems as complete as that of the adults but the time necessary is considerably reduced. The two examples of usual adult molt given in the section on "exceptionally late molting adults" show 31 days between the dropping of primaries 1 and 3 and 46 days between the dropping of primaries 1 and 4 and in neither case had the molt started in other tracts except the upper greater primary coverts. The inference is that an immature starting the primary molt with no. 3 or with no. 4, after having started the molt in many other tracts, will have a molt period in the order of 31 or 46 days, respectively, shorter than did these adults. There seems to be some rule of expediency in operation which we do not fully understand, but which appears to be largely influenced by the time available between date of hatching and early November, beyond which we have not found evidence of the molt continuing.

The extent of the variation in the numbers of primaries and of secondaries 1 to 6 that may be molted at the postjuvenal molt by birds that molt all rectrices and secondaries 7, 8, and 9 at that time is best explained by a statement of some of the combinations which this work has shown may occur. Some birds renew practically all these feathers. We record: All new except secondary 2; all new except secondaries 2 and 6; all new except primary 1 and secondary 2. The great majority retain some of the old proximal primaries and distal secondaries such as: Primaries 3, 4, 5, 6, 7, 8, and 9 new with a varying number of new secondaries: 6; 5 and 6; 4, 5, and 6; 3, 4, 5, and 6; 2, 3, 4, 5, and 6; 1, 2, 3, 4, 5, and 6. This same range of secondary variation holds for birds with only primaries 4, 5, 6, 7, 8, and 9 new and with only 5, 6, 7, 8, and 9 new. Occasionally the sequence of the new secondaries is disturbed by one or more old ones interspersed.

The greater number of birds molting in this manner begin the primary molt with no. 4 or no. 5. As the number of primaries molted decreases, the number of new secondaries also decreases, sometimes to none other than 7, 8 and 9.

There are instances in this group of birds of primaries 8 and 9 and even 9 alone being the only ones molted.

In this group of birds the molt of the upper greater primary coverts, each of which normally molts only when the primary beneath it molts, occasionally has irregularities other than the curious lag of nos. 7 and 8 as observed in the adults.

The rudimentary primary 10 and its covert molt, as in the adults, ahead of their order in their respective rows.

Immatures that molt no primaries or secondaries 1 to 6 and fail to molt some or all rectrices or secondaries 7 to 9.—This group is not separated sharply from the previous group. Whereas we have no record of a bird molting any primaries that failed to molt

all 12 rectrices, we do record one which replaced no primaries and did replace secondaries 5, 6, 7, 8, and 9, and rectrices 1-1, 2-2, and 6-6. Another replaced no primaries; it did replace secondaries 7, 8, and 9, and rectrices 1-1 and 6-6, which places this bird properly under the above heading. This pattern of the molt of the rectrices proved to be rather common. Another molted secondaries 7, 8, and 9 and rectrices 1-1, 2-2, 3-3, 4-4, and 6-6, but no primaries. These partial molts of the rectrices are as common as they are of the primaries and secondaries. In all cases, where any of the rectrices were molted, secondaries 7, 8, and 9 were also. Some of the late young returned with all rectrices, primaries and secondaries, except 8 and 9, or 9, unmolted.

Immatures that molt none of the primaries, secondaries or rectrices.—This group of very late-hatched birds is small in number. One (36-67246), banded on August 12, showed no sign of molt at almost daily observations until August 30 when a few pinfeathers were found in the upper middle secondary coverts. By October 18, except for the last traces about the head, the molt was completed, and the bird carried all the notched flight feathers. This, allowing a few more days, was well within two months for completion of its molt.

Another (36-67649), banded on September 16 while still with down on its head, was molting in the ventral, dorsal, upper greater and middle secondary covert tracts. On September 26 there was a trace of yellow on its head. By about November 1 it had completed its short molt into male plumage of such dull color that no one would have called it a male if seen free.

Comparisons of the probable dates of hatching of young and of the ages when their molts began is pertinent. The first, banded on August 12 without natal down on the head, waited 18 days before its molt began while the second, banded on September 16 with natal down, was then in active molt.

In the birds that molt no rectrices, primaries or secondaries, we have found the small ninth primary covert and the rudimentary primary ten molting in some cases. This was suspected from the color of these feathers before it was actually observed. It does not seem to occur in all cases.

In 1938 two of the latest-hatched birds captured were left in a large cage, because of the uncertainty of recapturing them frequently, to see if greater disparity between the molt of the adults and that of the latest-hatched young could be found. One of these (38-97120) was banded September 30 while in the early stages of its molt. The other (38-97152) was banded October 12, its molt being less advanced than that of the first. In each bird all the tracts that molted any feathers were involved at the same time. In 38-97120 there was no molt of any of the under wing coverts and the two distal feathers of the alula were not molted. In 38-97152, even more of the juvenal feathers were not molted. On the wing it renewed only the more proximal of both the upper greater and upper middle secondary coverts, the alula coverts and the most proximal of the three alula feathers. In addition to shortening the molt period by omitting the molt in some of the tracts, these two birds, by finishing their molt of the dorsal and ventral tracts in much less time than required by adults, lead to the thought that the molt of some of the feathers of these tracts also may have been omitted. Further observations would be necessary to settle this point.

In the areas normally red in adult males both these birds molted to a dull yellowish tinge, and the areas so colored were much smaller than the normal colored areas. Except in the hand they would be regarded as females.

The colors of the male postjuvenal plumages have been observed to vary all the way from the reds of the adults to the dull yellowish tinge of the late-hatched birds de-

scribed above, this gradation from red downward following in general the increase in the number of juvenal flight feathers retained after the postjuvenal molt, although there is a wide variation of color for any one molt pattern. The birds having the dullest postjuvenal plumage are often the first to start the first postnuptial molt.

We hardly can assume that we have caught the latest-hatched House Finch. Is it not possible that even later ones or birds hatched earlier in a harsher climate might fail to acquire even a trace of yellow at the postjuvenal molt? This is a possible explanation of the first winter males from the Charleston Mountains, Nevada, as reported by van Rossem (1936, p. 52), that were in the female type of plumage. Plumage color has been our only criterion of sex differentiation. All birds with dull yellowish or brighter colors on head, rump and throat have been called males. Those with dull yellowish on rump only, in addition to the normal female plumage, have been called females. Many of them have been known to be females. Obviously, dissection, to determine sex, at the first capture would preclude following the sequence of the molt in that individual and to dissect a bird after it has been repeatedly in hand over a long period during which it gives many evidences of becoming acquainted with and placing trust in its captors is not within the realm of our activities. So the most we can say is that from our own work we do not know of any male House Finch having a postjuvenal plumage without some trace of red or yellow. However, Moore (1939, pp. 180-181) in his studies of a large number of specimens finds in the coastal group of House Finches, which group includes those of our region, 1.2 per cent of the first winter males in the female type of plumage as compared with 7.4 per cent in the desert and plateau groups.

Effect of environment on plumage.—For some years our work on feathers has focused our attention on the effect of environmental changes on the plumage of individual birds. The bars that may show in all plumages and that become especially marked in any replacements made later than the normal molt, and the bands on juvenal feathers produced by any marked change in the bird's life are discussed in our last paper (Michener and Michener, 1938). The color of the male House Finches, particularly after the postjuvenal molt, and the adjustment of the number of feathers molted to the date of hatching are additional evidence of the flexible characteristics of the feathers of birds and of the importance of the annual postnuptial molt in holding the species to its characters. In all cases in which there are bands, overly strong bar patterns produced as winter replacements, shorter and paler flight feathers left unmolted after the postjuvenal molt, as well as yellow or yellowish brown on the male young of the year, these characters are replaced by the normal in the postnuptial molt. This restoration of the characters of the species is as impressive as the variation.

Our work is entirely with the population visiting one city lot from unknown distances in the surrounding area. Nevertheless, we have given considerable thought to the possibilities in the other members of this widespread species. It is, therefore, a great satisfaction to read Moore's paper (1939) in which he points out the numerous divisions of the subgenus made largely on the basis of plumage.

Molt studies of a species often offer a basis for the understanding of many events in the history of an individual by the examination of its plumage. Also, as shown by Miller (1933), the time of molt and its effect upon the postjuvenal plumage, if any, is worthy of study particularly with reference to the same species in different localities. Roberts (1932, p. 691) reports that Brewer Blackbirds in Minnesota molt from immature to adult plumage in late summer. Our many records show that the Brewer Blackbird here begins the postjuvenal molt as soon as or even before parental care ceases in the latter part of May at the earliest. By June the molt is evident in most of the immatures and

adults captured. May it be that when the same species molts at different times in different localities changes tending in the direction of race differentiation are in progress which might be detected by thorough molt studies, and might such molt studies of the different races of House Finches prove intensely interesting?

Molt observations on some other birds.—While studying the molt of the House Finch, we have handled many other species and have marked the wings and tails of all late-hatched young caught. The late-hatched young of Song Sparrows, Mockingbirds, California Jays, California Towhees, and Spotted Towhees do not molt all the flight feathers while the young of the earlier broods do. The number of notched feathers remaining until the postnuptial molt has varied in different individuals and we do not know at this time the extent of such variation.

On the other hand, immature Brewer Blackbirds and English Sparrows have never been observed to vary in any way from a complete postjuvenal molt. The immature blackbirds are comparable in age to the first young House Finches which we catch in April. These House Finches show no evidence of molt until July but the young blackbirds are beginning to molt at the time the parents cease feeding them, the earliest in the latter part of May. But the English Sparrows are hatching young throughout the spring and summer and in no case have we found one that did not complete its postjuvenal molt.

For a number of years we have watched warblers for evidence of the postjuvenal or postnuptial molt. We capture a few on the northward migration after the House Finches are nesting and almost at the time the earliest molting House Finches are beginning the molt. The warblers return as stragglers in July and August and many more in September at the height of the House Finch molt but none has shown even the last secondary short. The molt must be for them much more rapid and at a more definite time than it is for the House Finches.

SUMMARY

This work is based on observations over a period of four years on the House Finches handled at a banding station banding from 2000 to 2500 House Finches per year and having many times that many repeat captures.

Subsequent to the postjuvenal molt the annual autumnal or postnuptial molt is the only molt of the species.

The postnuptial molt is complete. It begins with the falling of primary 1 and ends with the completion of secondary 6; the time required is approximately 105 days, varying from 90 to 120 for different individuals. This molt has been observed in progress from May 15 to November 10.

There is a general sequence of molt of the feathers in a tract and of the tracts relative to each other, but there are also many variations from this sequence.

The extent of the postjuvenal molt was studied by notching all flight feathers on the right side of over 2000 juveniles.

The postjuvenal molt of the early-hatched young was found to be the same as the postnuptial molt of the adults while the latest-hatched young shortened the molt period by beginning the molt soon after leaving the nest, by retaining all juvenal flight feathers, and by molting all the other tracts more nearly at the same time. Those hatched at intermediate times varied the time of beginning the molt relative to age, molted a varying number of the flight feathers, and compressed the molt of the other tracts proportionately to the time available between the date of hatching and early November.

Although there are individual differences, it is generally true that the postjuvenal male plumages are red on the head, throat and rump in the earliest-hatched birds and in those hatched successively later, these areas are less and less red and then less and less yellow until the latest hatched show only a dull yellowish tinge.

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