

VARIATION IN COLOR OF MALE HOUSE FINCHES*

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Descriptions of the California House Finch (*Carpodacus mexicanus frontalis*) are quite uniform in recognizing that orange occasionally takes the place of the typical red in the color of the males. Bailey⁽¹⁾, Hoffmann⁽²⁾, Dawson⁽³⁾ and Wyman⁽⁴⁾ all mention this in their descriptions of the species. The fact that the range in color is far wider than this is recognized, if not in the general literature on the subject, by all ornithologists and by many who are merely bird lovers.

As previously stated (Condor, xxviii, 1926, p. 254), our banding work early led us to an interest in the color variation of this species, and, almost immediately, to the taking of notes on the color of each male House Finch. We soon felt this method cumbersome and inadequate, especially so because more than one person was engaged in the work, and notes on color, even by the same person, have a tendency to be extremely difficult to visualize at a later date.

It, therefore, was decided to preserve actual feathers for comparison and these were taken from the rump feathers, of which a few can be removed with apparently no discomfort to the bird. If the color on the head or chest varied from the rump, or if for any other reason a note on the coloring seemed desirable, these, together with the bird's number and the date, were written on the paper in which the feathers were wrapped. When a number of such samples had been collected they were transferred to sheets of paper, one for each bird represented by a feather sample. In addition, the date and band number of each sample was entered in a card index, and whenever a male linnnet was captured a glance in the index told whether a sample had been taken during the previous three months. If not, a new one was taken.

For the purpose of studying the colors this method has both defects and advantages. The great advantage is that it permits the study of the same bird in different plumages under natural conditions, provided the bird returns one or more times with intervening molts. We have had one of these birds in six successive plumages, and since linnets are reported as always turning yellow in captivity, it seemed worth while to follow their colors in the wild state. This we have had an unusual opportunity to do because of the large number handled in our banding operations. A total of 1982 plumage samples collected from 1563 male House Finches, 337 of which are represented by samples for more than one year, is considered in the present study.

The defects of the method are that it compels the collection of a great quantity of material because it is never known which birds will return and that there is a possibility that plucked feathers will be replaced by new ones of a different color, which at the next capture would be plucked and cause confusion. However, we think that such evidence as we have indicates that replacement feathers are the same color as those replaced. We have more than fifty birds from which samples were taken more than once during a year; from some, five or six times, but in none of these has there been any reason to think that the color has been changed by the plucking. As a matter of fact, the same feathers were not sought for this study. The effort was only to get the color shown by the bird. We have one instance of a bird which was red, but a rather pale red, in November, returning in June with head and breast red and the entire rump yellow. We did wonder if this could

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have been due to replacement following an injury, but we now feel that this could not have been the cause.

This House Finch returned to us for four years after he was found with these yellow feathers in June where pink feathers had been in November. The next year we have only one sample of his plumage taken in March. It is red, rather a light orange red, Carnelian according to Ridgway's Color Nomenclature, and a year later, in March, it is the same. The next year we have two samples, but close together, one in September and one in November, both of the same Carnelian red, and the last year's plumage was the same red in November, but in February there is much dull yellow mixed with it. Our notes say: "General effect more yellow than pink", so again this bird has turned to yellow in the spring. We have found in a number of cases that the earliest pink feathers in July or August have, in a month or two, turned more yellowish and this yellow tone is maintained for the year's plumage. We feel that this bird, in two of the five years for which we have records, offers the most pronounced case of this tendency in our records and that the change could not have been due to replacement.

Before comparing different plumages from year to year we wish to speak of the variation in a single year. There is frequent reference to this in the bird books. Bailey⁽⁵⁾ says the red areas are much brighter and deeper in summer than in winter. Dawson⁽³⁾ describes the male "in highest spring plumage". McGregor⁽⁶⁾ refers to the "indescribable lustre which is only ascribable to intensification or addition of pigment", and he refers to Keeler^(7, 8, 9), quoting "Many birds appear to become more brilliant in color as the breeding season approaches without either a molt or the wearing away of the tips of the feathers".

This is the most obvious change in the plumage during the year. We feel that it is not due to increased pigmentation. The new fall plumage may be of a soft rose, a most exquisite shade, and in spring the same bird certainly possesses the "indescribable lustre" of McGregor. Any dressmaker could immediately have described it as what one would get by removing the georgette or any fine, soft, pale grey veiling used as a covering for a shining satin, and that is what actually occurs. Despite the opinion of Keeler quoted above, the wear of the year gradually removes the barbules from the barbs at the ends of the feather leaving the glistening group of barbs without the filmy barbules and the spring plumage is at hand.*

There is another change in this summer plumage. While the color is intensified the areas of the colored patches are smaller. This has been apparent to us since we began banding. The red of the fall covers more surface than in June but is not so bright.

In studying this we used birds represented by three or four samples taken at intervals during the year. A typical example of this, and there are many, would be a bird from which we have samples for 1926-27 taken in August, October, November, January and April. These are red, but the January sample shows some brown mixed with the red and the April sample shows still more. The next year, from this same bird, we have samples taken in August, October, November, January and July, and again the January and July samples show admixtures of brown feathers. A large number of birds showed this but not to the same degree. Our first thought was that the brown represented feathers replacing former pluckings and that the new feathers, in these cases, had failed to develop the red pigmentation.

*Since offering this paper for publication we have been referred to Joseph Grinnell's paper "The Linnet of the Hawaiian Islands: A Problem in Speciation" (12): From this we learn that our findings, in regard to the effect of wear in causing the brightening of the linnet's feathers, could have been better stated by referring to this paper of Dr. Grinnell's written nineteen years ago.

tion. But that these brown feathers are not replacement feathers and are simply the remains of former red ones is made apparent by a careful comparison with birds having yielded a single plumage sample taken in the spring or early summer. The colored barbs last after the barbules are worn off but they also begin to wear at the tips as the season advances and we have our birds growing duller and brighter at the same time by the same process. One red bird in our records is by this rendered brown as far as the rump feathers are concerned and one, yellow in November, is brown in March. The yellow ones naturally show this the most, but it is apparent in all colors though not to the same extent in all birds.

This brings us to another point. While wear is responsible for the greatest change it is variable in different birds and in the same bird in different years. Some retain beautiful feathers in a long and almost perfect condition practically until the molt. Others show a badly worn plumage by March with only the tips of a few rump feathers showing their earlier coloring although the head and chest are still bright. This abrasion is much more apparent after nesting, but the difference in wear is great and not all House Finches are in brilliant and beautiful plumage at nesting time, but the bright ones create such an impression that the observer has the feeling that they are more numerous than they actually are.

An accumulation of dirt also changes the appearance of many birds as the year advances. During a cold winter, smudging operations leave much that lasts a long time and during the winter of 1928-29 some of our linnets were almost black for a time. They frequently have the forehead much darkened by a gummy substance and some of these birds smell very noticeably of the sagebrush, although we are three miles from the nearest brush area.

We have had one bird which had the rump white. Its sex is not known and its only interest in this connection is in the very good evidence it gives of the color being changed late in the year by the accumulation of dirt. This bird was almost pure white in December but in June it was matched by Ridgway's mouse gray, just four shades darker.

We have been able to follow about fifty plumages from the first appearance of the colored feathers through a year, and it is of interest to note that nearly all of them show that from the very young feathers, not completely out of their sheaths, it is not possible to know just what color that linnets will be. Some birds almost maintain this color, but most show a distinct change soon after the first new feathers appear. Some, that give promise of being very bright, will be found one or two months later to have turned towards the orange tones and also to have turned darker. Most of the birds examined, however, show that the young feathers just emerging are duller and paler than they will be two months later. By January they are often a shade darker and this is perhaps due to dirt. In many birds, feathers taken from January on have a spotty appearance due to brown tips where some colored ends have worn off, although the brightening due to the wear becomes apparent.

This progressive change that takes place in the coloring of some birds during the year is quite minor compared with the change that often takes place from year to year with the acquisition of new feathers. To study this color change with different plumages we have samples for two or more years from 337 birds, the "year", in this case, being from molt to molt. Obviously, we have no complete records for a single bird from its first mature plumage to the extreme age for the species.

In the method used in this study four empirical divisions of the birds were made

according to the color changes which took place from year to year. These groups are: (1) birds which, in our records, maintain the same red color; (2) birds which add red to the original color, becoming red or, if already red, deeper red; (3) birds all red in our last record of them but showing a mixture of red and yellow or, in one case red and brown, in a previous plumage; and (4) a group of irregular colorings usually losing red, or at least which we cannot place in the above categories.

Our first group, then, contains all birds which for two or more plumages have maintained a uniform red color; the shade of red, however, varying in different individuals. In separating these, allowance was made for the change between fall and spring if one year's plumage was taken in the autumn and the next year represented by a spring sample. The feathers were, however, usually placed in this group without hesitation and a repetition of the process gave practically identical results. There were 179 red birds that showed no change in color for two or more years. These comprise:

150 represented by plumages of two years which are often, but not always, consecutive;

19 from which we have plumages for three years;

6 from which we have feathers representing four years;

4 which have maintained the same red for five years.

Thus over half of the 337 birds have maintained a red that is almost identical from year to year, as far as our records go.

The second group, comprising all birds which added red to their first color in our record and for which the last plumage sample is red, contains 120 birds and is divided as follows:

37 turned from yellow to red for 9 of which we have first adult plumages;

31 turned from orange to red for 13 of which we have first adult plumages;

18 turned from orange-pink to red for 9 of which we have first adult plumages;

30 turned from red to deeper red for 15 of which we have first adult plumages;

4 turned from brown to red for 1 of which we have first adult plumages.

Each of these subgroups, well defined in the main, yet contains a few birds which could be shifted to another subgroup because it is extremely difficult to decide just when yellow becomes orange or orange becomes orange-red, but we felt that the colors were sufficiently distinct in each subgroup to justify it for the purpose. Here again, in this main group, the final red is variable but the separation of this group rests on the addition of red to the first plumage sample. Sometimes the change from a pale, dull yellow to a deep, vivid red comes in one molt. Sometimes the change is to a pink-red and a later molt may maintain this pink-red or the color may deepen, but it does not, in any of this group, change toward the yellow portion of the spectrum nor maintain a yellow, orange or orange-pink for more than one year. In most cases the change is abrupt. The small subgroup changing from brown to red might almost be excluded, since only one bird in this subgroup started with a truly brown plumage. The others were obviously the remnants left after excessive wear. The subgroup is so small, however, that it is unimportant.

The third group consists of 17 birds that in our last record are all red but show a mixture of red and yellow in some former plumage or, in one case, a mixture of red and brown. Thirteen of these birds show the mixed feathers in the first plumage recorded. One, with a record for four years, shows the mixed colors in the second and third years. One, with three plumages, shows the mixed colors in the second. One shows mixed yellow and red in the first record and brown and

red in the second, but all red in the third. Another, the last of this group of 17, has a mixture of dull yellow and red in a sample taken in October, but a December sample shows none of the dull feathers and the next year's plumage is red. We believe the first sample for this bird shows the difference between the oldest and the most recently developed feathers of the new plumage rather than a mixed red and yellow, but it is a pronounced difference. Of these 17 birds we have first adult plumages for 6.

The fourth group consists of 21 birds, about 6 per cent of the 337 under discussion, for which we have not yet accounted. These either lost or failed to acquire red coloring, as follows:

Number of birds	COLOR OF PLUMAGE SAMPLES		
	First	Second	Third
2	Red	Mixed red and orange	
8	Red	Orange	
1	Orange	Orange	
1	Orange-pink	Red	Pale red
1	Yellow	Red	Mixed orange and red
1	Yellow	Brown	
1	Red	Orange	Brown
1	Dull orange-pink	Dull orange-pink	
2	Yellow	Orange	
2	Orange	Deeper orange	

In addition to those tabulated above there is one bird which might be said to have kept its red color for five years if noted just after the molt but which shows yellow feathers in its rump at the latter part of two years, the first and the fifth.

This group is only a convenient pigeon-hole. Hardly two are alike. Five of them were in their first adult plumage.

There is, thus, a total of 316, or 94 per cent of the 337 birds for which we have plumage records for more than one year, that, as far as our records go, were red or turned red and 21, or 6 per cent, that lost red or failed to acquire red. Why were not all these birds red in all their plumages? Were the colors other than red confined to any particular age? The second question is partially answered by our records. Although our knowledge of the age of these birds is not complete we have shown under the second, third and fourth major groupings above that, of the 158 birds which were other than red in some plumage, 58, or 37 per cent, were known to be of the yellower tones in their first adult plumage.

In a further effort to study this problem we have at this point gone over all feather samples in our files for the birds which failed to return and for which we have only the plumage record for one year. We find 225 such birds in three years which show the colors which we have called yellow, orange or orange-pink. We know from our banding records that 39 per cent of these birds were in their first adult plumage when these samples were taken, since we had banded them as immatures and they had returned after the molt, or else they were captured at the time of their first molt. This gives almost exactly the same result as given by the birds represented by plumage samples for more than one year.

Combining all the birds that are other than red in any plumage we have 383, 42 per cent of which were in their first adult plumage and 7 per cent of which are known to be in the second or third adult plumage. This latter number consists of all the fourth group and three each from the second and third groups. A considerable portion of the remaining 51 per cent, whose ages are not known, are undoubtedly in their first adult plumage but were not in our traps before or during their first molt. This conclusion, that a large number of the birds of the lighter colors are

in their first adult plumage, is strengthened by our experiences in handling the same birds many times, sometimes hundreds of times, during several consecutive years. We have, coming to our traps at this time, birds that we have known through their first two years which have shown a color change from dull orange to red, and others, particularly one that is one of the most beautiful birds we have ever handled, which show no actual color change but in which the increase in extent of the red areas is marked. In the one cited this is so pronounced that the second adult plumage is much more brilliant in effect than the first, the red spreading the entire length of the back, on the flanks, under tail coverts, shoulders, and wing coverts, and we have wondered if the flight feathers do not show hints of it. The red is not remarkably bright in tone, however. Another bird has remained unchanged in color for five years and was in adult plumage when banded, so he must be at least five years old and for that long he has maintained a beautiful carmine red.

The color of any male House Finch becomes yellow in captivity (we are told that this change takes place after the second molt in captivity) and it thereafter remains yellow. This indicates a very quick response to conditions that are not normal, so that perhaps the retention of one shade for years is more remarkable than variation from it.

In this connection we wish to refer to Mr. Law's "The Role of the Runt"⁽¹⁰⁾ in which he points out the possibility that a young bird subjected to many hardships may fail to acquire full size and color. The lighter color of so many young linnets may be the result of parasitism by larvae of a fly which is common in our region. It is rather suggestive that sometimes the yellow linnets seem to occur in waves.

In an article by Mr. R. C. McGregor there is discussion of the color of this species and he quotes Mr. Charles A. Keeler and Dr. R. W. Shufeldt as holding the view that the yellow color probably preceded the red in the history of the bird in time and that the yellow is a more primitive stage than the red which has developed from the yellow. It is possible that both hard conditions of early life and recapitulation have a hand in these light colors of some of the young birds, but our feathers indicate that there is small chance that a light or dull colored bird will retain this color permanently or that a red one will not retain the red.

In studying the range of colors exhibited by the 1982 plumages we have collected we have used Ridgway's "Color Standards and Nomenclature"⁽¹¹⁾ as a basis for comparisons. The colored tips of the feathers were held together with a pair of forceps. This small spot of color was matched with a color on Ridgway's plates. It was rarely difficult to decide which color best matched the feathers under consideration.

The range of color is great. A single bird in the course of a year does not maintain a constant place on these plates. Even without the exactly graded color display of this book, a change is apparent as the year progresses. This has already been referred to and it is interesting to follow it in the light of these color plates.

In their brightest summer plumage a good many of the linnets' colors may be found on plates I, II, III, and IV. On plate I the colors chosen as matching House Finch colors are Scarlet Red, Scarlet, Carmine, Nopal Red, Brazil Red, Ox-blood Red, Garnet Brown and Morocco Red. Scarlet Red and Scarlet are the spectrum colors and all the other shades are produced by adding black to these two colors or to Spectrum Red, which is not represented by any House Finch we have. The spectrum colors are continued on plate II and named Grenadine Red, Flame Scarlet and Orange Chrome and these are all matched by the tips of pre-molt feathers. More

commonly these colors are darkened to English Red, Mars Orange and Orange Rufous. Sparingly the still darker shades, Mahogany Red, Burnt Sienna and Sanford's Brown, occur. A few are found that match the lightened spectrum colors of this plate, Grenadine, Bitter-sweet Orange and Salmon Orange, but these are represented by very few birds. The next plate, III, continues on down the spectrum with Cadmium Orange and Orange, but the pure spectrum colors of this page hardly occur in our House Finches although a very few were classified in this way. More were matched with the darkened shades of these colors, Xanthine Orange and Mars Yellow, but on the whole this page is little used. Turning to the next page, plate IV, we find the pure spectrum yellows occur in none of our House Finches, but the darkened shades of yellow, Analine Yellow and Sulphine Yellow and these further darkened to Orange Citrine and Citrine, are found. It is thus seen that the published descriptions of these birds as red and orange are right, since the yellow, while appearing very bright in the bird held in the hand, is not a pure yellow in any case we have found. All these colors, chosen from plates I to IV, were found on a good many birds, but not often except in samples of late spring and summer.

We have already spoken of the summer brightening as being due, in our opinion, mainly to abrasion. The loss of the filmy gray barbules is again apparent in studying the colors of the House Finch with Ridgway.

During a large part of the year plates I to IV do not match our linnets, but plates XIII to XVI are more useful. These plates correspond exactly with the preceding except that all the colors are dulled by the admixture of 32 per cent of Neutral Gray. On these pages are very good matching colors for most of our birds for most of the year. The bird that was classified as Scarlet in its June coloring became so by the loss of 32 per cent of Neutral Gray from Coral Red, its October and November color. One that was Nopal Red in June lost the 32 per cent of Neutral Gray that made it Pompeian Red in November or February. Changes in all birds do not correspond so exactly with this loss of Neutral Gray, but the use of this book illustrates that the bright summer color is due to a loss of Neutral Gray which is, we believe, due to the loss of the barbules. The presence of dirt, the absence of abrasion, or the opposite extreme makes many irregularities, but we feel that no one could go over our feathers with this book without coming to the conclusion that plates XIII to XVI are the ones that will match most House Finches most of the year.

However, for the first new feathers of the new plumage in late July and August, even these plates are too bright, and turning to plates XXVII to XXX, showing the colors further dulled, this time by an admixture of 58 per cent of Neutral Gray, we find many of the soft and lovely colors of the emerging feathers, although the brighter of these are found in the preceding plates, XIII to XVI. In a very few of the dullest new feathers, even the next addition of Neutral Gray to 77 per cent was found to give matching colors, but very rarely were the feathers this dull.

In conclusion we wish to summarize as follows:

A total of 1982 plumages from 1563 male House Finches was studied. Of the 337 males represented by plumages for more than one year, 179 maintained their red color, 120 added red to the plumages succeeding the first record, 17 were mixed red and yellow in some plumage but red eventually, 21 did not add red or did not retain the red existing in the earlier plumages.

Of the 1226 males represented by samples from only one plumage each, 1001 were red and 225 were not red.

Of the 383 males having plumages which were not red, 42 per cent are known to have been other than red in their first adult plumage, and 7 per cent are known to have been other than red in their second or third years. Undoubtedly a considerable portion of the remaining 51 per cent were in their first adult plumage.

The variation in the color of the plumage in a single year is chiefly due to wear. The reds become brighter as the filmy barbules are worn away and the extent of the colored areas decreases as the barbs wear off.

In matching plumage samples with colors in Ridgway's "Color Standards and Nomenclature" it is found that a very few of the dullest new feathers match the colors having 77 per cent of Neutral Gray, that the soft and lovely colors of the emerging feathers are matched by the colors having 58 per cent of Neutral Gray (plates XXVII to XXX), that the colors having 32 per cent of Neutral Gray (plates XIII to XVI) match most House Finches most of the year and that the colors on plates I to IV, which have no admixture of Neutral Gray, are the ones which match many of the linnets' brightest late spring and summer plumages. The loss of the barbules corresponds to the reduction of Neutral Gray in the standard colors and is the cause of the brightening of the red as the molting season approaches.

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