NOTES ON THE WING LENGTH OF THE EASTERN PURPLE FINCH
(Carpodacus p. purpureus)

BY CHARLES H. BLAKE

The present report is a cooperative undertaking. Mr. and Mrs. Parker C. Reed have, in the past few years, handled many hundreds of Eastern Purple Finches at their banding station in Lexington, Mass. Quite detailed notes have been kept on more than 1000 birds over the last year and a half (this paper was completed in January, 1954). For most of these birds, wing lengths (chord) are at hand. About a year ago, Mr. John W. Stewart in Burlington, Mass., joined us in keeping comparable notes. Reasonable identity of method has been attained because all of us have worked together and examined some of the same birds at the same time. I am greatly indebted to these colleagues for the care taken in keeping the records and their generosity in making them available to me.

Recently eight birds have been retrapped as fully adult males which were measured at banding when they were brown birds. Although the sample is small it sheds light on wing growth and leads to a new look at whether brown birds show a sexual difference in wing length. It should be noted that there is a distinction between the existence of a statistically significant difference between two populations (say two sexes) and a difference which is usable for diagnostic purposes.

The differences between the two measurements of the eight birds range from one to five mm. with an average of 3.4 mm. In each the adult bird is the larger. It is possible that a small part of this difference is due to lesser wear of the relatively new primaries of the adults. However, examination of many Purple Finches at various seasons convinces me that the primaries are subject to very little wear. Table I shows the statistics of these eight birds, in mm.

TABLE I. EASTERN PURPLE FINCHES MEASURED AS IMMATURE AND ADULT BIRDS

	MEAN	STANDARD DEVIATION	GREATEST	LEAST
IMMATURE MALES	79.6	1.7	81	79
ADULT MALES	83.0	1.7	85	80
DIFFERENCE	3.4	1.7	5	1

If this table is compared with Table III it will be seen that adults average longer winged and the immatures shorter winged, that the standard deviations are somewhat less, and that the difference between the means is greater. Examination leads to some fairly definite answers. In Table I the population of adults is, by definition, identical with the immature population. The differences between them can have only two causes, actual growth and errors of measurement. Various trials of the latter show that the precision of measurement is 0.5 mm. We expect the mean of a sample of 8 to have a precision of about 0.2 mm. and, hence, the lowest value for the mean difference due to growth to be 3.2 mm. This difference is significant statistically.

Before further comparison with Table III let us look at the correlation between adults and immatures. If every bird increased its wing length by the same proportion we would expect a correlation coefficient of +1.0 or perfect correlation. In the present case the coefficient is +0.45. We find that the chance that such a correlation coefficient could be obtained in the absence of real correlation is rather more than 1 in 10. This contrasts rather unfavorably with the chance of 1 in 1000 shown by the coefficients from Sutter's Greenfinch data (see below). However, the existence of real correlation in the Purple Finch is favored by two points. All of the differences are in the same sense and there is an inverse relation between the immature wing length and the amount of increase. The effect of the latter fact is to decrease the numerical value of the correlation coefficient and, hence, the purely statistical statement of its reliability. The percentage growth ranged from 6.3 percent down to 1.2 percent. (See below for my calculations on Sutter's data.)

Returning to Table III we find the series of adult males to be significantly longer winged than either series of immature birds. To this extent there is agreement with Table I. We also see that each of these series exhibits similar variability. Since the series in Table III are more variable than those in Table I we may question whether the two sets of data are derived from the same population. The application of the variance ratio test (F test) puts the difference at about the 40 percent significance level and we conclude, on this showing, that the samples were drawn from the same population. This is in spite of the fact that some of the adult males in Table III are in plumages later than the second winter plumage and may show additional growth. This may be countered by pointing out that there is no significant difference between the means of the two adult series nor between those of the three series of immature birds. The problem is not entirely a simple statistical one. The dates of capture of the birds in Table I suggest that they are derived only from one or more migrant populations. The birds of Table III include representatives of these same populations and also of breeding and wintering populations. Future study may throw some light on the extent of statistical agreement between these various populations in the matter of wing length.

The discussion of the relation between a sample consisting only of birds in second winter plumage and a sample of the same size also containing older birds can be carried a little further. Let us assume that the samples differ from two causes, first, random choice of individuals to compose the sample, and second, age distribution. It is fair to say that the second sample will be largely of second winter birds with a smaller number of third winter birds, a still smaller number of fourth winter birds, and so on. We assume also that each age group averages slightly larger than the next younger group. The over-all effect of these assumptions leads us to expect, relative to the pure sample of second winter birds, a small or very small increase in the mean, a slightly greater increase in the standard deviation and a still greater increase in the upper limit of the range.

Before going into the possible diagnostic value of wing lengths, it will be worthwhile to look at some European literature to which Dr. Ernst Mayr kindly drew my attention. I know of no American references on this subject.

Sutter (1946) gives actual examples of individual increase in both male and female Greenfinches *(Chloris c. chloris)* in Switzerland. At the first postnuptial molt males increase 1.7 mm. on the average with a standard deviation of 0.9 mm. The absolute value of the increase is quite variable, ranging from 0.5 to 3.5 mm., but is, in all cases, positive. The mean increase is 1.9 percent of the mean length of the wing in first winter plumage. The correlation between the first winter wing length and that of the second winter is very high, +0.78. Females show an even higher correlation of +.89. Table II summarizes Sutter's observations on the change at first postnuptial molt in the Greenfinch derived from his Table 1a.

TABLE II. GREEN FINCH WING LENGTHS (ARC)

	MEAN	STANDARD DEVIATION	GREATEST	LEAST
MALES, FIRST WINTER	88.2	1.7	91.0	85.5
MALES, SECOND WINTER	89.9	1.9	94.0	87.0
MALES, DIFFERENCE	1.7	.9	3.5	0.5
FEMALES, FIRST WINTER	85.9	1.3	88.0	84.0
FEMALES, SECOND WINTER	87.7	1.5	90.5	85.5
FEMALES, DIFFERENCE	1.8	.7	2.5	0.5

It will be seen without going into the calculations that the differences of age and sex are real but only diagnostic in the extreme cases. Sutter gives evidence for subsequent increase of about 0.5 mm. in at least one later molt.

In the case of the Redstart *(Phoenicurus p. phoenicurus)* Sutter found no change in females but did in males. This agrees with Weigold's (1926) findings on Helgoland but Banzhaf (1936) near Greifswald found an increase in both sexes at the first postnuptial molt. There is an indication here of differences between populations.

Kluijver, who has studied the Great Tit *(Parus m. major)* so intensively, found (1939) a similar increase in wing length at both the first and the second postnuptial molt. He followed individual birds as Sutter did for the Greenfinches of Table II. After the second postnuptial molt the Great Tit showed no further increases and two birds even decreased.

A more remarkable case is that of the Snow-finches *(Montifringilla n. nivalis)* studied by Lang (1946). He was able to demonstrate that increase in wing length continued until at least the fifth postnuptial molt. This bird is one of the unusual passerines that replaces its wing quills at the post-juvenal molt.

The foregoing species are all passerines but Klomp (1946) obtained similar results from the Lapwing *(Vanellus vanellus)*.

Two different methods have been used in studying this question. Sutter (in part) and Kluijver followed individual birds and their work corresponds with the present Table I while Weigold and Klomp used series of the general type shown in Table III. The disadvantage of the latter method is that one cannot always be certain that the different age classes really belong to the same population. Lang used individual birds without stating their actual ages.

To secure some further light on wing length I took four samples from the Reeds' data, namely: (1) 234 fully red males; (2) 31 immature males which were sufficiently pink to be certainly males; (3) 30 birds known to have been at least partly in juvenal plumage when banded; and (4) 503 other brown birds. For each of these I showed the mean, the standard deviation, and the extreme lengths, all in mm., in Table III.

TABLE III. PURPLE FINCH WING LENGTHS (CHORD)

	MEAN	STANDARD DEVIATION	SHORTEST	LONGEST
ADULT MALES	82.7	2.6	78	88*
IMMATURE MALES	79.8	2.2	76	85
FIRST WINTER BIRDS	80.0	2.3	76	86
OTHER BROWN BIRDS	79.6	1.8	74	85

*Mr. John W. Stewart tells me he has recently measured an adult male with a wing of 89 mm.

Comparing the figures in the table we find no difference between immature males and first winter birds. There is evidence from other investigations of mine that many (and probably most) of these immature males are actually in first winter plumage and only a few in second winter plumage.

The next question is whether the first winter birds could be divided into two size classes. On the basis of present data the answer is an unqualified negative. The chance that the "immature males" and the "first winter birds" differ in wing length for any cause other than the accidents of sampling is less than one in 100. The sample "first winter birds" must be assumed to be about half female. If there were a significant difference in size between males and females at this age we would expect a significant difference in the standard deviations between a sample composed of birds with two different size ranges about equally represented and one (immature male) containing chiefly a single size range. Actually the standard deviations of the second and third samples differ (to two decimals) by only 0.06, which is quite insignificant. Furthermore, "first winter birds" and "other brown birds" do not differ significantly as to either mean or standard deviation.

The crucial problem is whether there is any chance of distinguishing adult females from other brown birds by their wing lengths. Let us take as our first hypothesis that adult females have the same distribution of wing lengths as first winter birds. The argument of the two preceding paragraphs shows there would be no possibility of distinguishing them. If, on the other hand, the adult females had the same distribution as adult males then we could say that those in the upper two millimeters of the size range would be determinable. In other words those birds which were more than 1.27 standard deviations larger than the mean would be separable. This is 10 percent of the birds. *A priori* we expect adult females to be larger than first winter birds but smaller than adult males, so less than 10 percent can be distinguished.

It is almost certain that the sample "other brown birds" is composed largely of birds in first winter plumage. These could easily be 70 to 80 percent of the sample. The difficulty of determining any difference between female wing lengths in first and later winter plumages is accentuated by the composition of this sample. In any event the present sample bears out the view that no great difference exists.

The foregoing discussion leads also to some remarks on taxonomic practice. Van Tyne's (1952) comment on chord versus arc in wing measurements deserves emphasis, especially as the practices of banders and museum workers are likely to differ. Banders should certainly state whether their wing measurements are chord or arc. The presentation of data by ornithologists has often left something to be desired. If five or more observations are at hand, the minimum treatment would be: number of observations, mean, standard deviation, and range. I suggest detailing fewer than five observations so that future workers in the same area may add their own and build up more adequate series for statistical treatment. A fine example of adequate statistical treatment is Dickinson's (1952) study of Red-eyed Towhees. The final point is that a very short series may well fail to reveal the full range of size of a form, quite aside from any error or bias it may introduce into the mean or standard deviation.

We conclude that adult male Eastern Purple Finches do increase their wing lengths at the first postnuptial molt by about the amount of the average difference between adult males and first winter birds and that wing length does not offer a means of sexing brown birds.

We conclude further that different species have their own peculiar patterns in regard to duration and amount of growth in wing length and to sexual differences; that there are indications that each population of a species may have its own peculiarities. At present it appears that the use of individual birds is better than the use of series. The first method eliminates the question of diverse origins for different age groups.

Current methods of measurement appear to be capable of giving usable results if the wing length is 70 mm. or over. Measuring the chord rather than the arc of the wing is recommended for live birds because it involves less handling of the birds.

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Massachusetts Institute of Technology, Cambridge, Massachusetts.