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VARIATIONS IN BIRD MIGRATION FROM YEAR TO YEAR.

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The records of the Weather Bureau show that the average temperatures of the three spring migration months — March, April and May — vary very considerably from year to year. In some years all three months are below normal. In other years the whole season averages above normal. If the birds depended to any considerable extent on temperature to indicate to them the proper time for migration, their movements should vary up and down with these great changes in average temperature. If on the other hand the later theory is correct that the departure from the winter home has no connection with the weather, and that the *average* temperature at the *breeding grounds* is the principal factor that determines the time and speed of migration, then it should follow that local variations in temperature should have only a slight influence in varying the dates of arrival from year to year.

The latter assumption is borne out most strikingly by a long series of careful migration observations. They show that the average of migration at any locality for the entire season as compared with the average for other years is remarkably uniform. The migration arrivals in any given week may be much retarded by a great storm or a long spell

of exceptionally warm weather may induce the birds to arrive somewhat earlier than usual. But these variations from week to week largely balance one another and the average dates of arrival for the whole season show from year to year very slight variations.

Thus at Lanesboro, Minn., the average date of arrival for the ten years, 1884-1893, is 144.8 days after January 1; the variations are: 1886, 0.2 days late; 1887, 0.3 days early; 1888, 0.7 early; 1889, 0.4 early; 1890, 1.2 days late. The average variation is 0.6 days, and the maximum variation, 1.9 days, from 0.7 days early to 1.2 days late. The year 1885 is 1.9 days late, but there are evidences in the notes that this is due to lack of time in the field on the part of the observer rather than to actual variation by the birds.

The same test was made of the migration dates from Keokuk, Iowa. The year 1892 is 1.0 day earlier than the average; 1893, 0.1 day later; 1894, 1.7 days late; 1895, 0.8 days early; 1899, 0.5 days early; 1900, 0.5 days late. The extremes of variation are 2.7 days and the average variation 0.9 days.

Grinnell, Iowa, shows much the same: 1885, 0.7 days late; 1886, 0.2 days late; 1887, 0.7 early; 1888, 0.6 early; 1889, 0.1 late; 1890, 1.0 late; average variation only 0.5 days; maximum variation, 1.7 days from 0.7 days early to 1.0 day late.

The averages for Aweme, Manitoba, are: 1898, 1.2 days late; 1900, 0.2 days late; 1901, 0.8 early; 1902, 0.8 early; 1903, 0.2 days late; average variation 0.6 days; maximum variation, 2.0 days from 0.8 days early to 1.2 days late. The records for 1899 are omitted because that year the observer could not devote the usual time to the work and the average is several days late.

The records just given include the work of four observers in four widely separated towns during fifteen different years and hence ought to be a fair test. The remarkable agreement of the results is a strong indication that they represent the actual movements of the birds. The twenty-one series of observations give a maximum range of 2.5 days from 0.8

days early to 1.7 days late, with an average variation of 0.7 days. That is to say the whole migration of different years may vary as much as two and a half days, between the earliest spring and the latest, but the probable variation is less than a day. Or to say the same thing in another way, the notes of a first-class observer in any one year will give an average that probably will not vary more than two-thirds of a day from the date that would be obtained for that locality as the average of long years of observation.

The figure 2.5 days for the maximum variation is the sum of two variables — the actual variation of the birds in their times of arrival and the variation in the amount of time and care that the observer can give to the work in the different years. The fact that the sum of these two variables is so small shows both the extreme uniformity of the birds in their migrations and the very careful and accurate work done by the four observers whose notes were selected for the test.

The above may be summarized by saying that the migration of birds as a whole is remarkably uniform. A season may start out early or late and quite wide variations may occur in the times of arrival of any one species, but in the course of the whole season's migration, these extremes nearly balance and the result is very small net variations.

The dates of arrival of individual species show considerable variation between the extremes of early and late arrival, but the average variation from the mean date of arrival is surprisingly small. To arrive at a mathematical statement of this variation thirty-six species were selected, which are easily noted, and are common enough so that they would ordinarily be seen as soon as they arrive. The records at Lanesboro, Minn., for the six years 1885-1890 were used and there should therefore have been six times 36 records or 216 in all. Six of these records were lacking, while eight records were rejected because too early to show the ordinary movements of the species, and ten more because they were so late as to indicate that the species was overlooked on its arrival. Thus 18 records, or 9 per cent, were rejected.

The remaining records show an average extreme variation of 10.0 days between the earliest and the latest dates of arrival for each species, with an average variation of 2.9 days from the normal date of arrival.

The records of these same thirty-six species for the same six years at Grinnell, Iowa, after rejecting 13 per cent because too late or too early, show an average extreme variation of 9.4 days and an average variation of 3.4 days from the normal date of arrival. The records from Lanesboro are thus seen to be a trifle more regular than those from Grinnell. As it is hardly supposable that the birds themselves are more variable in one of these places than the other with such closely similar physical surroundings, it must be that this difference is due to differences in ability or opportunity on the part of the observer. In this particular case it is probable that the two observers knew birds about equally well, but the Lanesboro observer was so situated that he could spend more hours per day in the open air than the observer at Grinnell, with the result that he averaged seeing the birds a little sooner after their arrival.

These final averages of 2.9 and 3.4 days represent the probable variation in the observance of the arrival of the first, or in other words a first-class observer, who is in the field every day and is able to spend time enough each day to cover his neighborhood satisfactorily will make records that show an average variation from the normal date of arrival of about three days, and unless extreme attention is paid to the birds another half day will be added. This time — three days — is the sum of two variables, first, the variations due to the birds themselves as they vary their actual date of arrival from year to year; and second, variations due to failures on the part of the observer to note the species immediately on its arrival. Since the second of these causes must have some influence it follows that the birds themselves must be remarkably uniform in their spring movements.

The above investigation was undertaken for the purpose of obtaining some standard that could be used in testing mi-

gration reports. The Biological Survey during the past twenty-five years has received reports from more than two thousand different persons and it must needs be that this large number would include observers good, bad and indifferent. A large part of the most exacting work of the present writer for the past ten years has been the examining of these thousands of reports and separating the wheat from the chaff. No better single basis for a judgment has been found than the above three-day variation. It received a striking confirmation in a very extended set of records that were received from Raleigh, N. C. In some twenty years of records about half the years showed small variations, while the other years gave less regular results even to a fifty per cent increase in the amount of variation. Later the observer sent his original notes and diary and they showed conclusively that the variations were inversely according to the amount of time spent in the field. The more days a month and the more hours a day devoted to hunting for new records, the more regular the records obtained.

Conversely if an observer in a level district sends notes with wide variations it is certain that some of his records are not representative of the normal movements of the birds and extra care must be taken to ascertain which notes should not be used.

During all these years, as would be expected, there has been some nature-faking in the reports. The percent of spurious records has been very small and they have varied from the crude impossibilities of ignorance to the carefully worked out report of a person well up in birds and bird migration. But they can be detected with ease when the above rule is applied and they are compared with genuine records from neighboring districts. Either the variations will be too small — the dates more regular than the actual movements of the birds, or if they have taken pains to vary the dates they have placed the wider variations on the wrong birds, since species differ widely in their normal variations. It would probably astonish some of these nature-fakers if they

could see the comments that have been entered on their reports.

But to return to the original subject. The average variations of 2.9 and 3.4 days already mentioned are the average for the whole spring migration period of March, April and May, but birds are much more variable during the early part of the season when March storms interfere with their uniform northward progress. The average variation from the normal date of arrival at Lanesboro is for March, 4.0 days; April, 2.7 days, and for May, 2.6 days. At Grinnell the same averages are for March, 3.6 days; April, 3.6, and May 2.9 days. The average of the two places is for March, 3.8 days; April, 3.1, and May 2.7 days. The average extremes, that is, the difference between the earliest and the latest record for each species is at Lanesboro, for March, 12 days; April, 9 days, and for May, 8 days. At Grinnell, March, 10 days; April, 10 days, and May 9 days. Average of the two places for March, 11 days; April, 9.5 days, and for May, 8.5 days.

When the records of single species are considered of course the variations are much larger. The earliest ducks and geese migrating in the unsettled weather of the breaking up of winter show the widest variations, as will be seen from the following table of the movements of the Canada Goose.

SPRING ARRIVAL OF THE CANADA GOOSE.

PLACE	Number of years of observation	Average date of normal arrival	Extreme differences between normal date of arrival and recorded date of arrival	Differences between extremes of recorded dates of arrival	Average differences between normal date of arrival and recorded date of arrival
			DAYS	DAYS	DAYS
Nebraska, lat. 40°30′...	14	February 21	+9 to —34	43	10
Iowa 41°	9	February 24	+9 to —39	48	14
Iowa 42°	15	March 4	+6 to —31	37	12
Minnesota 43°40	8	March 18	+2 to —23	25	10
North Dakota 47°30.....	11	March 27	+5 to —28	33	10
Manitoba 50°	15	April 6	+6 to —23	29	9
Average				36	11

The table shows that the early geese are very variable in their movements; that early migrants sometimes appear a full month before the usual time of arrival, and that extreme variations in different years amount to a month and a half. Attention is called to the last column, which is the "probable error" in records of the arrival of the Canada Goose and means that when a good observer sees the first goose of the season, the probability is that the date is within nine to fourteen days of the normal date of arrival for that district. With such wide variation, a large series of observations is necessary to establish a reliable normal for any given locality.

The extremes of variation are considerably greater in the district just north of the winter range, since with these hardy birds, a few warm days may tempt them north even in January, and in mild winters, like those of 1888-9 and 1889-90, geese may be seen every few days all winter, many miles north of the usual winter abode. When it is remembered that the probable error in the date of arrival of the late migrants is hardly more than three days, it will be understood how great an influence the changeable spring weather has on the early migrants.

Birds differ quite decidedly in their tendency to vary the date of their arrival. The extreme is found in the Canada Goose just mentioned, which has an average variation of 11 days from the normal date of arrival. At Lanesboro and Grinnell, the birds showed the following as their average variations from the normal time of appearance.

Phœbe	4.9 days	Ruby-crowned Kinglet	2.1 days
Black-poll Warbler	4.9 "	Chipping Sparrow	2.1 "
Bluebird	4.0 "	Wood Thrush	1.8 "
Meadowlark	4.1 "	Chimney Swift	2.0 "
Bronzed Grackle	3.7 "	Kingbird	2.0 "
Whippoorwill	4.0 "	Baltimore Oriole	2.1 "
Purple Martin	3.9 "	Black-billed Cuckoo	2.0 "
Robin	2.5 "	Ovenbird	1.4 "

Thus the Canada Goose and the Ovenbird represent the extremes — the one eight times as variable as the other.