BIRD WAVES AND THEIR GRAPHIC REPRESEN-
TATION.

BY WITMER STONE.

In studying the migration of birds I have always recognized
the need of some method of representing graphically the great
combined movements or waves of the spring and fall and their
coincidence with changes in temperature.   It is hard to get any
idea of this coincidence from consulting a mass of data unless
one spends a considerable amount of time in studying it over, but
in a graphic representation the whole matter can be seen at a
glance.

The lack of exact data is a considerable hindrance to a satis-
factory graphic representation, as the majority of the observers of
migration have been content with noting the first and second
arrivals and the so-called 'arrival of the bulk,' while the subse-
quent fluctuations in the number of individuals of the species
have gone unrecorded.   This year I have been fortunate enough
to have at my disposal the observations recorded by the members
of the Delaware Valley Ornithological Club on the spring migra-
tion of 1890 in the vicinity of Philadelphia.   These records con-
sisted mainly of the exact numbers of the various species seen
from day to day at the several stations of the members of the
Club.   In some cases, however, after the early arrivals were
recorded, such terms as 'common,' 'several,' etc., have been
used to show the comparative numbers of the species present.
This method is much less satisfactory, and but little easier to the
observer, than noting the exact numbers seen or as close an esti-
mate of them as possible.   With this material I have been able
to construct several charts which show quite satisfactorily the
successive waves of the spring migration.

The method can best be understood by reference to the accom-
panying cuts.   Across the top of the chart is a temperature curve
showing the variation in the maximum daily temperature at Phil-
adelphia.   Beneath are recorded the daily observations on a few
species of birds at five stations,—Haddonfield, N. J. (Saml. N.
Rhoades) ; Wynnewood, Pa. (Wm. L. Baily) ; Tinicum, Pa.
(J. Harris Reed) ; Olney, Pa. (Geo. S. Morris) ; and German-

town, Pa. (Witmer Stone). The numbers indicate the exact number of birds seen; 'F' denotes flocks; 'A,' abundant; 'C,' common; and 'S,' several. Wherever a record shows that a movement was taking place, either by the arrival of a species not seen on the days preceding or by the marked increase in the number of individuals of a species, the record is surrounded by a heavy line. The idea is, to show how these records are massed on certain days, indicating a bird wave on that day or the night just preceding, and also how these waves always occur at times when there is a marked rise in temperature.

In these small cuts, it is only possible to record the observations on a very few species, and I have been able only to show two or

1890		-FEBRUARY-																				MAR.				
Temperature Variation																											
Day of Month.		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5
Quiscalus quiscula	H	3		60	20	F	F	4		F	F	F	A	F	S	A	A	A	A	A	A	1	F	A	A
	W				A		A	F	F	F	F	F	F	F	F	F	F	F	F	S	C	C	C	C
	T						100	8		2	20	7	9	15	10	15	5	3,50		30	200		5	30
	O	F	F	F			F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	G				1	3								F		F	F						3	
Merula migratoria	H																		1	F				8
	W																	9	A		1		1	
	T																		10					1
	O				6			3		S	S	5		F		S		6			F	F	F	F
	G																	6						
Sialia sialis	H	7			5	5		4	4	6	S			3	S	2	S		S					
	W					4				2				2			1	30		10				
	T									2				2	6		2	20					4	5
	O									3		2			6		3							
	G														1		1						1	
Colaptes auratus	H					2													1	1				
	W					3													1					
	T													1					1					
	O																							
	G																							
Agelaius phoeniceus	H				S		20		3	S	F	F	S	S	S	S	A	S	A	S	A	S		S	S
	W													1										
	T												10	7	20				60				1	
	O																							
	G																							

Chart showing the Second and Third Waves of 1890.

1890

- APRIL -   - MAY -

Temperature Variation.

Day of Month.

Turdus a. pallasii.

Harporhynchus rufus,

Chaetura pelagica,

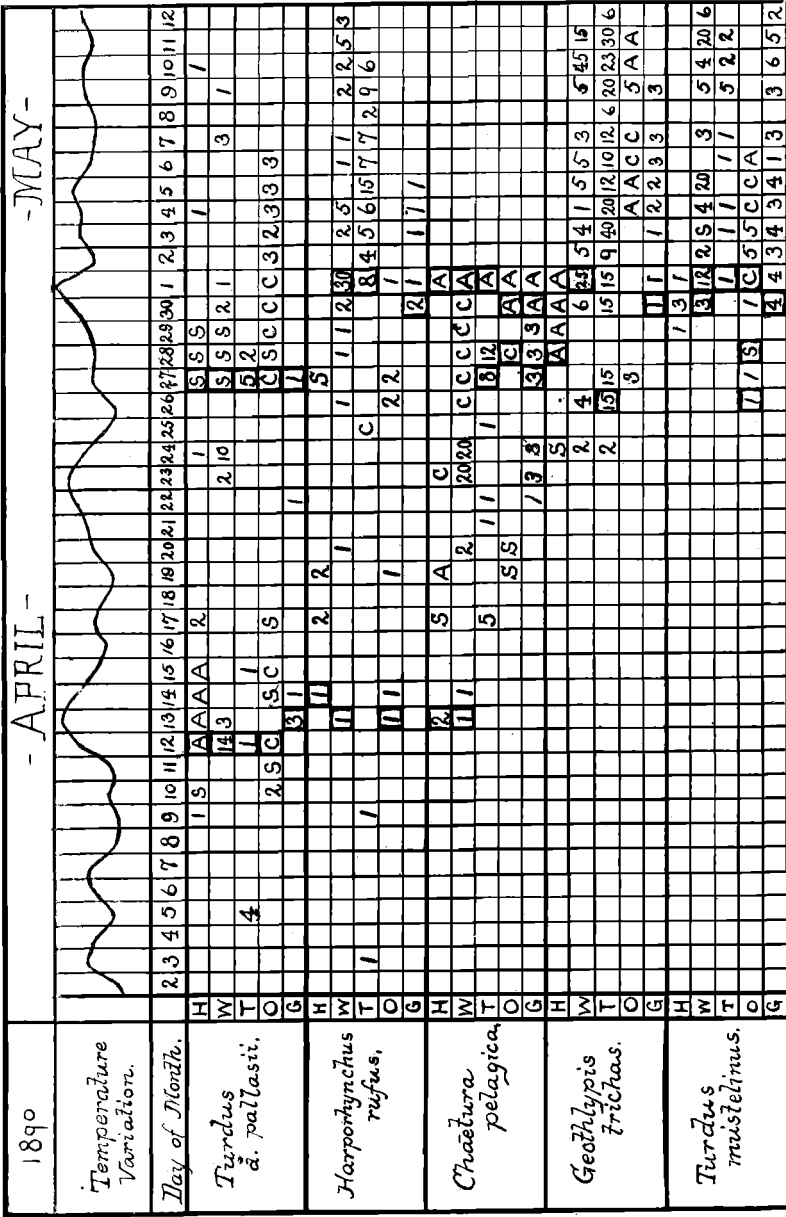Geothlypis trichas,

Turdus mustelinus.

Chart showing the Fifth, Sixth, and Seventh Waves of 1890

three waves distinctly in each. Therefore such records as indi-
cate migratory movements at other times have not been marked
with a heavy border, as it would only tend to make the whole
appear confused, the function of these cuts being to illustrate the
method rather than the results. A large chart giving the obser-
vations on twenty or thirty species shows a number of waves dis-
tinctly; each one corresponding to a rise in temperature. The
most prominent waves of the spring with a few of their most
characteristic species are as follows:

January 12.—Robin and Purple Grackle.
February 12-14. — Purple Grackle, Robin, Bluebird, Red-winged Black-
            bird, and Flicker.
February 26-27.—The same species.
March 12-13.—The same with the addition of Meadowlark and Cowbird.
April 12-14.—Song Sparrow, Chipping Sparrow, Savanna Sparrow, Her-
            mit Thrush, Golden-crowned Kinglet, and Snow Bird.
April 26-27.—Maryland Yellowthroat, Brown Thrasher, Myrtle Warbler.
April 30—May 1.—Chimney Swift, Barn Swallow, Bank Swallow. Mary-
            land Yellowthroat, Myrtle Warbler, Towhee, Wood Thrush,
            Baltimore Oriole, and numbers of Warblers.
May 4-5.—Mainly Warblers, also Towhee, Kingbird and Catbird.
May 10-11.—Warblers.
May 18.—Warblers.

As has been already stated two cuts, each based on only five
species of birds fail to show all the waves, and do not give much
idea of the amount of migration that occurred during the waves
which they are intended to illustrate. The following summary,
however, will show the amount of migration that took place on
the days just given as characterized by the occurrence of bird
waves, as compared with the other days of the spring. It must
be remembered that we do not expect all the records of migratory
movement to fall on the days of bird waves, as birds appear to
migrate on every clear night after the spring is pretty well
advanced; but we do expect a greater proportion of arrivals and
increases in numbers to occur on these days than upon the other
days of the spring, and this I think is clearly shown by the fol-
lowing: Taking into consideration the dates of first arrival of
fifty of our more common migrants at the five stations already
mentioned, between January 12 and May 12, we should have a
total of 250 records. Of these twenty-five are lacking in the
data before me, the birds having arrived after May 12 or having
been missed altogether. These records fall as follows:—

Jan. 12.—First wave.............................. 3

Jan. 13-Feb. 11............................... 4

Feb. 12-14.—Second wave...................... 4

Feb. 15-25.................................. 6

Feb. 26-27.—Third wave....................... 5

Feb 28-March 11.............................. 0

March 12-13.—Fourth wave..................... 6

March 14-April 11............................. 16

April 12-14.—Fifth wave....................... 20

April 15-25................................. 12

April 26-27.—Sixth wave...................... 16

April 28-29................................. 4

April 30–May 1.—Seventh wave................. 48

May 2-3.................................... 8

May 4-5.—Eighth wave....................... 28

May 6-9.................................... 16

May 10-11.—Ninth wave...................... 26

May 12..................................... 3

156   69

Summing up the result we find that on 19 days during which bird waves were in progress there were 156 first arrivals, or an average of 8.21 per day; while on 102 days when no waves were in progress there were but 69 arrivals, or an average of only .68.

It may be imagined that more careful observations were taken on the days upon which the waves appear to have occurred, but such was not the case, as the observers were aware of this possibility and guarded against it, endeavoring to spend a portion of every day in the field and to cover nearly the same ground daily.*

The increase in the numbers of individuals of each species seen daily, and the dates when the species became common, show a still greater coincidence with the dates which I have just mentioned as those of bird waves, than do the records of first arrivals just given. This is quite natural, so many of the latter are mere stragglers, and it is really surprising that so large a proportion of them as is shown by the summary do coincide with the waves.

In conclusion, I may say that this paper does not pretend to set forth any new theories in regard to bird migration, but simply to offer a few facts in corroboration of the already well-accepted wave theory; and to suggest a method for the graphic representation of the waves of migration and their coincidence with variations of temperature.

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* See beyond, 'Work of the Delaware Valley Ornithological Club during 1890, under 'Correspondence,' in this number of 'The Auk.'