CYCLES OF MIGRATION*

BY LEONARD WILLIAM WING

By means of the efforts of bird students, which have been directed towards the accumulation of observational facts of migration, we have built up a vast amount of data of incalculable value. We may be justly proud of the efforts in this direction and hope that they will be continued in the future as in the past. Of perhaps even greater pride is the individual, undirected, and unencouraged nature of the work. In no other branch of natural history has so much data been accumulated on so difficult a problem.

My studies of migration and obvious phenomena of nature such as meteorological conditions proved wholly unsatisfactory and inconclusive. No sooner would a relationship seem established than to be overthrown by additional facts. Some years ago, through the interest of a close friend, I turned to astrophysics as a possible means of finding an ultimate control of migration. It seemed reasonable that migration, which takes place at definite positions of the earth and sun each year would respond to any changes in the sun, the more variable of the two.

In a previous study,[1] I directed attention towards migration responses of birds to two solar cycles, the half and eleven year sun-spot cycles. Presenting the Loon as an example of a bird's response to the half[2] sun-spot cycle and the Sandhill Crane to the eleven year cycle, I attempted to show briefly that birds respond to solar cycles, most water birds to the half sun-spot cycle and most land birds to the eleven year cycle. Although only then surmised, additional periodicities have since been revealed by continued investigation.

In Figure 5, the topmost curve (the same as used in the paper referred to above) shows that the earliest arrivals of the loon at Ann Arbor, Michigan, occur both at sun-spot maximum and minimum. This type of response may be termed *extremal* (after *extremum i. e.* either maximum or minimum).

The middle curve of Figure 5 demonstrates the same migration relationship for a closely related bird, the Pied-billed Grebe. The same five oscillations occur.

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*Presented at the Fifty-first Stated Meeting of the American Ornithologists' Union, New York, November 21, 1933.

[1]Presented at the Fiftieth Stated Meeting of the A. O. U., Quebec, 1932. Published in the Auk, Vol. LIX, July, 1934, pp. 302-305.

[2]The half cycle is half of eleven years.

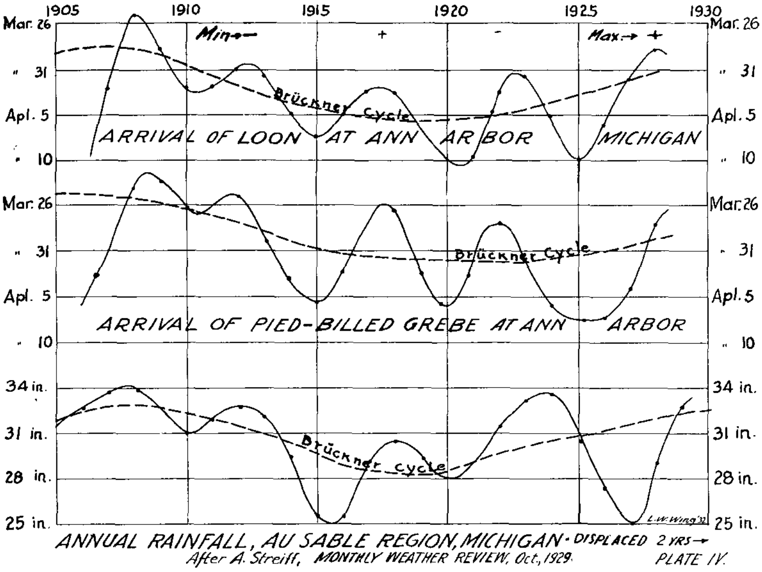

FIG. 5. Curves of earliest arrival of the Loon and Pied-billed Grebe at Ann Arbor, Michigan, and precipitation in the Au Sable River region. The plus and minus signs indicate sun-spot maxima and minima.

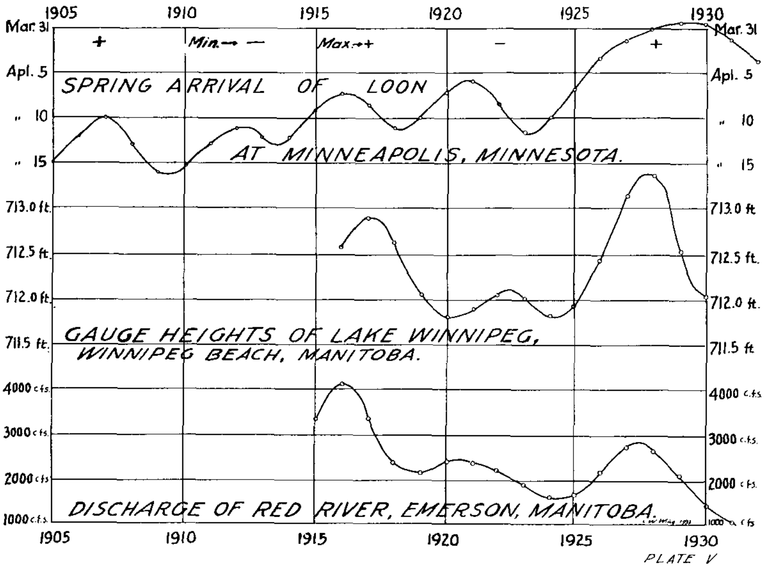

FIG. 6. Migration of the Loon; levels of Lake Winnipeg (above sea level); flow of the Red River, in cubic feet per second.

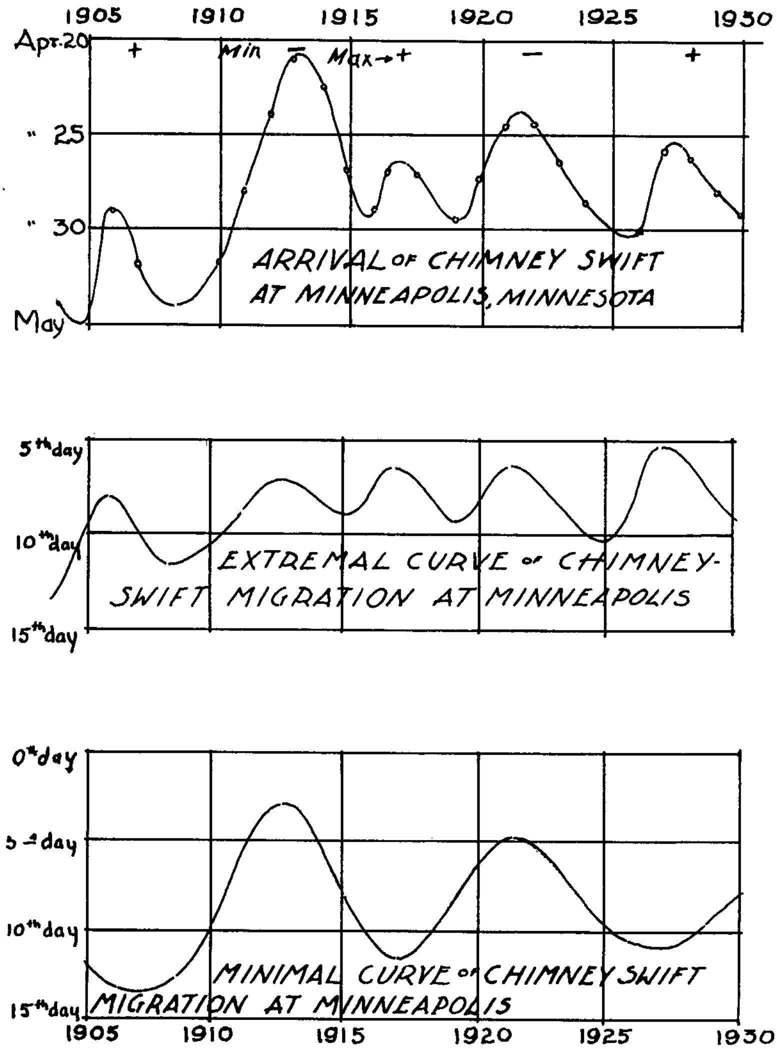

FIG. 7. Analysis of Chimney Swift migration. The ordinates of the two lower curves are based on a "zero" day.

The third curve of Figure 5 shows the rainfall curve for the Au Sable River region 200 miles north of Ann Arbor. I have used this curve (prepared by Mr. Abram Streiff, of Jackson, Michigan) as it represents the only comparable series of integrated precipitation data available. I have displaced this curve to the right two years to assist in comparison with the three curves in the figure. For example, the precipitation for the year 1918 appears under 1920 in the figure, etc. In this displaced position we note a correspondence of all three extrema. According to Mr. Streiff, the cumulative action of ground-water is evidenced in regions of glacial drift by this displacement of the rainfall curve. Stream flow and surface water in turn are reflected in the ground water levels and this displaced curve is indicative of their conditions.

The sun-spot cycle is not one simple cycle but rather a complication of interrelated periodicities. Mr. Strieff[3] has pointed out several long-term cycles. One, with an average length of thirty-three years, has been called the *Brückner Cycle* by him. A change of smoothing averages reveals the Brückner Cycle in the present data of the loon and grebe migrations. It is represented in Figure 5 by the broken-line curves. A feature of significance is the appearance of the Brückner Cycle in phase (*i. e.* the oscillations occurring simultaneously) in the migrations and in the rainfall.

Through the generosity of Dr. Thomas S. Roberts of the University of Minnesota, I obtained arrival data for the loon at Minneapolis. The data have been supplemented, through the courtesy of Dr. Harry C. Oberholser, by records from the files of the Biological Survey, Washington, D. C. The Minneapolis data, Figure 6, bear out the Ann Arbor records. The same five peaks of arrival are present and occur at the sun-spot extrema. The second and third curves of Figure 6 show the levels of Lake Winnipeg and the discharge of the Red River at Emerson, Manitoba. I am indebted to the Dominion Water Power and Hydrometric Bureau for the use of these data. The three sets of curves show a distinct relationship. The lag of the lake levels behind the run-off is clearly apparent.

The arrivals of the Chimney Swift at Minneapolis are shown in Figure 7. These data were also received from Dr. Roberts. The top curve was plotted directly from the smoothed data and shows the extremal migration as in the loon and grebe. The greater amplitudes at sun-spot minima indicate a complex curve and lead one to sus-

[3] 1926 Monthly Weather Review, Vol. 54, p. 7.

pect that the Chimney Swift responds both extremally and minimally. This complex curve can be resolved into two curves as shown. It indicates that the Chimney Swift comes the earliest at sun-spot extrema and also possesses a separate set of early arrivals at minima. The combination of the two which occurs at the minima gives earlier early arrivals at minima than the early arrivals of the maxima. From survey of other data, I am inclined to believe that this is a widespread migration phenomenon.

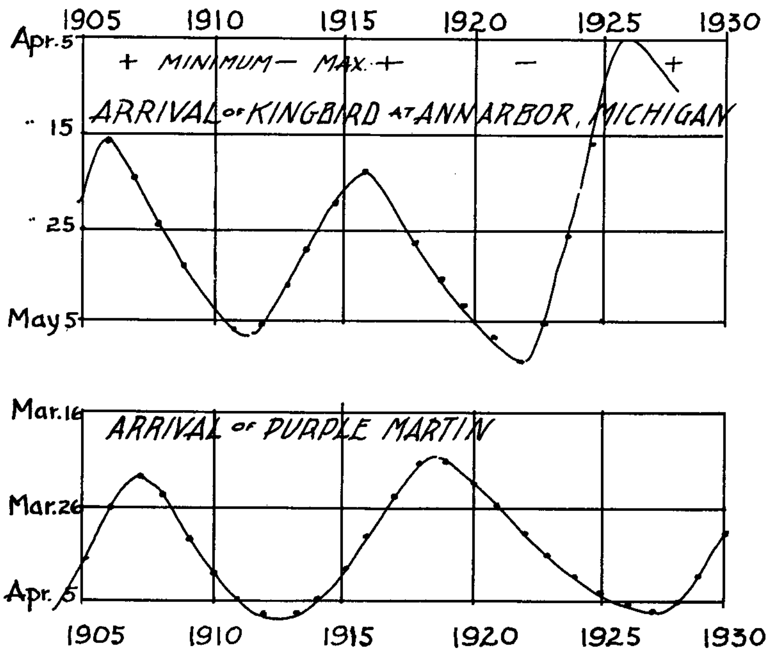

FIG. 8. Migration curves for the Kingbird and Purple Martin.

Figure 8 shows the arrivals of the Kingbird at Ann Arbor and the Purple Martin in southern Michigan. The latter has been compiled from several sources in southern Michigan in order to fill gaps in the Ann Arbor data. These two migration curves are further evidence of the maximal migration as of the Sandhill Crane of my previous paper.

The opening dates for Eastern Brant shooting on Monomoy Island, Massachusetts, as published by Dr. John C. Phillips[4] furnish definite evidence that the start of spring shooting, coincident with the arrival of the Eastern Brant, has followed a definite rhythmic cycle and is not

[4]Auk, Vol. 49, October, 1932, pp. 445-453.

due to fortuities. I have taken the dates from Dr. Phillips' paper, analyzed them and plotted them as shown in the bottom curve of Figure 9. For the convenience of the reader, I have added the curve of the Wolf Numbers (the index of sun-spot conditions) as well as the Brückner Cycle discovered by Mr. Streiff. It will be seen that the early shooting occurred at the sun-spot minima and the later shooting at the maxima. The Brückner Cycle is clearly evident in the brant curve. Its effect is manifest in the earlier shooting at the minima

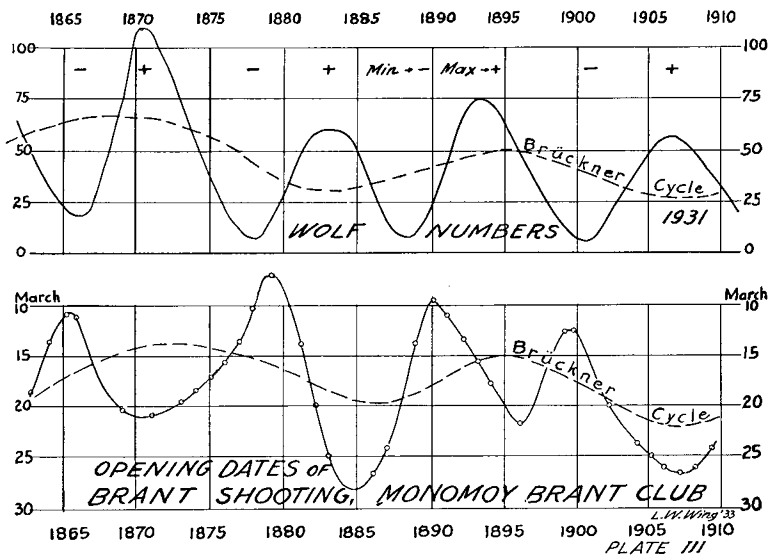

FIG. 9. Analysis of the Wolf sun-spot numbers and of Brant shooting.

of 1871 and 1896 as compared with the minima of 1885 and 1907. The shooting began earlier at the sun-spot minima than at sun-spot maxima and again earlier at the Brückner maxima than at the Brückner minima.

It has been shown that other cycles of longer period than the Brückner may be identified in the Wolf Numbers. There is no reason to disbelieve the presence of the long-time cycles in the migration of birds.

It is not my desire to give the impression that the migration of loons and grebes is controlled by fluctuations in water levels which accompany solar changes. They are introduced here as evidence that the environment has definite rhythms paralleling the migration rhythms. The same cycles found in both migration and the environment indicate an external control over migration. The accelerations and the retardations of migration with changes in the sun lead to the belief that it is not only the guiding influence in migration movements but is probably the seasonal starter of the movements. The demonstrated limited control by the sun places us a step closer to the causal factors of migration.

From consideration of the cyclic character of migration, it is evident that there is a *continuity* to the yearly migration. We must speak of the *regularity* of migration and look upon the difference in arrival dates from year to year as a manifestation of this regularity. The time when a species is due to arrive at any point of its migration path is not accidental but is dependent upon *real cosmic* factors. This continuity of arrival, as attested by the half century record of the brant and shorter records for others, demonstrates that migration takes its place as another of the inter-related mechanics of nature.

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FIELD EXPERIENCES WITH MOUNTAIN-DWELLING BIRDS OF SOUTHERN UTAH

BY ALDEN H. MILLER

Some of the mountains of southern Utah were visited in the late summer of 1872 by H. W. Henshaw and a considerable amount of information on the birds of this section of the state was set forth by him in the reports resulting from his ornithological explorations and the explorations of his associates (*U. S. Geog. and Geol. Explorations and Surveys*, Vol. V, Chap. III, 1875). Since then little has been added regarding the birds of this region. In 1927 Tanner (*Condor*, XXIX, 1927, pp. 196-200) listed the birds of the lowlands of the Virgin River and mentioned also certain species found in Zion Cañon and in the Pine Valley Mountains. Stanford in a recent article (*Auk*, XLVIII, 1931, pp. 618-621) offers notes on the hawks and owls of Sevier County, including the high mountains of the Fish Lake district. Accompanying the increased accessibility of the mountains of this part of Utah due to the development of national parks and other scenic features, considerable advance in the knowledge of local bird distribution is to be expected. It may appear presumptuous for me to offer comments on the birds of southern Utah on the basis of a short acquaintance with the region. But, my systematic collecting and study during late June and July in Utah in 1931 have disclosed a number of