Continuous rainfall for over a month (at Mt. Montezuma, in the most cloudless region of Chile) made solar observations impossible. . . . The River Loa became a raging torrent, and the excessive rainfall caused great damage to bridges and property.—*Sci. Serv.*

PHENOLOGY: RESPONSES OF LIFE TO THE ADVANCE OF THE SEASONS

By CHARLES F. BROOKS AND FRANCES V. TRIPP

Instead of using instruments to measure the climatic elements or to appraise the daily weather as a whole, we may observe the periodic phenomena of plant and animal life and the distributions and associations of the several species to indicate the facts of climate. In the spring especially we have before us every day new indications of the advancing season, not in the higher temperatures and longer days alone, but in the swelling of buds, the blossoming of early flowers, the arrival of birds and the appearance of bees and flies. According to his bioclimatic law[1] Dr. Hopkins finds that the upward and northward advance of spring averages four days for one degree of latitude, 400 feet of altitude or 1 degree F. rise in mean temperature, and that the advance of autumn is at the same rate in the opposite direction. Dr. Hopkins has found also that there is an average difference of 32 days in 40° of longitude, spring on the Pacific coast arriving phenologically earlier than spring at the same latitudes on the Atlantic coastal plain. On the immediate Atlantic shore the cold water induces a local delay in the arrival of spring. Other major sources of departure from the average are slope, wet vs. dry soils, type of vegetation, early or late individuals, and locally early or late seasons.

Bird migration[2] in the spring is dependent upon food supply. Wild ducks move northward when ice on rivers and lakes has disappeared sufficiently to allow them access to their food. Other birds are similarly limited as to their northward rate by the dates at which their particular food supply becomes available. Different species requiring different sorts of food, therefore, migrate at different periods and at different rates. A study of bird migration and the weather recently made by Prof. Frank H. Smith of the University of Illinois shows that, over a period of years (1909-1916) birds came in waves, by far the greatest number arriving on days when an approaching low caused a rise in temperature and southerly winds.[3] In the fall, failing food supply starts some flocks southward. A number of the English starlings of the northern states, after more than 30 years' residence, migrated southward for the first time in the fall of 1923.[4] "Until recently through sheer ignorance, they have had to adapt themselves to a climate wholly unnatural in its severity, for at home in northern Europe, the species migrates regularly to southern Europe." Their first knowledge of migration in America, ornithologists believe, probably came from their

[1] Hopkins, A. D.: Periodical Events and Natural Law as Guides to Agricultural Research and Practice, *Mo. Wea. Rev., Supplement*, No. 9, 1918.

[2] For a full discussion of this subject, see Bulletin No. 185 of the U. S. Biological Survey by W. W. Cooke.

[3] Smith, Frank: The correlation between the migratory flights of birds and certain accompanying meteorological conditions, pp. 32-35, State of Illinois, Circular No. 151, 1921, pp. 21-29. See note in Bull. Amer. Met'l Soc., April, 1924, pp. 56-57.

[4] *Sci. Service News Bulletin*, No. 140 C & D, Nov. 28, 1923.

contact with the flocks of blackbirds and grackles with which they mingled.

The dates for planting of garden truck in any locality are often estimated from a knowledge of the average date of the last killing frost. Since seasons frequently differ from the average, however, the progress of natural vegetation is usually a safer guide for farm operations. "Some examples of commonly recognized events in the advance of the season are the following: the opinion of the Indians is that the proper corn planting time is when the white oak or maple leaves are the size of squirrel ears; the saying in the Rocky Mountain region that sheep shearing should not be done until the 'spring sown grain begins to carpet the fields in green,' or 'the wool goes off as the fruit blossoms come on;' calling *Amelanchier Canadensis* or 'lance-wood' bush the 'shad bush' because when it came into bloom it was recognized along the Atlantic coast that it was time to fish for shad. The ornamental shrubs are more or less constant in this response to the advance of the season and serve as very good guides." [5]

In spite of the wide application of such data, however, there have been comparatively few phenological observations published in the United States. In Canada, in contrast, phenological observations are carried on in every province, and are published annually.[6] For over thirty years local nature observations have formed a part of the curriculum of every school in Nova Scotia, where record sheets are sent to every teacher on which are set down the dates of the first leafing, flowering and fruiting of plants and trees, both wild and cultivated; the beginning of farm operations; the first appearance in the locality of birds migrating north in spring and south in autumn; the opening and closing of rivers and lakes, the highest and lowest water in streams; the first and last snow and frost; and the number of thunderstorms. Observations are made by pupils on their way to and from school, and as some of them radiate as far as two miles from the schoolroom, few changes in the district can take place without coming to their notice. These records have been compiled from year to year so that with very little trouble to any one person a wealth of phenological observations has been compiled.[7]

Dr. A. D. Hopkins says in a recent letter, "Phenology as a science, or a branch of the new sciences of Bioclimatics, not only requires some knowledge of all the natural sciences, but long study and experience to gain sufficient knowledge of technical detail to warrant the undertaking of special lines of research; [and yet] as a matter of personal interest to lovers of nature in general, and as a source of instruction and inspiration to school children and young college students there is perhaps no subject that will serve the purpose better than simple records of observations on season phenomena of their immediate locality." [8]

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[5] Smith, J. W.: Agricultural Meteorology, N. Y., 1920, pp. 30-31.

[6] In *Trans. Roy. Soc. of Canada.* See also No. 1667 in *Bibliographie Géographique* for 1923.

[7] Material for this paragraph was kindly sent by Col. A. H. MacKay, Supt. of Education, Nova Scotia.

[8] Three recent publications dealing with phenological observations are found in the following magazines: (1) *Nature*, Oct. 25, 1924, p. 607; (2) *Quart. Journ. Royal Met. Soc.*, Vol. 50, Oct., 1924, pp. 277-325; (3) Dr. E. Ihne's *Phaenologische Mitteilungen*, Arbeiten der Landwirtschaftskammer für Hessen, Heft Nr. 33.