A CYCLE IN NORTHERN SHRIKE EMIGRATIONS

BY DAVID E. DAVIS

THE problem of periodicity in organisms has been recognized since the beginning of the century. The cycles of several species have been studied in detail. The Northern Shrike (*Lanius borealis borealis*) has attracted attention by its occurence in New England and adjoining States in large numbers in certain years. Since the species is predatory, a correlation with the well-known cycle of mice (*Microtus* spp., *Dicrostonyx* spp.) was suspected.

The Northern Shrike breeds in the Hudsonian and Canadian zones from northern Ungava south to central Quebec and northern Ontario, probably as far west as York Factory. Westward it intergrades with *Lanius borealis invictus*. It winters southward to New England and in smaller numbers as far as Kentucky, West Virginia and even South Carolina. The food of this shrike consists of small birds and rodents. The animal is killed either by a few blows of the bill on the skull or by shaking. In the winter small birds are the chief source of food but in summer the small rodents and large insects undoubtedly provide food. Birds as large as a Hairy Woodpecker (*Dryobates villosus*) have been caught. Many House Sparrows (*Passer domesticus*) and Starlings (*Sturnus vulgaris*) are killed. On the whole the species is considered as beneficial (Forbush, 1929, p. 176).

I wish to acknowledge the suggestions and help of Dr. Glover M. Allen. Mr. J. C. Greenway, Jr., facilitated the examination of the specimens in the Museum of Comparative Zoology. Mr. Ludlow Griscom suggested the use of the Linnean Society's records.

A thorough examination of the available literature was made for records concerning shrike invasions. It was soon apparent that the Christmas Bird Census in 'Bird-Lore' supplied the only data which could be used to compare one year with another. These records are here presented in a graph showing the number of birds observed per census for each Christmas period. During the first few years the number of censuses is small and hence the data are only indicative. The Maine Ornithological Club conducted a Christmas census during the years 1900–1910. These records are included in the graph. To show that the census actually does indicate the variations in abundance from year to year, the number of Crows (*Corvus brachyrhynchos*) observed was analyzed over a period of years, and, as would be expected, the number of records was very constant.

The Christmas census was examined for records of the Rough-legged Hawk (*Buteo lagopus s. johannis*) and the Goshawk (*Astur atricapillus*). These were, however, too few to be of significance.

The records of the Linnean Society of New York indicate that the shrikes begin to arrive in that region about the first of November and are most abundant in the latter part of the same month. In the spring a few stay as late as April.

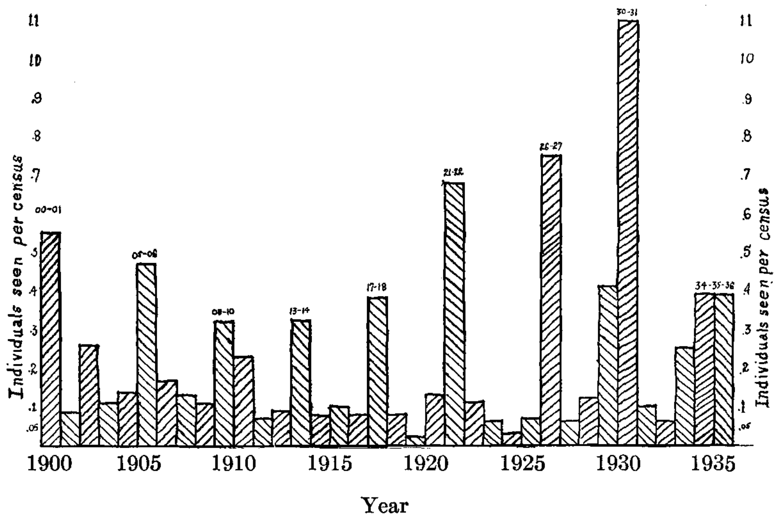

FIG. 1.—Graph showing relative abundance of Northern Shrike in successive years in the Northeast.

The fact that the minima are constant is proof that the maxima are real and are not the result of the interpretation of the data or of the method of making the census. For no matter how many observers were in the field, only a few shrikes were seen in the minimal years.

Several invasions are recorded. Brewster (1906, p. 310) remarks that fifty were shot on the Boston Common in one year. The city hired gunners to protect the recently imported House Sparrows! Shrikes are reported as being abundant in the winter of 1878–79.

The specimens in the collection of the Museum of Comparative Zoology were examined. The ages were distributed as follows: adults; 32.5%; first-year birds, 67.5%; 44.5% were males. Miller (1931) has concluded that the normal winter and spring population of shrikes is 77% of first-year birds. From a comparison of these data it may be concluded that the invasion is not restricted to any particular age group.

Gross (1927), discussing the invasion of Snowy Owls (*Nyctea nyctea*), points out "the strong tendency of the owls, also noted on former migrations, to congregate along the seacoast and, to a lesser degree, the chief river courses." Further, "it is apparent that the owls concentrated on our large lakes and on the seacoast because of the abundant supply of dead fish, birds, rats, and other food which is found there." The shrikes also were confined to the coasts and rivers. In the 1930 migration sixty-eight of the seventy-one individuals recorded were near a river or the coast. In 1926 none of the records was more than a few miles from the coast or a river. Similarly, in 1917, all the records were on the coast or near rivers. Roberts (1932, p. 162) includes carrion in the food of the shrikes. Thus it seems that the shrikes are attracted to the coasts and rivers for the food found there.

That there is a definite cycle is at once apparent from the graph. The average is 4.2 years. It should be noted that there are two five-year periods and no three-year periods. The winters of maximum abundance are 1900–01; 1905–06; 1909–10; 1913–14; 1917–18; 1921–22; 1926–27; 1930–31; 1934–35. That there was a maximum in the winter of 1900–01 is supported by Brewster (1906, p. 15) who states that shrikes were not seen in 1902, 1903, or 1904, but were rather common in 1901.

The Snowy Owl periodically invades southern Canada and northern United States. Gross (1927; 1931) has recorded two of these invasions. The emigration of 1930–31 was not as large as that of 1926–27, perhaps due to a mild winter. Other invasions are recorded for 1901–02, 1905–06, 1917–18. These dates are either four years or some multiple of four years apart.

The maximum abundance of the Arctic Fox (*Alopex lagopus ungava*) coincides remarkably with the emigration of the owls (Gross, 1931) and the shrikes. The years for maximum numbers of foxes may be determined by the fur returns of the Hudson's Bay Co. These years agree exactly with the Snowy Owl and shrike invasions.

A change in the length of the period is indicated. Since 1893, the period of maximum abundance of foxes has been, except for one five-year period, four years. But before 1893 the period was usually three years and the average was 3.3 years. Since the years of the invasions of the Snowy Owl and shrikes are the same as the years of maximum abundance of the Arctic Fox, it follows that the period of emigration of these birds has also changed.

A cause for the correlation between these three species is at once apparent. Mice form the principal food of these three predatory species and any fluctuations in the abundance of mice would be reflected in the numbers of shrikes, owls and foxes. Cabot (1921) records a peak in the abundance of *Microtus pennsylvanicus enixus* in Labrador, in 1905. Falcons, Snowy Owls and Ptarmigan increased. The Ptarmigan became abundant, of course, because the predators had plenty of mice to feed upon. In 1906, the mice had disappeared.

I am indebted to Mr. A. C. Weed of the Field Museum of Natural History for the following information. At Nain, Labrador, in the summer of 1926, the mice were everywhere. In order to collect them it was only necessary to dig a hole in the ground the size of a bucket. During the night from thirty to fifty mice would fall into the hole. It is significant that late in the season several mice were found dead in the nests. Food was abundant and hence starvation was not the cause of their death. In July 1927, there were no mice. None of the various baits or traps was able to catch more than a few and collecting was given up. In the summer of 1928, however, the mice were becoming common. The effect of the disappearance of mice on the other members of the fauna was marked. In 1926, there were twelve nests of the Rough-legged Hawk at Indian Harbor. In 1927 and 1928, there were no nests. There were almost no Ptarmigan in the winter of 1927–28 and the natives had a difficult time to find food. Only two or three Spruce Grouse, one of the Eskimo's sources of food, were caught during the entire winter. In the summer of 1928 only three hares and only one Snowy Owl were seen. The Arctic Foxes were forced to feed on fish. In the winter of 1927–28 about seventy-five furs were brought in. Almost all of these came from one place where the foxes had been able to find fish. The normal catch is about fifteen hundred. The Great Horned Owl and the Raven were not affected. Jays, Robins, Crossbills, and Chickadees were as common in 1927 as in any year.

It is quite obvious that the mice increase and periodically die out. During the increase of mice, the predators likewise increase. Since mice are so abundant, the Ptarmigan and Grouse are not preyed upon and also increase. When the mice disappear the predators first exhaust other prey and then either migrate or die. This periodic fluctuation in abundance is not due to the mere geometrical increase of each species, as is shown by the fact that the lemmings of Norway, whose cycle is the same as that of the North American species, have the same period on different mountain tops.

A change in ultra-violet radiation has been suggested as a cause. A decrease in ultra-violet would result in a deficiency in vitamins not only in the animals directly but also in the food plants. Abbot (1935) concludes from extensive studies on solar radiation that there are twelve or more periodicities, all of which are integral submultiples of twenty-three years. This period is reflected in the weather as indicated by lake levels, the flow of the river Nile, Eocene and Pleistocene varves, and tree rings.

As was shown above, there was a change of period from 3.3 years to 4.1 years. The former is an integral submultiple of twenty-three but the latter is not. It seems unlikely, then, that the cycle of mice as reflected in the abundance of predators, is the result of a cycle of solar radiation.

Severtzoff (1934) has pointed out that the length of time between decreases due to disease is dependent upon the fertility of the species, since an epizootic disease requires a certain threshold number of animals before it becomes a plague. It is thus unnecessary to postulate a periodic climatic cycle as the fundamental and complete cause. The epizootic disease is present at all times but only reaches plague proportions after the host has passed a certain threshold of numbers. Those species whose coefficient of fertility and threshold of numbers are the same would have the same period but the periods would not necessarily be synchronous. When several predators are dependent upon one animal, their cycles will obviously be synchronous.

Elton (1935) has described the periodic epidemic among *Microtus agrestis* in England. A protozoan infection of the brain due to *Toxoplasma* has been shown to be the cause. It seems certain that a similar cause will be discovered for the epidemics in the mice of the Labrador peninsula. Weather fluctuations, variation in solar radiation, lack of food due to overpopulation, may modify the cycle more or less in certain years, perhaps even hasten or retard it for one year. The fundamental periodicity, however, is probably determined by the epizootic disease.

A cycle of ten years is also known. The Snowshoe Rabbit is apparently responsible for the increase in coyotes, Red Fox, and lynx. A cycle in grouse which may depend upon grasshoppers (Criddle, 1930) coincides. No correlation between the shrike invasions and the ten-year cycle is apparent. It is possible that the ten-year cycle would become apparent in data over a longer period of years. This ten-year cycle is not correlated with the sunspot cycle (11.2 years) nor with the cycle of the revolution of the moon's orbit (8.85 years). There is also a cycle of 18.6 years in the relative shift of the planes of the orbit of the moon and of the earth. It has been suggested that the ten-year cycle may be a combination of these but it seems unnecessary to seek such a remote cause.

Wing (1935) has correlated migration dates with solar activity. As indicated by the "Wolf numbers," there are four cycles: 5.65 years (half cycle); 11.2 years; 23 years; and 73 years. Sandhill Cranes and Kingbirds arrive late in the season when the "Wolf numbers" are low. Grebes, loons and Chimney Swifts arrive early at both the lows and the highs of the "Wolf numbers." Brant arrive early when the "Wolf numbers" are high. Wing further states that the Ruffed Grouse, Sharp-tailed Grouse and Prairie Chicken have a cycle of abundance of 5.7 years. The Scottish Grouse (*Lagopus scoticus*) has a cycle of 5.8 years. These agree with the half cycle. He finds that the Snowshoe Rabbit and the English Rabbit (*Oryctolagus cuniculus*) synchronize with the eleven-year cycle. His conclusion is that "the sun is a dominating factor in wild life." From the data presented, his conclusions are not convincing. He makes no mention of the four-year cycle dependent upon mice.

In evolution by natural selection periodic fluctuations in numbers are of great significance, as Elton (1924–25) has pointed out. When the population is at a maximum, selection takes place according to the ability to resist disease and to obtain mates and raise young successfully. At the minimum the animals are selected for their ability to avoid enemies, find mates, and resist unfavorable environmental conditions. Thus selection affects different attributes alternately. It must be remembered that only a change in the severity of selection can affect the genotypical constitution of a population.

During the increase in numbers a mutation, which has little or no adaptive significance, has an opportunity to become established. Since there is relatively little struggle for existence at the time when a species is recolonizing an area, any indifferent mutation would have a chance to become firmly established.

In the frequent cases where natural selection does not seem to be a factor in evolution, the fluctuations of numbers permit the automatic reduction of potential polymorphy. According to this principle (Du Reitz, 1931) the genotypical constitution of a population tends to become uniform. Heterozygotes can produce homozygotes, but the reverse is not possible. Hence the number of heterozygotes tends to be reduced. Whenever the population is continued from a fraction of the number of individuals, or where a colony is started by a few individuals, the chance of heterozygotes being included is proportional to their number. Thus it is possible for the less common genes to become extinct. In this manner, emigration may affect the genotypical constitution of a species.

SUMMARY

The Northern Shrike emigrates periodically. The Christmas censuses of 'Bird-Lore' provide a reliable source of data and show that the period is 4.2 years.

Snowy Owl invasions and the maximum abundance of Arctic Foxes coincide with the shrike invasions. These three predators are dependent upon a periodic abundance of mice. This period has changed from 3.3 years to 4.2 years.

A periodic fluctuation is not due to mere geometrical increase.

It is unnecessary to assume that solar variation must be a fundamental cause. It is suggested that the periodicity may be determined in the following manner. An epizootic disease, which requires a certain threshold to become a plague, would break out only after the threshold had been reached. The length of the period would, therefore, depend upon the coefficient of fertility and the threshold of abundance of the host.

Emigration may affect the genotypical constitution. Natural selection operates on different attributes at different times and may not operate

during increase. A decrease in population tends to produce a uniform genotypical constitution.

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