

FLUCTUATIONS IN NUMBERS OF BIRDS IN THE TORONTO REGION

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THE numbers of any animal species present in a given region fluctuate year by year. In some cases there has been a tendency for the years of greatest abundance to occur at regular intervals. The purpose of this paper is to put on record certain periodic fluctuations which have been detected in the Toronto region, in the winter populations of Northern Shrike, Snowy Owl, American Rough-legged Hawk, Pine Grosbeak, Horned Owl, and Goshawk. In this paper the Toronto region is that area within twenty-five miles of the Toronto city limits. This area reaches to Burlington on the west, to Newmarket on the north, and includes Whitby on the east. The years of greatest abundance will be called peak years, or simply peaks.

The records from which the conclusions presented in this paper have been derived consist of a great mass of data of varying quality. Few of the identifications have been made from collected specimens but with the increased use of binoculars and with the increased quantity and quality of reference books it is no longer necessary to identify birds by collecting them, certainly not for a statistical work where exceptional records automatically play an insignificant rôle. The largest source of data used in this study is the mass of sight records recorded by local bird students.

The chief sources of records are as follows:

1. The file of checking cards in the Royal Ontario Museum of Zoology. These cards list all the species of birds which have been identified in the Toronto region in recent times. Spaces are provided for indicating the number of each species seen on a trip, the locality, the date, the name of the observer, the time spent observing, and the weather. The file contains continuous records since 1885. Records previous to 1920 have been obtained from the diaries of a number of naturalists.

2. The author's records. These consist of daily lists of all species observed, starting from January 1, 1924. Numbers were used in a few cases before 1931 and starting in January, 1931, all the lists have included estimates or counts of the numbers of each species seen.

From these two sources about 10,000 complete daily lists are available and about 3,000 lists that are more or less nearly complete. The number of available daily lists varies from about ten per day in late July to about forty-five per day in early May.

3. These data are supplemented by numerous scattered records in the following sources: the records of the Brodie Club and the Toronto Ornitho-

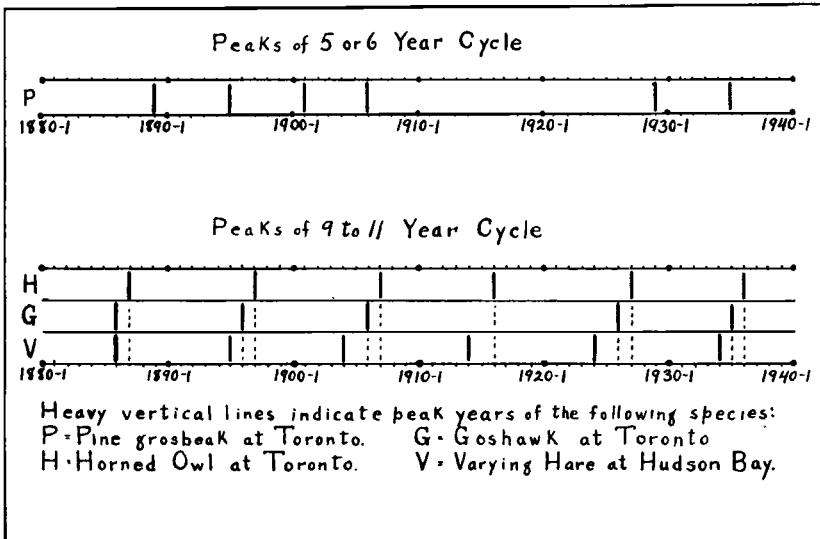
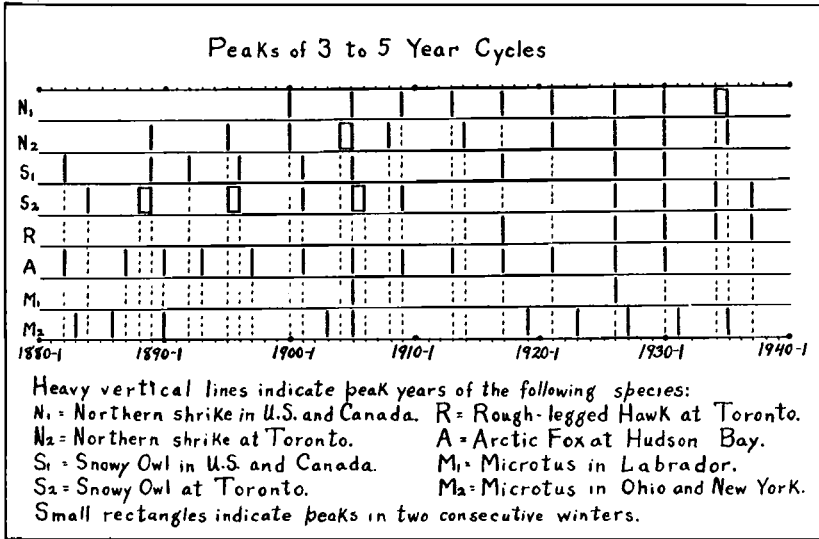
logical Club; specimens in the collections of Mr. J. H. Fleming and the Royal Ontario Museum of Zoology; the literature file of the Royal Ontario Museum of Zoology, in which the ornithological literature is catalogued by species and by locality; the 'Canadian Field-Naturalist'; the 'Transactions' of the Ornithological subsection of the Royal Canadian Institute.

For certain species of birds which winter in the Toronto region these records have been tabulated by years, as is illustrated by the following table for the Horned Owl. From these tables it is possible to pick out certain peak years for each species. These peak years have been indicated on a graph so that the periodicity, if any, might be apparent and so that peaks of different species might be compared.

Periodic Fluctuations of the Horned Owl

Winter of	Records	Winter of	Records
1887-88		1914-15	
1888-89	x, x, 1, 1.	1915-16	
1889-90	1, 1, 1.	1916-17	x, "hundreds."
1890-91	1, 1, 1, 1.	1917-18	1, x, 1.
1891-92	1.	1918-19	
1892-93		1919-20	
1893-94		1920-21	
1894-95		1921-22	
1895-96	1.	1922-23	x, 1.
1896-97	1, 1, x.	1923-24	x, x.
1897-98	x, x, 1, x, 1, 1, "several."	1924-25	1.
1898-99	1, 1, 1.	1925-26	1, 1, 1, 1.
1899-00		1926-27	2, 1, 1, 1.
1900-01	x.	1927-28	1, 1, 1, 1, 1, 4, 2, 1, 2, 1, 1,
1901-02	x.		1, 2, 1, x, 3, 1.
1902-03		1928-29	1, 2, 1, 1, 1, 1, 2, 1, 2, 1, 1,
1903-04			1, 1, 1, 2.
1904-05	1.	1929-30	1, 1.
1905-06	1.	1930-31	
1906-07	1, 1, 1.	1931-32	3, 1, 1, 2, 2, 2.
1907-08	1, 1, 1, 1, 1, 1, 1, "125 shot within 60 mi. of Toronto."	1932-33	
1908-09	x.	1933-34	1.
1909-10	x.	1934-35	1, 1.
1910-11		1935-36	1, 1, 1, 1, 1, 1, 1, 1.
1911-12	x.	1936-37	1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1912-13			1, 1, 1, 1, 1, 1, 1, 1, 1,
1913-14	x.		2, 1, 2, 1, 2, 1, 1, "11 shot."

In Text-figure 1 the years of peak abundance of a number of species of birds and mammals are indicated by solid vertical lines. The vertical level at which these lines begin indicates the species to which they refer. For instance in the nine- to eleven-year cycle, the varying hare peaks for the



TEXT-FIG. 1.—Fluctuations in numbers of birds in the Toronto region.

Hudson's Bay watershed are indicated by solid vertical lines running between the time axis and the next horizontal line. The Goshawk peaks for the Toronto region are indicated by solid vertical lines running between the second and third horizontal lines. The Horned Owl peaks for the Toronto region are indicated by solid vertical lines running between the third horizontal line and the upper time axis. The same system is used in indicating the peaks of abundance for animals which exhibit a three- to five-year cycle. Dotted lines are used to carry these solid vertical lines down to the time axis on which the dates are indicated at intervals of ten years beginning with the winter of 1880-81. When peaks have occurred during two successive winters the solid vertical lines have been joined at the top and bottom so that these two-year peaks appear on the graph as little rectangles.

THREE- TO FIVE-YEAR CYCLE

American Rough-legged Hawks, Snowy Owls, and Northern Shrikes have shown year-by-year fluctuations in numbers in the Toronto region, with peaks at intervals of from three to five years.

American Rough-legged Hawk cycle.—It is only in recent years that American Rough-legged Hawk peaks have been recorded in the Toronto region. It will be noted from Text-figure 1 that peaks have occurred during the following winters:

Peak Winters	Intervals
1917-18	
.....	
1926-27	9 years (4+5)
1930-31	4 years
1934-35	4 years
1937-38	3 years

It will also be noted that these peak years have in every case coincided with peaks of the Snowy Owl. It is therefore reasonable to suppose that similar peaks occurred before 1918 but escaped record. The existence of this three- to five-year cycle in the numbers of American Rough-legged Hawks does not appear to have been noticed previously.

Snowy Owl cycle.—The periodic fluctuations in the numbers of this species have probably attracted more attention than the fluctuations in the numbers of any other American species of bird. Fleming (1907) recorded peaks for this species as early as 1833-34, while Gross (1927, 1931) has recorded the Snowy Owl peaks which have been observed in the northeastern United States and Canada since 1876-77. It will be noted from Text-figure 1 that Snowy Owl peaks have occurred during the following winters:

Toronto Region	U. S. and Canada	Intervals
.....	1882-83	
1884-85	.....	2 years
1888-89-90	1889-90	4 or 5 years
.....	1892-93	3 years
1895-96-97	1896-97	3 or 4 years
1901-02	1901-02	5 or 6 years
1905-06-07	1905-06	4 or 5 years
1909-10	.....	3 or 4 years
.....	.....	8 years (4+4)
.....	1917-18	
.....	
1926-27	1926-27	9 years (4+5)
1930-31	1930-31	4 years
1934-35	1934-35	4 years
1937-38	.....	3 years

It will be apparent from the above table that Snowy Owl peaks have occurred at intervals of from two to six years (usually three to five).

No evidence has been obtained which suggests that a Snowy Owl peak did occur in 1913-14. The fact that Snowy Owls did not appear on the 'Bird-Lore' Christmas censuses for that year indicates that this expected peak actually did fail to materialize. The 1922-23 peak, which was not recorded by Gross nor in the Toronto region, may have occurred but the number of owls may not have been sufficient to attract general attention. Snowy Owls were recorded near London, Ontario, during that winter (Saunders and Dale, 1933).

Northern Shrike cycle.—Davis (1937) drew attention to the existence of fluctuations in the abundance of the Northern Shrikes in the northern United States and Canada. Similar fluctuations have been detected in the Toronto region. It will be noted from Text-figure 1 that peaks have occurred during the following winters:

Toronto Region	U. S. and Canada	Intervals
1889-90	.....
.....	
1895-96	.....	6 years (3+3 ?)
1900-01	1900-01	5 years
1904-05-06	1905-06	4 or 5 years
1908-09	1909-10	3 or 4 years
1914-15	1913-14	4 to 6 years
.....	1917-18	3 or 4 years
1921-22	1921-22	4 years
1926-27	1926-27	5 years
1930-31	1930-31	4 years
1935-36	1934-35-36	4 or 5 years

From the above table it will be apparent that peaks of this species have occurred at intervals of from three to six years (usually four or five).

Some other three- to five-year cycles.—Gross (1927, 1931) drew attention to the correspondence of Snowy Owl peaks and peaks of the Arctic fox, the latter based on the Hudson's Bay fur returns. From Text-figure 1 it will be seen that these peaks have agreed very well since 1900, but that prior to 1900 the agreement was poor, possibly due to less accurate records. Davis (1937) drew attention to the coincidence of both of these peaks with peaks of the Northern Shrike. Here again the agreement is evident since 1900 but not before. He also placed on record two peaks of *Microtus* sp.? in Labrador which coincided with the peaks of the Snowy Owl, Northern Shrike, and Arctic fox. These were the peaks of 1905–06 and 1926–27. Hamilton (1937) studying *Microtus* in the northern part of the United States found a cycle which has been of approximately the same length as the cycles of those species mentioned above. An examination of Text-figure 1 will show that his peaks have been decidedly out of phase with those recorded for the other species.

From the above discussion the following conclusions may be drawn. The American Rough-legged Hawk, the Snowy Owl, the Northern Shrike, the Arctic fox, and that form of *Microtus* living in Labrador all have exhibited fluctuations in abundance with peaks at intervals of from three to five years. Since 1900, the peaks of abundance of all these species have agreed very well but before 1900 the agreement was poor, possibly due to inaccurate data. The form of *Microtus* living in the northern United States has exhibited a three- to five-year cycle also, but its peaks have been out of phase with the peaks of the other species. The Rough-legged Hawk, Snowy Owl, and Northern Shrike all live chiefly on mice and other small mammals, yet in 1905–06 and again in 1926–27 they appeared in the south, when according to Davis (1937) *Microtus* in the north was at its peak of abundance. It seems obvious then that these predators did not on those occasions emigrate due to lack of food.

The following alternative explanation for the appearance of large numbers of birds in the south in certain years has been suggested. A peak in the abundance of the food species has resulted in an unusually successful breeding season which has produced a peak population. When such peak populations have come south in late autumn the large numbers have attracted general attention and bird students have received the impression that an unusual migration was taking place. The numbers which came south in years when these species were less abundant were so small that it was not worth while looking for them. As they were not looked for, very few were seen. It is possible also that when the birds became very numerous their migratory tendencies were accentuated (as has been proved to be the

case with certain locusts). This would result in these northern species being seen in great numbers in the south during the winters immediately following an unusually successful breeding season.

FIVE- OR SIX-YEAR CYCLE

Pine Grosbeaks have shown marked fluctuations in numbers in the Toronto region. Peaks have occurred at intervals of five or six years (usually six). From Text-figure 1 it will be noted that these peaks have occurred during the following winters:

Peak Years	Intervals
1889-90	
1895-96	6 years
1901-02	6 years
1906-07	5 years
.....	
.....	23 years (6+6+6+5)
.....	
1929-30	
1935-36	6 years

It will be noted that the peaks during the interval 1910-25 have escaped record. This is not remarkable when the scarcity of observers during that period is considered. The four early peaks were also recorded by Saunders (in litt.) at London, Ontario.

NINE- TO ELEVEN-YEAR CYCLE

Goshawks and Horned Owls have shown very well-marked peaks of abundance in the Toronto region at intervals of from nine to eleven years. From Text-figure 1 it will be noted that these peaks have occurred during the following winters:

Goshawk Peaks	Intervals	Horned Owl Peaks	Intervals
1886-87		1887-88	
1896-97	10 years	1897-98	10 years
1906-07	10 years	1907-08	10 years
.....		1916-17	9 years
1926-27	20 years (10+10)	1927-28	11 years
1935-36	9 years	1936-37	9 years

MacLulich (1937) and Clarke (1936) have demonstrated the existence of similar cycles in populations of the varying hare and the Ruffed Grouse. The Goshawk and Horned Owl cycles for the Toronto region are compared in Text-figure 1 with the varying hare cycle as presented by MacLulich

(1937) for the Hudson's Bay watershed. The figure shows that these cycles are of approximately the same length but that they are out of phase. The Goshawk peaks and the Horned Owl peaks have usually been respectively one and two years later than the hare peaks as recorded for the Hudson's Bay watershed.

Although the Goshawk and Horned Owl peaks have been very conspicuous, at least in the Toronto region, no reference to a nine- to eleven-year cycle in these species has been noted in the literature. Individual peaks have frequently been recorded. Mr. C. E. Hope, of the Royal Ontario Museum of Zoology, who has examined a large number of Goshawks and Horned Owls collected during these flights, states that these birds were in good condition, i.e., that there was no evidence from the birds' condition to indicate that lack of food had caused them to come south into the Toronto region.

Some of the species of birds that have wintered in the Toronto region have fluctuated markedly in numbers from year to year. The peak years for any one of these species have tended to be separated by definite intervals, but variations from this average interval have occurred which have probably been distributed about the average value according to the probability curve. The peaks of abundance of the American Rough-legged Hawk, the Snowy Owl and the Northern Shrike have usually occurred at intervals of from three to five years, while peaks of the Pine Grosbeak have occurred at intervals of five or six years, and peaks of the Goshawk and Horned Owl have occurred at intervals of from nine to eleven years. The peaks have occurred in the years immediately following the maximum abundance of their food in the north. No evidence has been detected to suggest that lack of food drove the birds south.

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