MISCELLANEOUS REPORT NOR-Y-3

W. G. H. Ives (1972)

DEGREE-DAYS IN RELATION TO FOREST TENT CATERPILLAR INFESTATIONS IN CENTRAL AND WESTERN CANADA.

(Contribution to a workshop held at the 23rd Annual Western Forest Insect Work Conference, Macdonald Hotel, Edmonton, Alberta; 6-9 March 1972.)

Northern Forest Research Centre
Canadian Forestry Service
Department of the Environment
5320 - 122 Street
Edmonton 70, Alberta, Canada.

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The forest tent caterpillar is a native insect that overwinters as fully developed larvae within the eggs, which are laid on small twigs in July and hatch the following May. The insect is therefore exposed to the adverse effects of weather throughout its life cycle. Hodson (1941)[1] studied the ecology of the forest tent caterpillar in Minnesota and found that embryonic development was completed in about three weeks. He later showed that this was followed by a period of obligatory diapause lasting about three months.[2] Further development in the fall is normally prevented by the advent of cool weather. Occasionally, however, unusually warm weather occurs in the late fall, winter, or early spring, and this has been observed to cause premature hatch or increased mortality when normal hatching finally occurs.

While working over some old forest tent caterpillar data I became interested in determining if there were any detectable relationships between overwintering temperatures and the occurrences of forest tent caterpillar infestations. After considerable trial and error I decided to use the degree days above 40°F, calculated by the modified Lindsey-Newman formulae:

$$\text{Degree days} = \frac{(\text{Max.} + \text{Min.})}{2} - \text{Thres.}, \quad \text{Min.} \geq \text{Thres.};$$

$$= \frac{(\text{Max.} - \text{Thres.})^2}{2\,(\text{Max.} - \text{Min.})}, \quad \text{Max.} > \text{Thres.}, \ \text{Min.} \leq \text{Thres.};$$

$$= 0, \quad \text{Max.} \leq \text{Thres.}$$

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[1] Hodson, A. C. 1941. Tech. Bull. 148, Univ. Minn. Agric. Exper. Stat. 55 pp.

[2] Hodson, A. C. and C. J. Heinman. Tech. Bull. 170, Univ. Minn. Agric. Exper. Stat. 31 pp.

These formulae are only an approximation to the true degree-day accumulation, but they are close to the formulae given by the sine curve and can be manipulated more easily, especially on a small desk top computer. Since any calculation based on daily maximum and minimum air temperatures is an approximation at best, I felt that the Lindsey-Newman formulae met my requirements. After additional trial and error, I finally settled on an overwintering period extending from October 13 to the following April 26.

Finding a useful expression for the spring feeding period was more difficult. Numerous reports can be found in the literature, attributing population crashes to adverse spring weather, but there seemed to be little consistency between temperatures and reported collapses. I finally tried the number of degree-days above 60°F during a three week period following an estimated hatch date. The latter was found to be approximated by the date on which the degree days above 40°F, starting on April 27, equalled or exceeded 110. I purposely made the [redacted] estimated date conservative, and to be even more conservative, I did not start accumulating the degree-days above 60°F until the third day after the estimated hatch date.

The hatch date was based on observations in Alberta, so it may not be too reliable in eastern Canada. However, dates given by Hodson agree quite well, so the error probably isn't too serious. In addition, since the estimated hatch date will be late, if anything, the errors will tend to minimize the effects of spring weather, because the younger larvae are the most susceptible to unfavorable weather.

I then examined published maps of forest tent caterpillar infestations and selected a number of weather reporting stations in areas where

...3

there had been a fairly well documented infestation. For each of these stations I calculated the overwintering degree-days above 40°F, the estimated hatch date and the spring degree-days above 60°F during years with increasing and decreasing populations. My criteria for selecting these stations were simple: the station had to be in the area of infestation; there had to be temperature records for the period concerned; and the years of increase and decrease had to be fairly well defined. These excluded a number of areas, either because there were no meteorological stations, or the periods of build-up and decline were ill-defined. The stations selected, as shown on the hand-out, represent a reasonable cross section of the known forest tent caterpillar outbreaks in central and western Canada.

If overwintering and spring degree days are not related to population trends, the plotting of these values for increasing versus decreasing populations should give a random scattering of points. However, there is a definite grouping of points for overwintering and spring degree days, thus indicating relationships in both cases. Periods of increasing populations have significantly cooler winters and warmer springs than periods of decreasing populations.

I next calculated the overwintering and spring degree-days for a number of consecutive years at each of six stations. The graphs of these values show wide variation from year to year. At first glance there seems to be little relationship between these values and periods of tent caterpillar infestation. However, closer examination reveals that all of the outbreaks were preceded by relatively cool winters and warm springs 2 - 4

...4

years before the first recorded defoliation. In addition, some, but not all, of the population collapses were accompanied by cool springs and sometimes by warm winters. However, the effects of temperature seems to be related to the stage at which they occur in the outbreak. Favorable weather seems to trigger population build-up, but unfavorable weather, unless extreme, does not appear to be able to terminate an outbreak in the initial stages. As the infestation becomes older, the effects of disease and starvation become more pronounced, and the additional stress imposed by adverse weather then seems to become important.

The graphs that I have shown are a preliminary analysis of weather data from a larger network of stations. If the trends continue for the remainder of the stations, as I expect they will, it will have been shown that weather is a major factor influencing epidemics of the forest tent caterpillar.

TABLE 1. Estimated forest tent caterpillar hatching dates in years with increasing and decreasing populations at a number of locations in central and western Canada.

Location	Increasing Population		Decreasing Population	
	Year	Date of Hatch	Year	Date of Hatch
Saskatchewan (cont'd)				
North Battleford	1950-51	May 2	1953-54	May 17
Poam Lake	1939-40	May 10	1941-42	May 16
Manitoba				
Russell	1939-40	May 10	1942-43	May 20
Dauphin A	1943-44	May 10	1944-45	May 23
Indian Bay	1950-51	May 10	1952-53	May 8
Morden	1937-38	May 9	1938-39	May 2
Sprague	1950-51	May 6	1952-53	May 8
Swan River	1960-61	May 19	1964-65	May 9
The Pas	1937-38	May 13	1939-40	May 11
	1960-61	May 20	1963-64	May 10
Ontario				
Atikokan	1933-34	May 6	1937-38	May 6
	1950-51	May 6	1952-53	May 8
	1962-63	May 9	1967-68	May 12
Chalk River	1949-50	May 16	1953-54	May 10
Dryden	1949-50	May 21	1952-53	May 8
	1960-61	May 17	1965-66	May 22
Franz	1940-41	May 6	1941-42	May 2
	1943-44	May 11	1944-45	May 24
White River	1949-50	May 23	1954-55	May 4
Kapuskasing	1940-41	May 7	1942-43	May 19
	1949-50	May 23	1953-54	May 15
North Bay A	1934-35	May 18	1937-38	May 6
	1949-50	May 19	1953-54	May 12
	1964-65	May 7	1967-68	May 13
Sioux Lookout	1932-33	May 15	1935-36	May 16
	1949-50	May 23	1952-53	May 8
	1960-61	May 19	1965-66	May 23
Sudbury A	1959-60	May 15	1960-61	May 13
Timmins	1941-42	May 2	1944-45	May 25

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Location	Increasing Population		Decreasing Population	
	Year	Date of Hatch	Year	Date of Hatch
Alberta				
Athabasca	1938-39	May 4	1940-41	May 3
	1960-61	May 18	1963-64	May 9
Beaverlodge	1958-59	May 16	1959-60	May 13
	1962-63	May 16	1964-65	May 18
Campsie	1962-63	May 15	1964-65	May 10
Edson	1939-40	May 11	1940-41	May 4
	1951-52	May 12	1953-54	May 19
	1960-61	May 19	1964-65	May 12
Elk Point	1957-58	May 11	1963-64	May 7
Fort Vermilion	1943-44	May 8	1944-45	May 17
	1959-60	May 11	1963-64	May 10
Grande Prairie	1957-58	May 9	1963-64	May 16
Lac La Biche	1960-61	May 18	1963-64	May 9
Lethbridge	1957-58	May 7	1958-59	May 14
	1960-61	May 15	1961-62	May 12
McMurray	1962-63	May 13	1963-64	May 7
Medicine Hat	1960-61	May 13	1961-62	May 10
Moon Lake	1963-64	May 13	1964-65	May 10
Pincher Creek	1957-58	May 8	1958-59	May 15
Rocky Mountain House	1950-51	May 9	1953-54	May 19
	1957-58	May 9	1958-59	May 16
	1960-61	May 19	1961-62	May 19
	1963-64	May 15	1964-65	May 10
	1967-68	May 12	1968-69	May 11
Slave Lake	1939-40	May 11	1940-41	May 3
	1950-51	May 9	1951-52	May 11
	1960-61	May 19	1963-64	May 9
Waterton	1957-58	May 8	1958-59	May 16
Whitecourt	1960-61	May 19	1964-65	May 11
Saskatchewan				
Consul	1957-58	May 10	1963-64	May 9
Loon Lake	1960-61	May 19	1964-65	May 6

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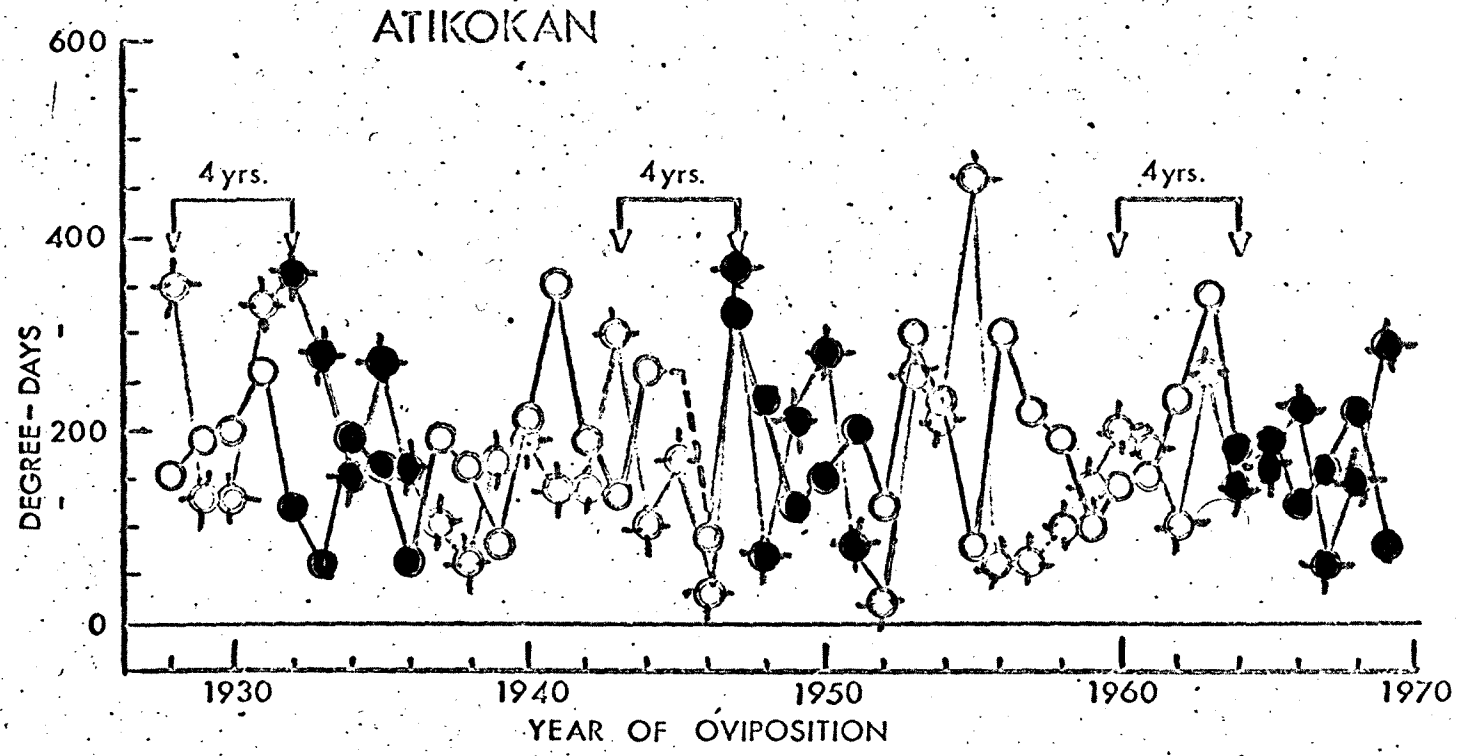
No Outbreak Outbreak

Spring (X4)

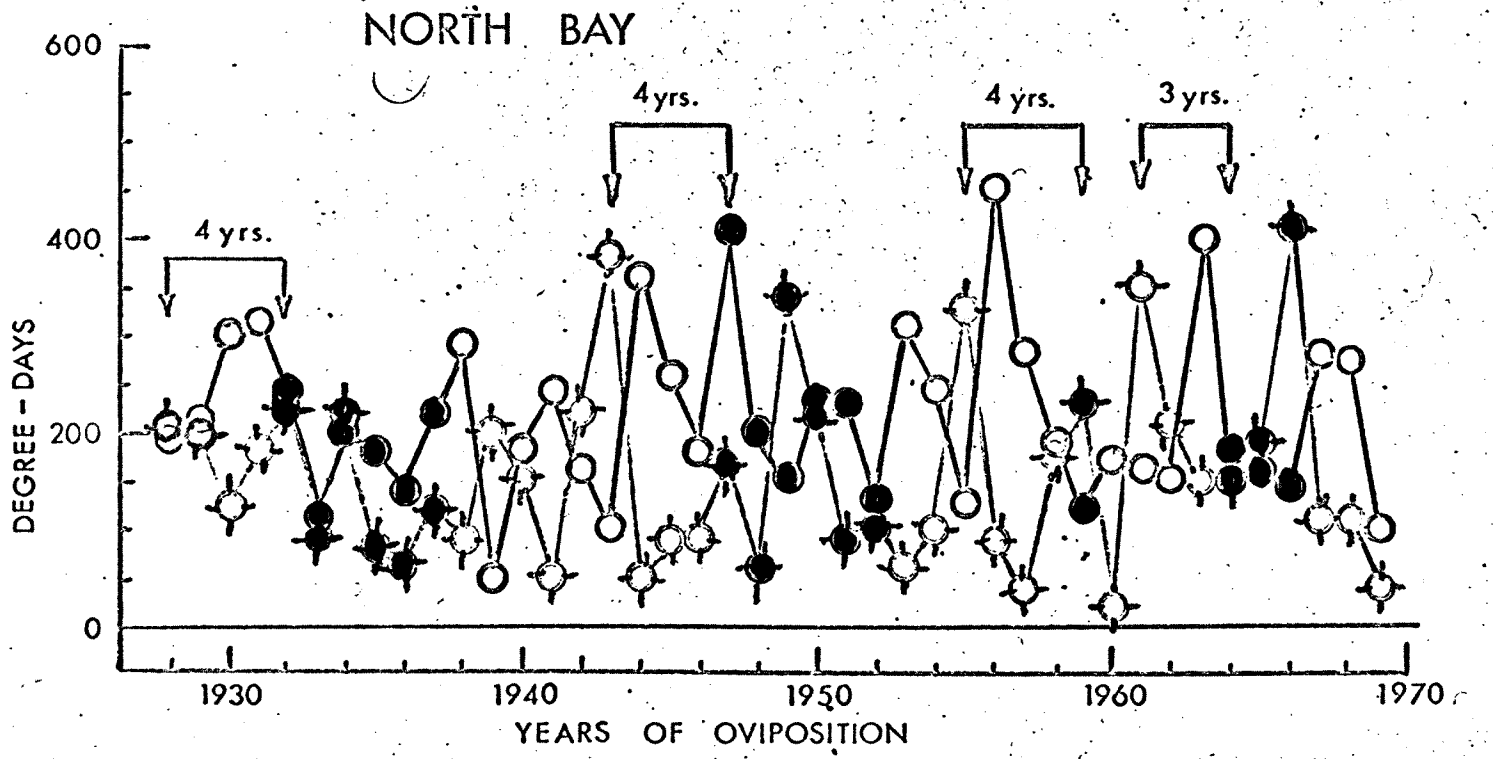
Winter



No Outbreak Outbreak

Spring (X4)

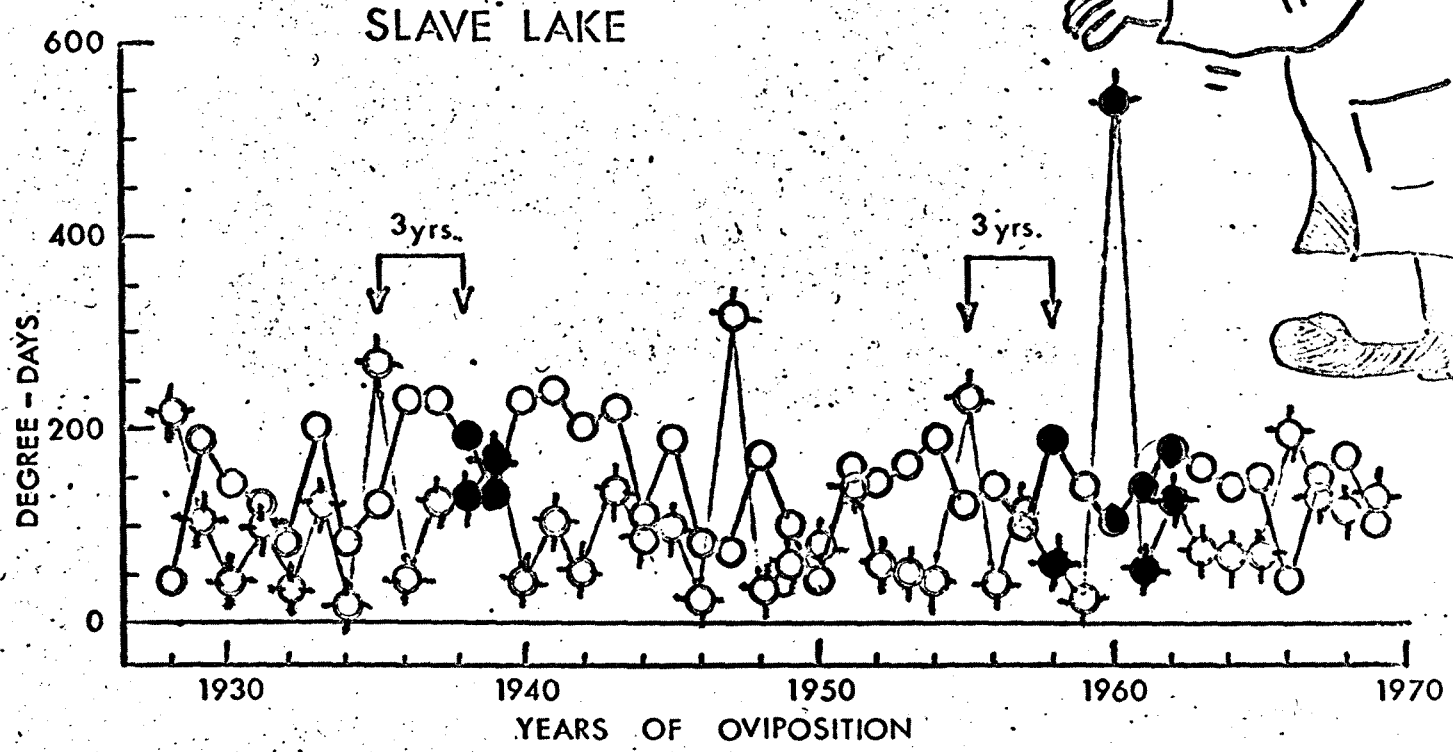
Winter

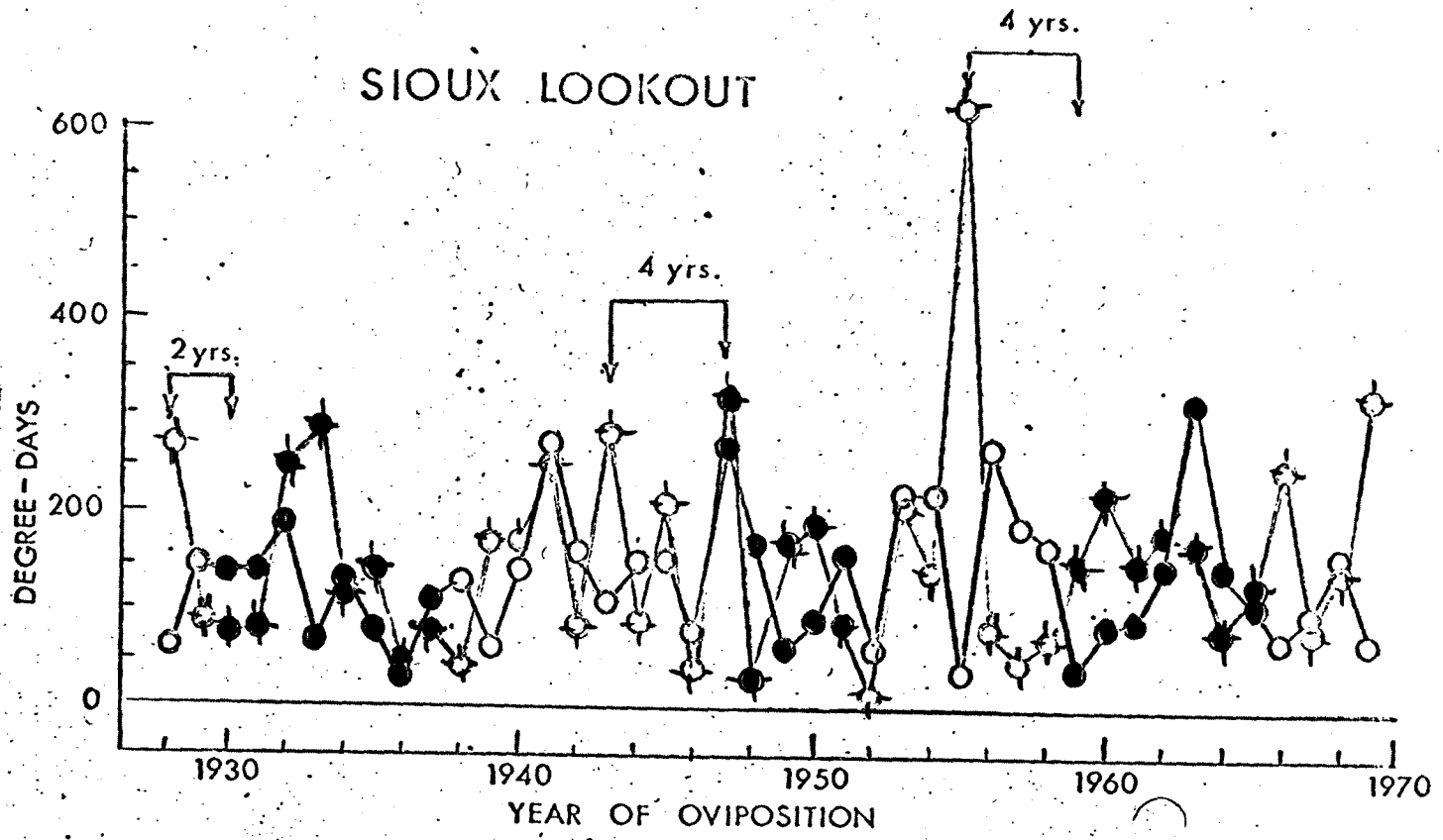


No Outbreak Outbreak

Spring (X4)

Winter

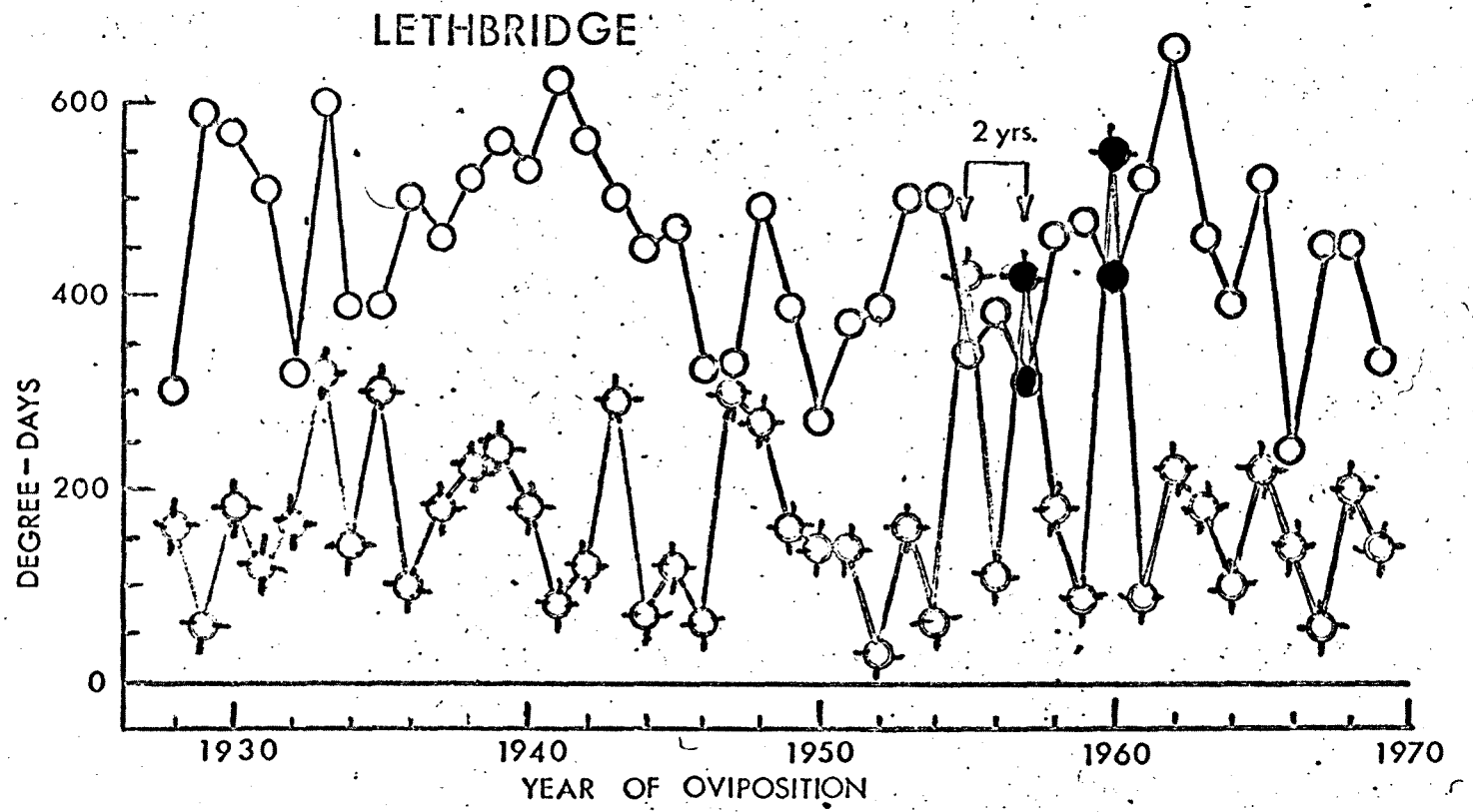




No Outbreak Outbreak

Spring (X4) ⊕ ●

Winter ○ ●



No Outbreak Outbreak

Spring (X4)

Winter

No Outbreak Outbreak

Spring (X4)

Winter