



A study of the climatic conditions favoring the abundance of groups of cutworm moths (Phalaenidae)
by Ernest R Tinkham

A Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science in
Entomology.

Montana State University

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Abstract:

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A STUDY OF THE CLIMATIC CONDITIONS FAVORING
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OF
CUTWORM MOTHS (PHALAEINIDAE)

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INTRODUCTION.

Every species or group of species has an area of optimum life conditions within its range in which it occurs in abundance or in destructive numbers. This paper attempts to show that the climatic conditions favoring the abundance of different groups of moths, in areas outside this zone, approach the normal conditions in the optimum of each group. A group is comprised of a series of species having similar life conditions and similar distribution geographically.

Before proceeding further the author wishes to express his sincere appreciation of the invaluable assistance received from Doctor William C. Cook, who suggested the thesis and who has kindly given pointers and submitted data all along the way. Acknowledgement is made of the kind support given by Mr. H. L. Seamans in the preparation of light trap records, and by Doctor J. McDunnough and Mr. E. P. Van Dusee and many others who have kindly contributed distributional data.

In beginning this work the light trap records of cutworm moths of Lethbridge, Alberta, operated by Mr. H. L. Seamans, Dominion Entomologist, and Doctor W. C. Cook's records from Roseman, Hamilton and Havre, stations in Montana, were compared and the most desirable Phalaenid species separated.

The species were selected in the following manner:

1. The abundance of a species at the light traps at Lethbridge and Montana stations
2. Economic importance of the species

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3. The phototropic response of each species.

All species do not come to light at night in ratio to their numbers flying in the fields. Some, such as Euxoa catenula, may be very plentiful in the fields but few are ever attracted to light. Only species coming to light in fair proportion to their abundance in the field were chosen for this thesis, with the possible exception of these important economic cutworms - Chorisaagrotis auxiliaris Grt., Euxoa ochrogaster Gn. and Euxoa messoria Harris.

Doctor Cook's Three Forks flower collecting records from various flowering plants and shrubs, such as sunflower, rabbit brush and sage brush, were used when these records indicated abundance of value in this work.

To arrange the cutworm species into groups geographically, it was obvious that the range of each species must first be ascertained in so far as possible.

The main source books giving distributional data are:

Smith's "Revision of the Genus *Agrotis*", Bul. 38.

United States National Museum. 1890.

Smith's "Catalogue of the Noctuidae found in North America", Bul. 44, United States National Museum. 1891.

Holland's "The Moth Book", Doubleday, Page & Company, New York. 1903.

Dyar's "List of North American Lepidoptera", Bul. 52, United States National Museum. 1902.

Hampson's "Catalogue of Lepidoptera Phalaenae, British Museum of Natural History, Vols. IV, V. 1903, 1905.

Valuable distributional data were obtained from Doctor J. McDennough, Chief Division of Systematic Entomology, Ottawa, Canada, and Mr. E. P. Van Duzee, California Academy of Sciences, San Francisco. Desirable information as to the range and abundance of species in various states were received from the following: E. S. Brimley, North Carolina; K. M. King, Saskatchewan, Canada; S. C. McCampbell, Colorado; A. E. Miller, Illinois; L. P. Rodsword, Oregon; and M. H. Swenk, Nebraska. Manuscripts -Light trap records of Noctuidae caught at the University Farm, St. Paul, 1926, and list of Noctuidae in the Minnesota collection gave additional information. Minor fragments were received through correspondence with other states. Although far from being complete, due to lack of collecting throughout the country, the range of the different species is nearly as complete as could be expected from the data available.

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Nineteen species of cutworm moths were chosen for this work. They belong to the subfamilies: Agrotinae, Hadeninae and Acronyctinae of the family Phalaenidae (Noctuidae) and comprises nine genera, six of which contain many species of economic importance. When the approximate range of the different species was mapped out as accurately as the data would allow, a careful comparison of their distribution showed that the different species fell arbitrarily into five groups.

They are as follows:

A. Eastern Group

1. Euxoa messoria Harris. The Dark Sided Cutworm.

2. Feltia ducens Wlk. The Dingy Cutworm.
3. Feltia venerabilis Wlk.
4. Polia renigera Stephen.
5. Nephelodes emmedonia Gram. form tertialis.

B. Trans-Northern Group

6. Euxoa ochrogaster Gn. and forms insignata and gularis.
The Red Backed Cutworm.
7. Euxoa divergens Wlk.
8. Euxoa tristicula Morr. and form neasilens. The Early Cutworm.
9. Epipsilia littoralis Pack.

C. North Western Group

10. Protagrotis niveivenosa Grt.
11. Caradrina extima Wlk.

D. Western Plains Group

12. Perosagrotis orthogonia Morr. The Pale Western Cutworm.
13. Euxoa pallipennis Sm.
14. Chorisagrotis auxiliaris. The Western Army Cutworm.
and forms introferens, agrestis.

E. Mountain Pacific Group

15. Euxoa sponsea Sm.
16. Euxoa rena Sm. and form cervinea.
17. Euxoa intrita Morr. and forms redda, alticola, titubatis,
strigilis.
18. Polia stricta Wlk.
19. Feltia vancouverensis Grt.

A. EASTERN GROUP.

This group is truly Eastern in aspect, indigenous to the Central Mississippi Valley region. In the West the distribution is restricted to the Rocky Mountains and the Coast ranges, as is clearly depicted by the map of this group. In the East the range follows the Appalachian Highlands south to the Carolinas. This group is absent throughout the entire short grass plains region from the southern tip of Alberta to New Mexico as records would indicate. The mean annual precipitation of 10-15 inches of these plains is such that the conditions are probably too arid for the group. In the irrigated districts of the plains the members of this group are usually present, for with irrigation the conditions are much more humid, and as such are quite similar to the conditions existing in the Mississippi Valley. North and east of these semi-arid plains the rainfall increases and the conditions are opportune - the group inhabiting the Canadian prairies and the long grass prairies extending from the eastern half of the Dakotas to Oklahoma and east throughout the Mississippi Valley.

Needless to say that the hot desert and arid plains regions of the interior plateau, comprising parts of Arizona, California, Nevada, Utah, Oregon, Idaho and Washington, are avoided as the conditions are such that the group could not possibly exist.

An exhaustive perusal of all available economic literature reveals the fact that the greatest concentration of outbreaks of the five species of the group is centered in the eastern half of Nebraska, in Iowa, Missouri, Illinois, Indiana, Ohio and the Southern part of Michigan.

Apparently this area indicates the area of greatest abundance, or the optimum for the group.

A climograph representing the mean monthly temperature and precipitation conditions for this section would indicate the factors most favorable for the group. See map 1, graph 4.

Twenty-six weather stations were selected as typical of this area and the mean taken as the normal or optimum conditions for this group.

To ascertain whether the climatic features of the years favoring the abundance of this group of Phalaenids in an area outside the optimum, approach the optimum for the group, a comparison of the relative abundance from light trap catches must be made.

Comparison of moth abundance from light trap records

Lethbridge	1921	1922	1923	1924	1925	1926	1927
<u>F. ducens</u>	896	848	1653	1356	5456	1486	2015
<u>F. venerabilis</u>	43	98	139	108	407	161	337
<u>E. messoria</u>	0	24	129	9	0	51	74
<u>N. emmedonia</u>	12	77	67	0	0	3	7
<u>P. renigera</u>	5	4	169	0	202	78	313

Boseman	1919	1923	1924	1925	1926	1927
<u>F. ducens</u>	384	121	220	183	240	206
<u>F. venerabilis</u>	0	1	7	2	20	10
<u>E. messoria</u>	0	0	0	1	9	7
<u>N. emmedonia</u>	17	6	37	32	123	61
<u>P. renigera</u>	5	8	50	85	133	139

The favorable years selected were:

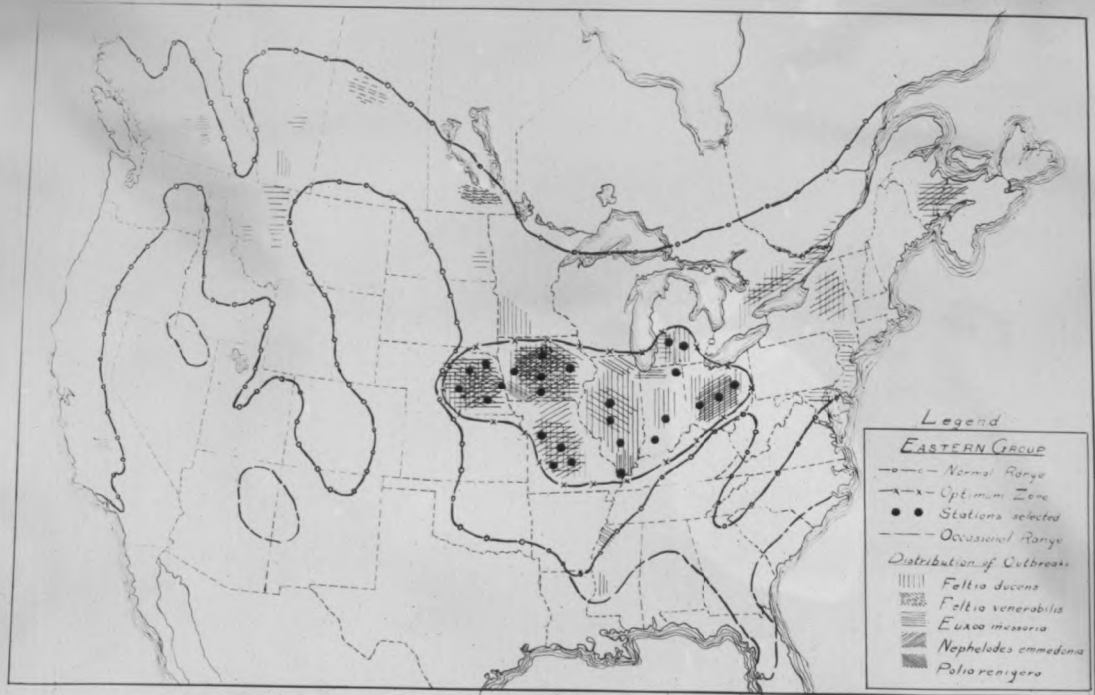
Lethbridge - 1923, 1925, 1927.

Boseman - 1919, 1924, 1926, 1927.

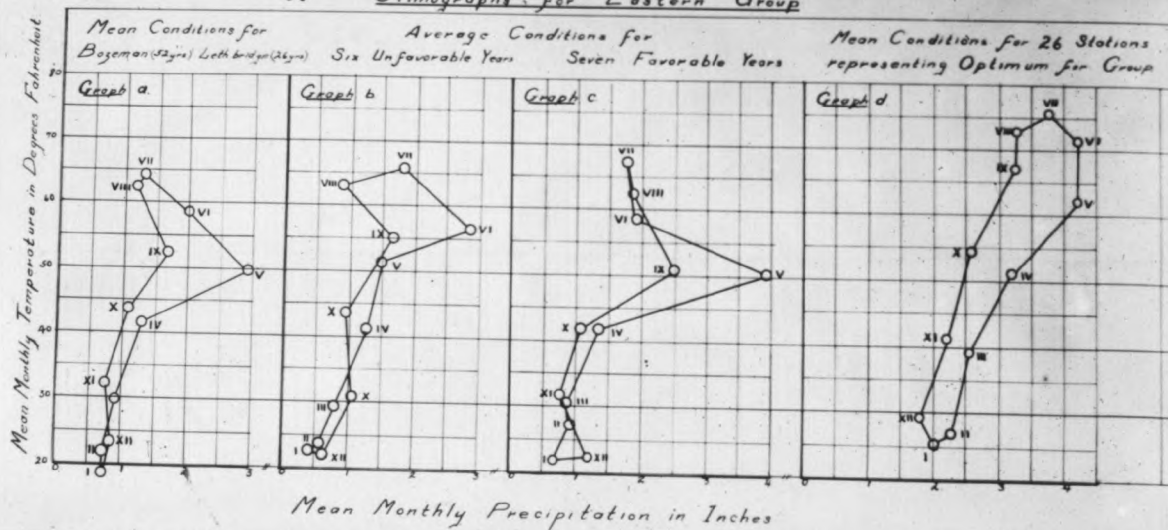
Unfavorable years:

Lethbridge - 1921, 1922, 1924, 1926.

Boseman - 1923, 1925.



A Climographs for Eastern Group



Time of Flight.

Dates indicate extremes in flight for the light trap years.

	Lethbridge	Bozeman
<u>F. ducens</u>	July 7 - Sept. 24	July 17 - Sept. 15
<u>F. venerabilis</u>	Aug. 5 - Sept. 26	July 10 - Sept. 21
<u>E. messoria</u>	July 7 - Sept. 19	July 3 - Sept. 16
<u>H. emmedonia</u>	Aug. 1 - Sept. 7	July 19 - Sept. 16
<u>P. renigera</u>	June 23- Aug. 18	June 24 - Sept. 13

Maximum flight approximately July 15 - August 15.

For favorable and unfavorable years, the climatic conditions during the life of the moth were used. For example: At Bozeman, 1924, Feltia ducens showed an increase of 99 specimens over over 1923 captures. However, 1924 weather conditions would not correctly show the weather factors favoring an increase, as the adult moth of August, 1924, began its life from an egg oviposited by a moth of the preceding generation in August 1923. Hence it is essential to consider the life conditions for each species of moths. A climograph of mean monthly conditions from August, 1923, to July, 1924, would clearly exhibit the climatic features during this generation of moths. See graphs (b) and (c) which are climographs for the six unfavorable years and seven favorable years for the group respectively.

Favorable years for the Group.

Graph A (c) shows clearly that the rainfall for the five summer months approaches the conditions existing in graph (d), the optimum. May and September rainfall are pulled far toward the optimum conditions of the group. It is readily seen that a May rainfall of 4 inches at 50°F. as exhibited in graph (c) is approximately equivalent to a May rainfall of 4.25 inches at 62°F. where evaporation, due to higher temperature, is

greater, as in graph (d).

A comparison of graph (a) (mean combined conditions of Roseman and Lethbridge) with graphs (b) and (c) (unfavorable and favorable conditions respectively) show that graphs (a) and (b) are alike in many respects. For this reason this group will never be abundant, as the unfavorable years are nearly identical with the normal conditions for these two stations. The spring rainfall (graph (c) favorable years) is much greater than in graph (a), and hence an abundance of moths of this group can be expected in years wetter than the normal.

B. TRANS-NORTHERN GROUP.

Boreal in distribution this group inhabits the northern agricultural areas of this continent confined principally within the Canadian boundaries. Nearly every year the Red-Backed Cutworm, Euxoa ochrogaster Gn., and its associate, the Early Cutworm, Euxoa tristicula Morr., take a heavy toll of the grain crops of Western Canada. In 1925 these two species were especially destructive in Saskatchewan, doing million of dollars worth of damage. The distributional map shows the region where members of this group have occurred in outbreak forms. This region will represent the optimum for the group. Forty-six weather stations were selected as typical of this region and graph B (d) represents the mean combined conditions.

Comparison of light trap records.

Lethbridge	1921	1922	1923	1924	1925	1926	1927
<u>E. ochrogaster</u>	75	18	45	0	22	150	439
<u>E. divergens</u>	59	1	11	0	51	20	8
<u>E. tristicula</u>	309	37	331	577	521	200	101
<u>Epipsyllis</u> <u>littoralis</u>	26	1	59	94	274	53	86

The 1922 records are short as the light trap began on the first of August.

Boseman	1919	1923	1924	1925	1926	1927
<u>E. ochrogaster</u>	8	--	1	2	2	14
<u>E. divergens</u>	23	100	158	99	54	95
<u>E. tristicula</u>	66	3	13	38	16	16
<u>Ep. littoralis</u>	1	11	43	49	15	28

Three Forks plant collection records.

	1925	1926	1927
<u>E. ochrogaster</u>		0.71 moths per hr.	0.23 moths per hr.
<u>E. tristicula</u>	3.87 moths per hour	3.39 " " "	0.25 " " "

Favorable years for group - (9 years)

Lethbridge- 1923, 1924, 1925, 1927

Boseman - 1924, 1925, 1927

Three Forks - 1926

Unfavorable years for group - (7 years)

Lethbridge - 1921, 1922, 1926

Boseman - 1919, 1923, 1926

Three Forks - 1925, 1927

Duration of moth flight.

Extreme date records for light trap years.

	Lethbridge	Boseman
<u>E. ochrogaster</u>	July 10 - Sept. 11	July 10- Sept. 17
<u>E. divergens</u>	June 8 - Sept. 12	June 17 - Sept. 18
<u>E. tristicula</u>	June 3 - Sept. 13	June 6 - Aug. 22
<u>Ep. littoralis</u>	June 7 - July 30	May 31 - Aug. 6

Like the Eastern representatives, the period of flight for the members of the Trans-Northern group is quite similar, possibly slightly earlier. Due to the variability of the seasons and since the earliest and latest captures of each species for the years 1923-1927 at Lethbridge and Boseman have been used, the dates extend over a greater period of time than would pertain to the flight of each species during a single season.

However, for both groups the maximum flight occurs through July and early August, and for this reason the group-year is considered the same as in group A, namely, August to the following July.

A glance at the climographs of the Trans-Northern group, on the following page, shows that the graph of favorable conditions, graph B (c), approaches the optimum conditions of the group graph B (d). It is of interest to note that the mean normal conditions of Lethbridge and Roseman combined, graph (a), lie somewhat between the unfavorable and favorable conditions for the group, graphs (b) and (c). By comparing the normal precipitation of Lethbridge with the summer conditions determining the relative abundance of E. ochrogaster at Lethbridge, the datum would appear to corroborate this statement.

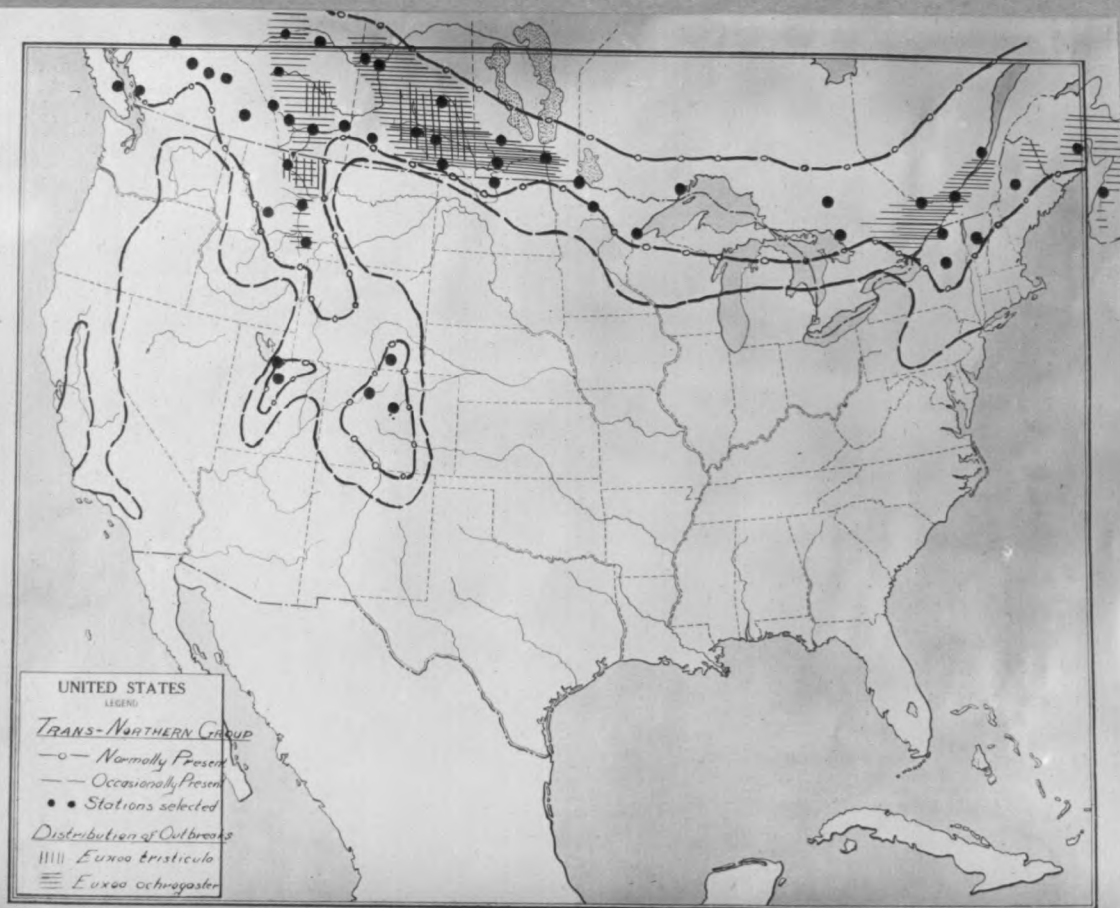
Lethbridge summer rainfall in inches.

Normal for	Apr.	May	June	July	Aug.	Sept.	Total	Moths
26 years	1.05	2.55	1.01	1.50	1.60	1.72	11.43	captured
1922	2.57	.89	1.87	2.30	.46	1.29	9.38	18
1927	1.48	7.32	1.60	1.90	2.31	4.86	20.47	<u>439</u>

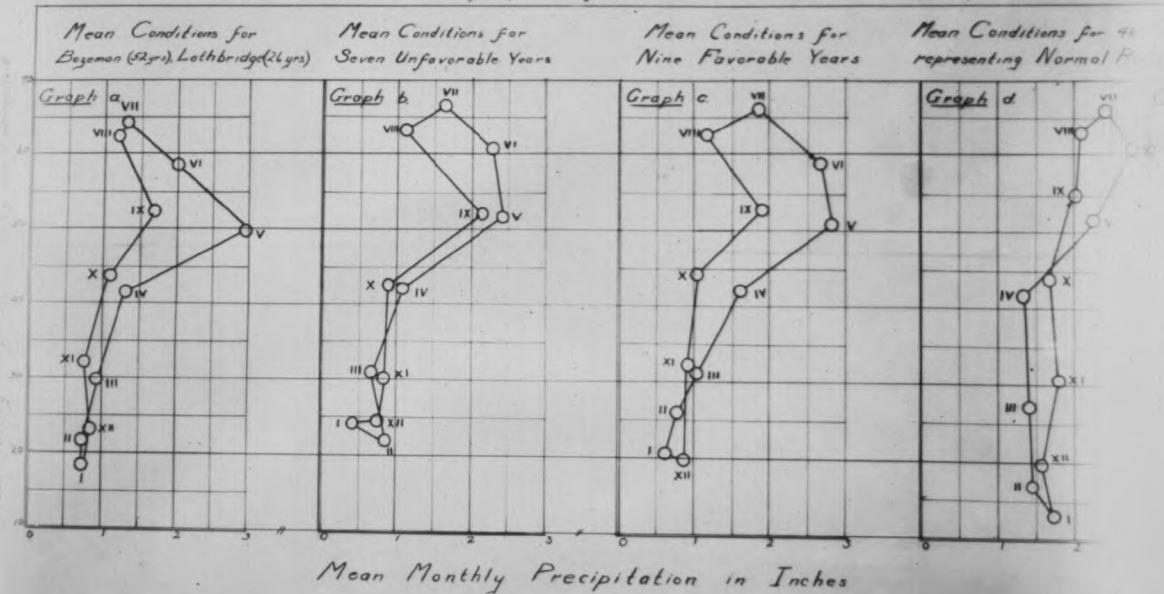
Rainfall appears to be a deciding factor in abundance for this species. When the rainfall is below normal, small captures can be expected; when above normal large numbers will be taken. As E. ochrogaster is representative of the group, the abundance of the respective members of this group will correspond likewise. The average weather conditions are such that these moths will always be present in fair numbers at Roseman and Lethbridge.

C. NORTH-WESTERN GROUP.

This group is composed of two species - Caradrina extima Wlk.



B Climographs for Trans-Northern Group



and Protagrotis niveivenosa Grt. In range these two species are nearly identical, inhabiting the plains east of the Rockies from Central Alberta to Colorado and extending east across the prairies of Saskatchewan and the Dakotas to Manitoba and central Minnesota. Caradrina extima occurs sparingly west of the Divide in British Columbia and the Pacific Coast Ranges. Protagrotis niveivenosa is a less abundant species and records west of the Rockies fewer. Only east of the Rockies are they normally plentiful and this region would indicate the optimum for the North-Western group.

Thirty-six stations were chosen as representative of this range. Map C. Graph C (d) indicates the mean conditions for this area.

Comparison of light trap records.

Lethbridge	1921	1922	1923	1924	1925	1926	1927
<u>P. niveivenosa</u>	94	128	199	436	511	143	157
<u>C. extima</u>	1939	913	630	348	483	217	124

Lethbridge 1922 records incomplete.

Boseman	1919	1923	1924	1925	1926	1927
<u>P. niveivenosa</u>	70	47	236	118	123	312
<u>C. extima</u>	140	0	4	12	13	11

Three Forks	1924	1925	1926	1927
		moths per hour		
<u>C. extima</u>	2.83	2.53	3.02	1.31

Period of flight.

	Lethbridge	Boseman
<u>P. niveivenosa</u>	July 9 - Aug. 25	June 30 - Sept. 1
<u>C. extima</u>	June 5 - Oct. 22	June 30 - Sept. 31

It is obvious that different weather factors govern the abundance

of these two. Caradrina extima appeared in maximum flight at Bozeman 1919 and Lethbridge 1921, both very dry years. Protagrotis niveivenosa in the same years occurred only in minimum numbers. C. extima is also double brooded, occurring in continuous flight from June until late in the fall. For these reasons these two species will be dealt with individually under group C.

As the flight of P. niveivenosa corresponds to those of the preceding group, its moth-year will be from August to July. The maximum flight of C. extima occurs in July and early August, although double brooded, and will be dealt with as its associate.

Protagrotis niveivenosa Grt.

Favorable years

Lethbridge - 1922, 1923, 1924, 1925

Bozeman - 1924, 1927

Unfavorable years

Lethbridge - 1921, 1926, 1927

Bozeman - 1919, 1923, 1925, 1926.

Caradrina extima Wlk.

Favorable years

Lethbridge - 1923, 1924, 1926, 1927

Bozeman - 1923, 1924, 1925, 1927

Three Forks - 1927, 1928

Unfavorable years

Lethbridge - 1921, 1922, 1925

Bozeman - 1919, 1926

Three Forks - 1924, 1925, 1926.

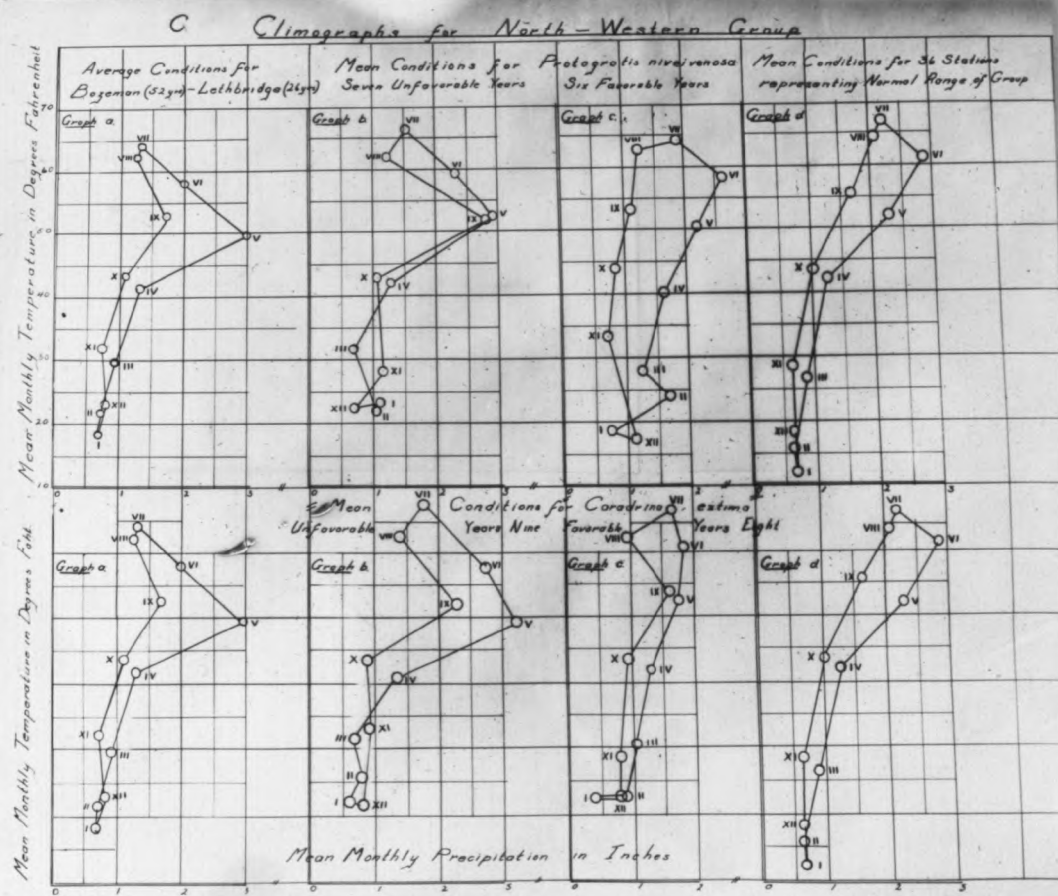
A comparison of the graphs for P. niveivenosa (see following page) show that favorable years for this species depend upon the amount of rainfall in May and September. When the rainfall in these two months decrease as clearly depicted in graph C (c), an increase occurs and the climograph is very much akin to that of the normal distribution of this group. (Graph d).

Graphs (c) and (d) are very much alike in early summer rainfall and the late summer conditions of these two are not far divergent from the same conditions in graph A. Hence, this species could be expected in fair numbers every year at Lethbridge and Bozeman. The light trap records show that this is the case. Only in years when the late summer precipitation is far beyond the normal can a decrease be expected. Graph (b).

C. extima is even a better example. Graph (b) shows that the summer months, May, June, July and September, bear much on the abundance of this species. This species is double brooded and conditions favoring its increase would vary somewhat from niveivenosa. When, however, the rainfall in May, June and September is higher than the normal (graph d) unfavorable conditions exist. Graphs (c) compared with graph(d) shows clearly that favorable years occur only in the years dryer than the normal. A glance at the light trap records will verify this. The years August 1915-July 1919 at Bozeman and August 1920-July 1921 at Lethbridge were very dry years and the catch during these two years were the highest on record.

D. WESTERN PLAINS GROUP.

This group is composed of three species - Perosagrotis orthogonia.



Euxoa pallipennis and Chorisagrotis auxiliaris and forms, whose range is rather extensive. P. orthogonia, the Pale Western Cutworm, occupies the short grass plains region from Southern Alberta to Northern New Mexico, and occupies sparingly west through Arizona to California and Utah. E. pallipennis occurs through the short grass plains region east of the Rockies but is also found occasionally west of the Rockies in Idaho, Utah, California and British Columbia. C. auxiliaris, the Western Army Cutworm, appears to have a wider range, inhabiting the short grass prairies of North America east of the Rockies, and is also found in Idaho, Utah, Arizona, Nevada and extends down the Coast Mountain Range to California. Its northern limit appears to be boreal - one record from Rampart, Alaska, and it has certainly a much more northern range than the other two as it is common in the Peace River-Grand Prairie region of Northern Alberta.

An examination of the economic distribution, where the greatest number of outbreaks have occurred (see map) show that these three species are indigenous to the short grass plains region. In this faunal region from Southern Alberta to Northern New Mexico, east of the Rockies in a strip of plains varying from 100 to 200 miles in width, the conditions are such that these three species are always present. These plains are the normal range of these species and 21 stations were selected to represent the optimum for this group. (See map).

Comparison of light trap records.

Lethbridge	1921	1922	1923	1924	1925	1926	1927
<u>P. orthogonia</u>	1071	1019	291	75	72	34	46
<u>E. pallipennis</u>	154	450	331	0	799	159	133
<u>C. auxiliaris</u>	253	14	20	16	194	337	222

1922 captures incomplete for C. auxiliaris.

Bozeman	1919	1923	1924	1925	1926	1927
<u>P. orthogonia</u>	5	1	2	6	20	8
<u>E. pallipennis</u>	9	0	6	4	6	3
<u>C. auxiliaris</u>	48	12	14	11	60	12

Three Forks	1924	1925	1926	1927
	Moths per hour			
<u>P. orthogonia</u>	18.13	8.9	7.2	4.5
<u>E. pallipennis</u>	15.8	63.4	15.1	3.4
<u>C. auxiliaris</u>	5	11.4	7.8	6.1

Havre	1921	1922
<u>P. orthogonia</u>	17,779	173
<u>E. pallipennis</u>	28,977	1335

Favorable years for the group (8 years)

Lethbridge - 1921, 1922, 1925, 1926

Bozeman - 1919, 1926

Three Forks - 1925

Havre - 1921.

Unfavorable years for the group (10 years)

Lethbridge - 1924, 1925, 1927

Bozeman - 1923, 1924, 1925, 1927

Three Forks - 1926, 1927

Havre - 1922

Period of flight.

Longest flights during years 1919-1927.

	Lethbridge	Bozeman	Havre
<u>P. orthogonia</u>	July 29 - Sept. 26	Aug. 16-Sept.18	Aug. 1-Sept.10
<u>E. pallipennis</u>	Aug. 1 - Sept. 28	Aug. 11-Sept.13	Aug.12-Sept.13
<u>C. auxiliaris</u>	June 8 - July 23	July 2 -Oct. 5	June 21-July 19
	Aug. 13 - Sept. 11		Aug. 17-Sept.30

The variability of seasons extend these flight periods over a greater number of days than would actually occur during one generation.

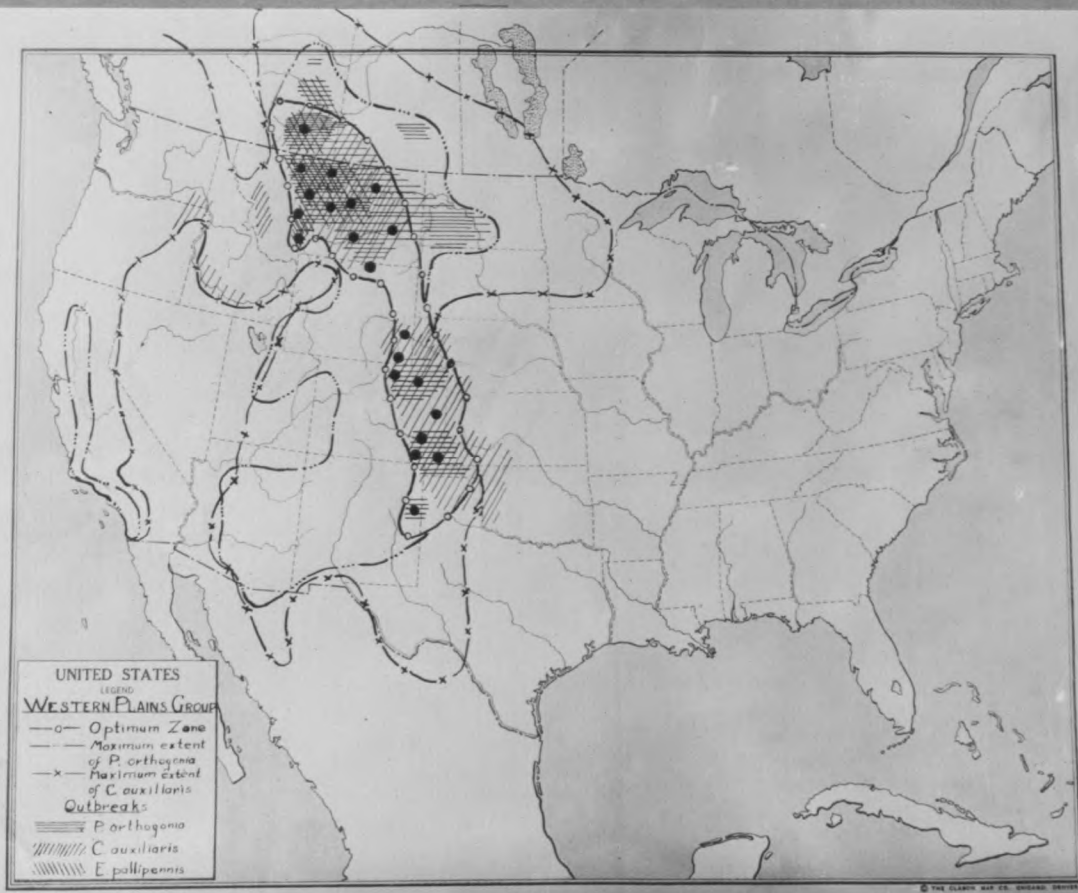
C. auxiliaris usually appears early in June continuing its flight until

about July 20. The maximum flight occurs usually in early July. During the hot weather very few are found active, the majority are aestivating under cover. About mid-August with cooler temperatures, mating occurs and egg laying proceeds until September. August to July following was used to represent the life period for this group.

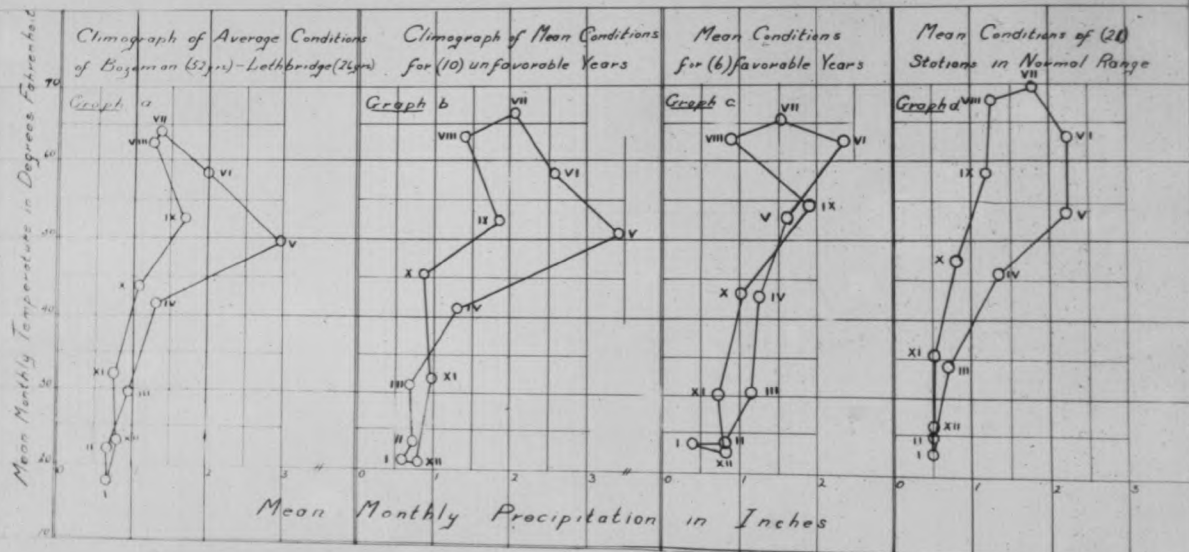
An examination of the graphs D (a), (b) and (d) on the following page reveals the fact that May rainfall is the great controlling factor for this group. During the years 1919-22 P. orthogonia and E. pallipennis were in outbreak form as evidenced by the huge captures from Havre, the approximate center of outbreak, and economic literature. Graph (c) exhibits May rainfall below normal. Such conditions are the most favorable conditions possible. Normal conditions are favorable for this group; a rainfall less than normal tends toward outbreak form, and precipitation greater than normal brings the species down to a very small numbers.

Graph (a) shows that normally the number of moths of these two species at Lethbridge and Boxman could not be expected to be large, as the rainfall in May is too heavy.

Because the Western Army Cutworm, G. auxiliaris, hibernates as an adult moth during the hot summer months, and the larvae are nearly mature in the fall, the above statements are not so applicable to this species as to P. orthogonia and E. pallipennis whose larvae hatch usually from the ova in early spring and are more susceptible to moisture conditions. However, it is clear that favorable conditions for the group certainly are very close to the optimum conditions as shown by graphs (c) and (d), and that unfavorable years swing away from the optimum as shown by graph (b).



D Climographs for Western Plains Group



E. MOUNTAIN PACIFIC GROUP.

This group comprising five species, Euxoa intrita, sponsa and rena and Polia stricta, have nearly the same distribution, being common in the mountains of Montana, Idaho, British Columbia and extending down the Pacific Coast range to California. E. vanconverensis has a range slightly more extensive, being found on the prairies of Southern Alberta. It will be considered separately in this group.

Comparison of light trap records.

Bozeman	1919	1923	1924	1925	1926	1927
<u>E. sponsa</u>	22	2	13	65	127	61
<u>E. intrita</u>	358	78	349	627	1262	264
<u>E. rena</u>	1	10	28	43	47	48
<u>P. stricta</u>	75	133	22	76	44	15

Hamilton	1925	1926	1927
<u>E. sponsa</u>	65	156	119
<u>E. intrita</u>	26	13	67
<u>E. rena</u>	72	139	10
<u>P. stricta</u>	3	11	33

1926 Hamilton records are incomplete as the light trap was discontinued on August 17, and the catch not as large as it otherwise would have been.

Favorable years for E. sponsa, intrita, rena and P. stricta:

Bozeman - 1919, 1924, 1925, 1926

Hamilton - 1926.

Unfavorable years

Bozeman - 1923, 1927

Hamilton - 1925, 1927.

Period of flight.

	<u>Bozeman</u>	<u>Hamilton</u>
<u>E. sponsa</u>	June 26 - Sept. 19	June 18 - Sept. 4
<u>E. intrita</u>	July 11 - Sept. 21	July 9 - Sept. 9
<u>E. rena</u>	July 16 - Sept. 19	July 18 - Sept. 11
<u>E. stricta</u>	July 11 - Sept. 21	July 29 - Sept. 2

The flight of these four species is nearly identical. The moth year was taken from August to the following July.

Light trap records for *Feltia vanouverensis*.

	<u>1919</u>	<u>1921</u>	<u>1922</u>	<u>1923</u>	<u>1924</u>	<u>1925</u>	<u>1926</u>	<u>1927</u>
Lethbridge		219	season missed	390	1	13	115	155
Bozeman	1	-	-	18	50	22	9	7
Hamilton						209	77	season missed

Time of flight for *F. vanouverensis*

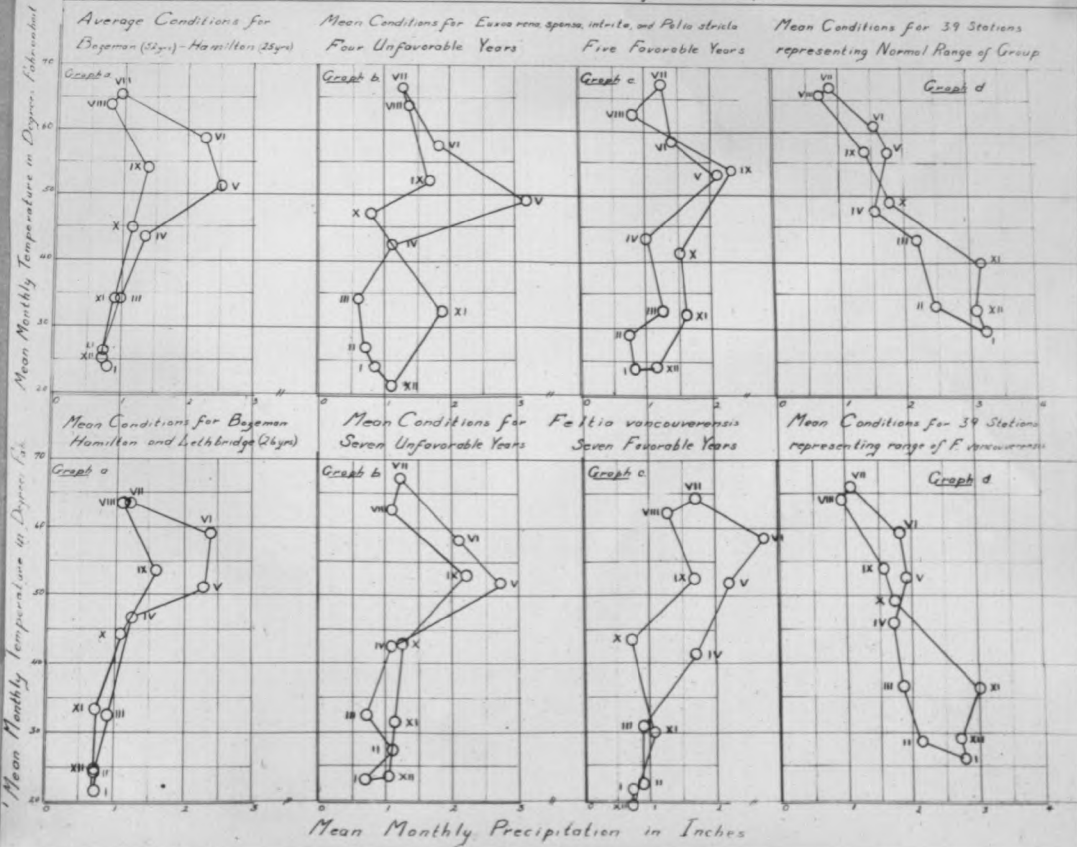
<u>Lethbridge</u>	<u>Bozeman</u>	<u>Hamilton</u>
May 14-July 30	May 24-Aug. 3	May 27-June 30

The moth year was taken the same as for the other species.

The graphs of the Mountain Pacific group on the following page show clearly that the summer conditions favorable for this group swing toward the optimum conditions for this group. It is remarkable that the optimum is so closely approximated by the conditions in favorable years, for the precipitation features east and west of the Rockies are vastly different. It is unreasonable to expect that the winter conditions will ever swing over to those of graph (d), as two entirely different climatic regions are involved. In the Pacific Coast region west of the Rockies, the maximum precipitation comes in the winter months, November to February and March, and in the Rocky Mountain region the maximum precipitation comes in May, June and September. The normal conditions of the two stations, Bozeman and Hamilton, appear to be such that they are favorable



E. Climographs for Mountain-Pacific Group



to this group, somewhat similar to the optimum conditions especially in later summer, graphs (a) and (d). This fact would appear to be correct, as a glance at the light trap records show that each year these species occur in rather large numbers.

May, June and September rainfall appears to regulate the abundance of F. vancouverensis. A high precipitation in May and September seems to be unfavorable, while a May and September rainfall identical with that in the optimum and a wet June favor the abundance of the species. Graphs (b), (c) and (d). In this respect the favorable conditions diverge from the optimum. It is this factor that makes F. vancouverensis an inhabitant of Alberta where the maximum rainfall occurs in May and June. It is too much to assume that the weather features of these stations that have totally different climatic features from that of the Pacific Coast, would closely approach these conditions existing in the optimum. With more datum on this species its range may be found to be more extensive and then may not appear to fall in this group.

However, the four other species of this group excellently illustrate that the summer conditions in the optimum and during favorable years are very much akin.

SUMMARY.

A short synopsis of the different groups will serve to summarise this paper.

A. Eastern Group:

With the aid of climographs illustrating the unfavorable and favorable conditions at the stations in Montana and Alberta, it has been shown that the conditions appertune for the abundance of moths of this group approach the normal conditions exemplified in the optimum.

B. Trans-Northern Group:

June rainfall appears to be a deciding factor in the abundance of this group. The graphs clearly exhibit a June precipitation in favorable years near that of the same month in the optimum. In unfavorable years it is not so, and accounts for the small captures of this group. The normal conditions at Lethbridge and Bozeman have a low June rainfall and this will only be abundant in years with June abnormally wet.

C. North-Western Group:

The graphs ably illustrate that favorable years closely approximate the optimum. A heavy rainfall in May and September depict unfavorable climatic features, especially referable to Caradrina extima, which is abundant in abnormally dry seasons. The normal conditions of Lethbridge and Bozeman are such that these two species, particularly Caradrina extima, will never be abundant in average years.

D. Western Plains Group:

May rainfall appears to be the climatic factor regulating the abundance of this group of moths. A comparison of the graphs has shown that May rainfall for favorable years is nearly identical with the normal rainfall in the optimum. Unfavorable years feature a May precipitation greater than three inches. The normal conditions of Lethbridge and Bozeman are similar to those in unfavorable years, and hence this group will be abundant only in seasons with a dry spring.

E. Mountain-Pacific Group:

This is a fine example illustrating the purpose of this paper. The climatic features during favorable seasons diverge far from the normal conditions of Bozeman and Hamilton, and very closely approach the normal in the optimum for the group. This is rather striking as the optimum lies in the Pacific type of precipitation, with the rainfall maximum in winter, while Bozeman has the maximum in the spring. That the conditions favorable for this group at these two stations is similar to the normal in the optimum, is ample proof that the favorable conditions for a group outside the optimum zone approach the normal in the optimum of the group.

A study of each group has revealed the fact that the years favoring an increase in the species of each group tend toward the normal conditions in the optimum.

BIBLIOGRAPHY

Distributional Literature

1882. Pilate, G. R. List of Lepidoptera taken in and around Dayton, Ohio. *Papilio* 2:65-71.
1883. Fernald, C. H. List of Noctuidae taken in Orono, Maine, and vicinity. *Papilio* 3:21-23.
1895. Luggar, Otto. List of Owlet moths taken on sugar at St. Anthony Park. 1st Ann. Rept. State Ent. of Minn. pp. 143-147.
1901. Beutenmüller, Wm. Descriptive catalog of the Noctuid moths found within 50 miles of N.Y. City. *Bul. Am. Mus. Nat. Hist.* 14:277-305.
1904. Dyar, Harrison G. The Lepidoptera of the Keotenai District of British Columbia. *Proc. U.S. Natl. Museum* 27:511-565.
1918. Turner, W. B. Female Lepidoptera at light traps. *Jour. Agr. Res.* 14:135-149.
1919. Bowman, Kenneth. Annotated check list of the Macrolépidoptera of Alberta. *Alberta Nat. Hist. Soc. of Red Deer*.
1920. Turner, W. B. Lepidoptera at light traps. *Jour. Agr. Res.* 15:475-481.
1921. Strickland, E. H. Biological notes on parasites of prairie cutworms. *Canada Dept. Agr. Tech. Bul.* 26 N.S.
1924. Cook, W. C. The distribution of the Pale Western cutworm, *Perodesmogrotis orthogonia* Merr. A study in physical ecology. *Ecology* 5:No.1, 60-69.
1926. Cook, W. C. Weather relation of Pale Western cutworm, a preliminary study. *Ecology* 7: No.1, 37-47.
1927. Cook, W. C. Studies in the ecology of Montana cutworm, *Phalaenidae*. *Ecology* 8: No.2, 158-173.
1928. Leonard, Mortimer D. List of insects of New York. *N.Y. State Coll. Agr., Cornell, Memoir* 101:654-664.

Economic Literature

1869. Riley, Charles V. 1st Ann. Rpt. State Ent. of Missouri. pp 67-87..
1882. Lintner, A. 1st. Ann. Rpt. State Ent. of New York. pp 99-110.
1888. Lintner, A. 4th Ann. Rpt. on the injurious and other insects of the State of New York. pp 54-57.
1888. Forbes, S. A. 16th Rpt. State Ent. of Illinois. pp 84-101.
1896. Fletcher, James. Rpt. Ent. and Botanist, Canada Dept. Agr. p 247.
1900. Forbes, S. A. The economic entomology of the sugar beet. Ill, Agr. Exp. Sta. Bul. 60:448-452.
1905. Forbes, S. A. 23rd Rpt. State Ent. of Illinois. pp 17-51.
1905. Fletcher, James. Rpt. Ent. and Botanist, Canada Dept. Agr. p 169.
- 1910-1922. Cooley, R.A. 7th to 19th Ann. Rpts. of State Ent. of Montana.
- 1911-12. Swenk, Myron H. Bul. State Ent. of Nebraska, 1:22-41.
1912. Gibson, Arthur. Cutworms and army worms. Canada Dept. Agr. Bul. 70.
1914. Gibson, Arthur. A new destructive cutworm of the genus *Perosagrotis*, occurring in Western Canada. Jour. Econ. Ent. 7:201-203.
- 1912-17. Hewett, C. Gordon. Rpt. Dominion Ent. 1912 p. 177; 1915 p.20; 1916 pp 31, 59 62, 63; 1917 p 10.
- 1913-14. Hewett, C. Gordon. Rpt. Div. of Ent. 1913 p 506; 1914 p 861.
1915. Gibson, Arthur. Cutworms and their control. Dom. of Canada Bul. 10.
1916. Strickland, E. H. The army cutworm, *Chorisagrotis auxiliaris*. Canadian Dept. Agr. Bul.13.
1916. Cooley, R. A. and Parker, J. R. The army cutworm in Montana. Mont. Agr. Exp. Sta. Circular 52.
- 1919-20. Gibson, Arthur. Rpt. Dominion Ent. pp 7-11.
1921. Parker, J. R., Strand, A. L. and Seamans, H. B. The Pale Western cutworm, (*Perosagrotis orthogonia* Morrison). Jour. Agr. Res. 22: No.6. 289-322.

1921-27. Insect Pest Survey Bulletins.

1922. Hyslop, J. A. Summary of insect conditions throughout the United States in 1921. U.S.D.A. Bul. 1103:19-21.

1924. Webster, R. L. and Ainslie, C. H. The Pale Western cutworm in North Dakota. N. D. Agr. College Bul. 179.

1926. Seemans, H. L. The Pale Western cutworm. Canadian Dept. of Agr. Pamphlet 71, N.S.

1926. King, Kenneth M. The Red Backed cutworm and its control in the prairie provinces. Canadian Dept. of Agr. Pamphlet 69, N.S.

**1926. International Great Plains Crop Pest Committee.
Lethbridge, August 1926.**

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