OBSERVATIONS ON THE OPERATION OF TWO LIGHT TRAPS AT MANHATTAN DURING TWO SEASONS AND AN ANALYSIS OF THE CATCH OF TWENTY-FIVE SPECIES OF LEPIDOPTERA

by

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INTRODUCTION

Early entomological literature abounds with references to various types and uses of light traps especially for the control of insects of economic importance. During recent years, this control idea has been largely discarded and light traps are being used now chiefly for collecting nocturnal insects for museums or for special studies. During the summers of 1932 and 1933 some studies were made with two distinct types of trap lights at Manhattan, Kansas, to determine the effect of the various meteorological factors on the nocturnal activities of a few of the commoner species of Lepidoptera, some of which are of economic importance. Some additional observations were made in regard to the seasonal abundance of these species, the relation of the catch to generations as well as the activities of some other insects with respect to light traps. Comparative data were taken in regard to the efficiency of the two types of light traps, the location of the traps and the possible effect of nearby vegetation. The writer was particularly attracted to this study by the opportunity it offered for a broad acquaintance with the insect fauna of this region.

REVIEW OF LITERATURE

In the available literature relative to trap lights, one finds that some of the traps developed were very simple and others were more elaborate, patented contrivances. Slingerland (1902) in his trap light work used an ordinary lantern set on a brick in a common tin pan filled with water. Enough kerosene was used to form a thin film over the water in order to kill the insects. According to White (1928), Purdum and Sons used as trap lights on their truck farm near Danville, Virginia, ordinary lights suspended six feet from the ground and protected by reflectors, with a three quart pan containing kerosene suspended from the reflector at about six inches under the lamp.

Hiestand (1928) stated that the conventional type of trap was the age old box trap with plates of glass so arranged as to keep the moths in the killing chamber. Either an electric bulb or an oil lamp was used in the light chamber. The funnel-shaped bottom of the killing chamber had, at its end, a screw top jar containing the killing agent. His funnel type trap light resembled the funnel type used in these experiments.

Several investigators have kept extensive records of flight activities of Lepidoptera, but have not stated which weather factors might be of importance. Lugger (1896) studied the flight of Minnesota Noctuidae and prepared a list of species captured, the duration of their flight, and their abundance. Forbes (1923) made a seasonal record of Lepidoptera taken at light traps during the seasons of 1919 and 1922, at Ithaca, New York. The season records were in the form of plots; the height of each column for each week corresponding to the catch of that week. In 1922 when a 500 watt light was used the total catch amounted to over 8,000 specimens; in 1919, when a less intense light was used, less than 5,000 specimens were taken, although the lights were located at the same place.

Some observations have been made by various investigators relative to the influence of meteorological conditions on the flight activities of moths.

Ainslie (1917) in making a study of Crambid moths collected his material at strongly lighted windows of laboratory buildings and his residence. He stated that he did not know what meteorological conditions influenced the attraction of Crambid moths to lighted windows, but that he had repeatedly noticed that it did not depend on temperature or humidity. He suggested that barometric pressure might be one of the factors.

Criddle (1918) stated that the most favorable weather conditions for insect flight were warmth and cloudiness. According to Criddle, a perfect night should combine these two factors at a time when the moon is not visible, with a stormy atmosphere and preferably a light rain. Such a combination of conditions is of rare occurrence.

Cook (1920) studied the flight of nocturnal Lepidoptera from June 18 to September 30, using 65 bait traps with a 10 per cent solution of molasses in water. The moths captured were divided into three groups, large Noctuidae, small Noctuidae, and Microlepidoptera. He considered only the larger Noctuidae. His conclusions were as follows: the fluctuations in catches could not be closely correlated with any one of the weather curves, but the catches apparently tended to increase with a rise in temperature, and decrease as either humidity or pressure deviated very far in either direction from the optimum. The relative effects of the various factors were greater the farther the conditions departed from the optimum. The largest catches were made when all factors were at or near their respective optima. Humidity was by far the most important factor studied. Any increase in the humidity taken at 7:00 p.m., up to about 54 per cent tended to increase the catch, while beyond this value, it decreased the catch in almost the same proportion. In 1923, Cook extended his discussion with data obtained at Havre, Montana. He found that the flight activities of moths were at their best when the humidity was about average for the season. Moths flew more freely on warm, dry nights following cool, damp nights, than when the reverse was true. Variations in temperature and pressure from night to night were of more importance than humidity.

Turner (1920) kept partial records of temperature and humidity while collecting Lepidoptera at trap lights. From his somewhat scanty data, he concluded that night-flying habits of moths were little influenced by the aforementioned factors. On the other hand, such weather phenomena as strong winds, rains, or fogs, materially restricted flight.

Parker, Strand, and Seaman (1921) used a trap light to capture adults, in their work on the pale western cutworm, Porosagratis orthogonia. They observed that on still, dark, fairly warm nights, the moths came to the traps in large numbers. If the wind were strong, if the temperature had dropped below 58° F., if the moon were bright or during a rain or shortly after a rain, they noticed that practically no moths were caught.

Collins and Nixon (1930) studied the possibilities of catching certain orchard insect pests by the use of light traps. During the summer of 1929, one-hundred-five pan light traps were set, one in each tree, in a four acre section of a large orchard in Monroe County, New York. Each trap was lighted by a 75 watt, type C, clear Mazda bulb. During the entire season, 27,726 budmoths, and 16,432 fruit tree leafrollers were caught and counted. Budmoth flight began June 18 and ended August 22; leafroller flight extended from June 23 to August 5. The maximum flight activities of both moths occurred on July 7. Temperature was found to be an important regulator of flight, as few Lepidoptera were active when temperature fell below 60° F.

Trap lighting of leafhopper was carried on by Lawson (1930) by means of a 200 watt Mazda bulb suspended about six inches above a funnel nearly two feet in diameter which tapered to a tube four inches in diameter and 18 inches long. This tube was built into three sections and holds cyanide enclosed in a perforated two-ounce box. His results were that leafhoppers swarmed in large numbers to lights when there was little wind and when there was a favorable combination of high temperature and high humidity. A favorable evening following several unfavorable evenings was conducive to large catches.

MATERIALS AND METHODS

Most any kind of an artificial light will attract certain insects at night. If there is some arrangement for entrapping those attracted, the device is called a trap light. The trap lights used in the experiments herein reported were of two different types.

The funnel type trap light is illustrated in Figure 1. This trap was designed by Doctor Roger C. Smith at Charlottesville, Virginia, in 1919, for a 500 watt electric bulb. It consisted of a galvanized tin funnel, 17.5 inches in diameter, to which was added an 18 inch spout. Attached at an angle to this main spout were two short spouts six inches apart. The ends of each of the three spouts were covered interiorly by screen. The screens were of different mesh so that the insects would be somewhat separated, the larger insects in one jar, smaller insects in another, etc. A Mason fruit jar screw cap, with the top cut out, was soldered to each of the spouts on the exterior end, so that

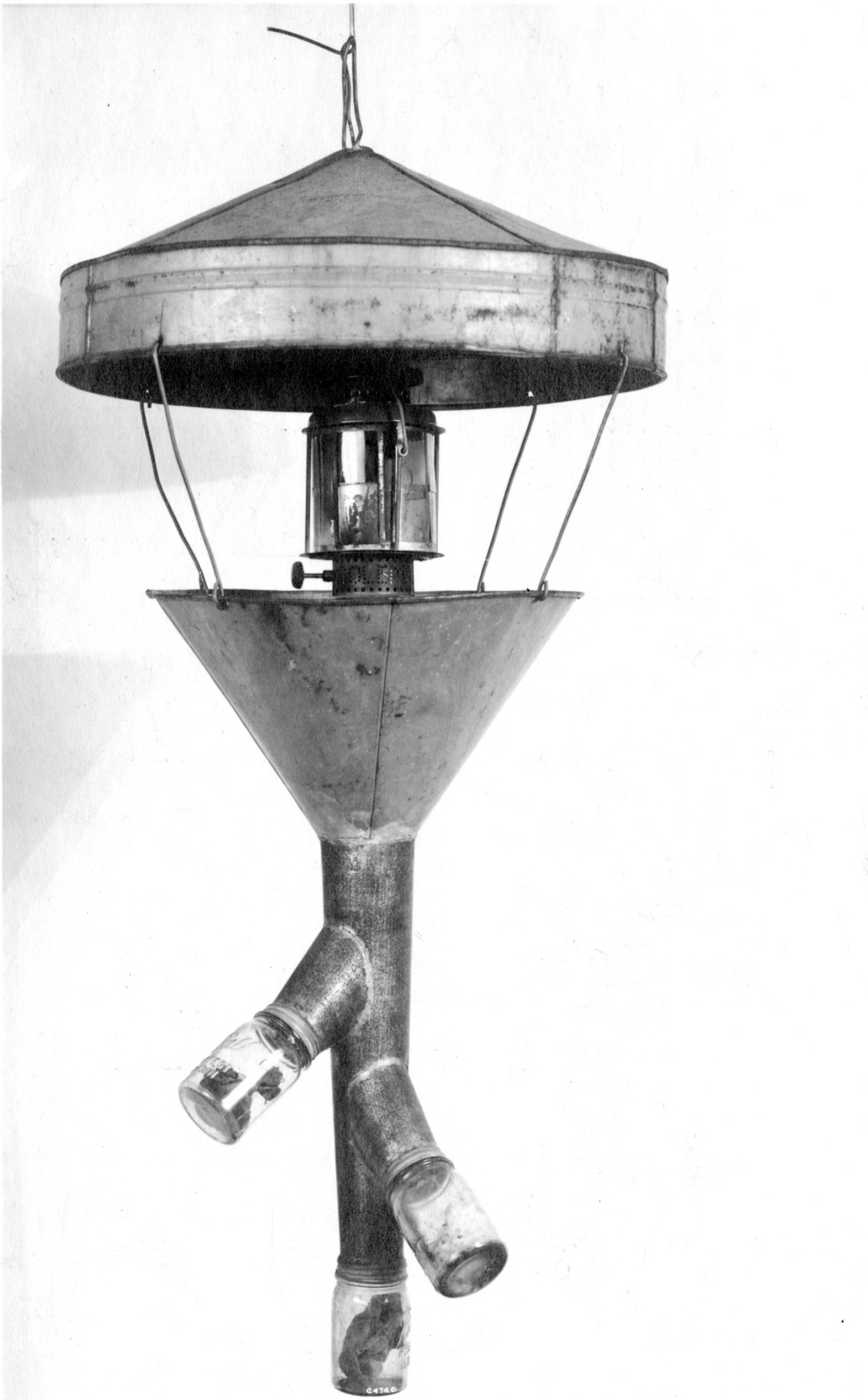

Figure 1.

a jar could be fastened on.

The funnel was suspended by four rods with one end bent to form a hook so that they could be taken off readily, to a galvanized cone, 24 inches in diameter and with a four inch rim. A porcelain socket to hold the Mazda bulb, was bolted to the peak of the cone shade. The distance between the cone and the funnel depended upon the size of the bulb used. Best results were obtained when the tip of the bulb projected about an inch below the top of the funnel. An eyelet was soldered to the top of the cone to support the trap.

The box type trap light, illustrated in Figure 2, was designed by Doctor Smith, at Manhattan, in 1932, for a Coleman gas lantern. It has been used both with the gasoline lantern, and with an electric light. This trap consisted of two parts, a light compartment, and a gable roof. The light compartment was 30 inches square and 16 inches in height. The spout and funnel, at the bottom of the light compartment, were 16 inches long. A Mason fruit jar lid, with the top cut out, was soldered to the end of the spout, so that a fruit jar could be easily attached. Each of the four sides of the light chamber had two glass panes, placed at an angle to allow insects to enter easily, and to prevent, as far as possible, their escape. The upper pane of glass

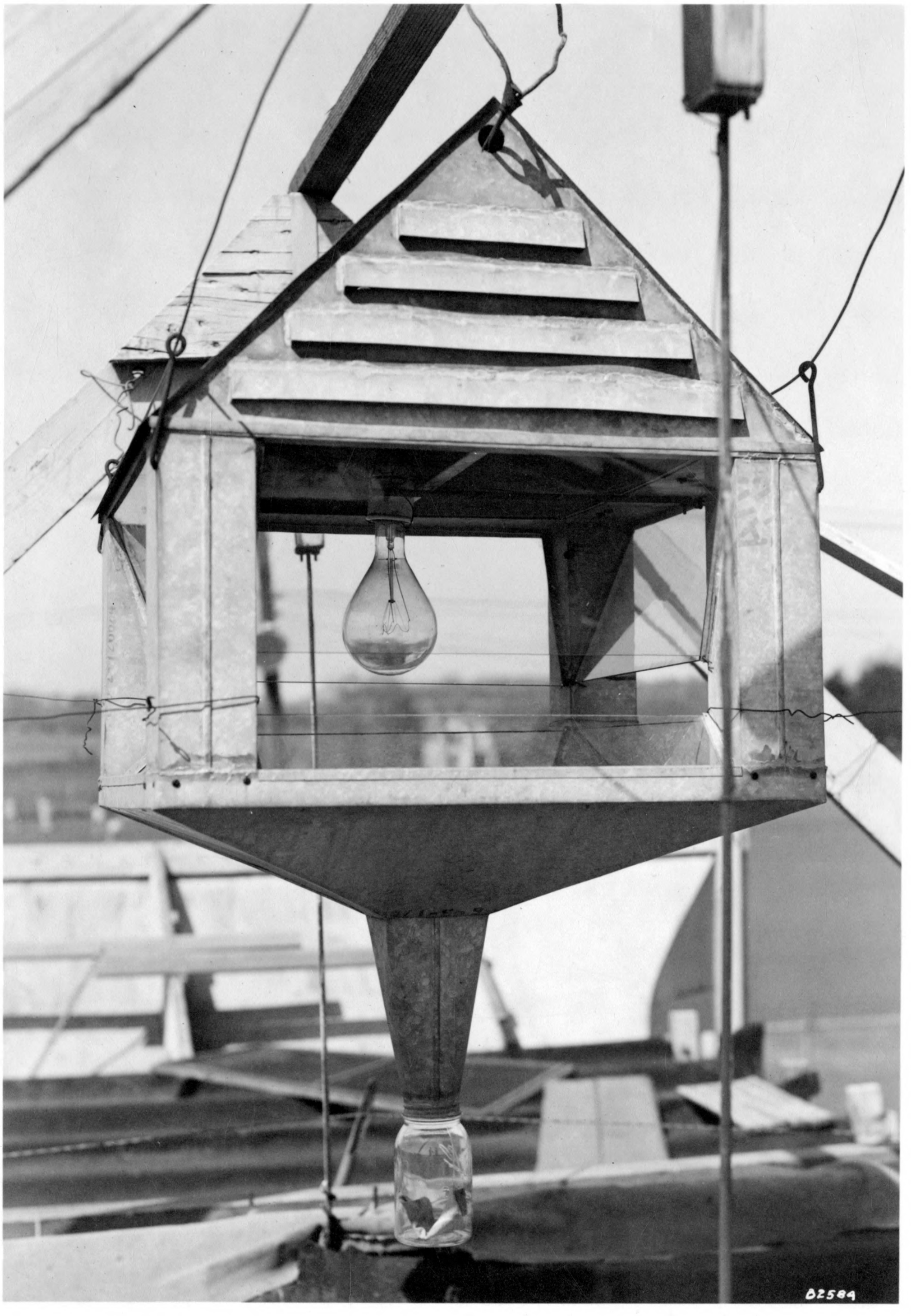

Figure 2.

was 10 x 22 inches and the lower pane was 5 x 22 inches. The compartment was covered by two screen doors that opened outward. The object of the doors was to prevent the insects from entering in the upper chamber and yet allow one to clean the light compartment, or to put the lantern in place. The lantern was held on a hook on a rod upon which rested the two unattached ends of the screen doors. The upper chamber, covered by the gable roof, was 15 inches in height, and 30 inches square. At each end of this compartment were ventilators. The entire trap was supported by short rods at each corner, fastened to four posts.

The killing jars used were ordinary fruit jars with a small cloth bag of flake calcium cyanide in the bottom. These jars can be washed frequently and are easily handled. The calcium cyanide was renewed each time the traps were operated. This killing agent has been very successful, and few moths have been found rubbed.

The two trap lights, located on the Kansas State College campus, were operated at different locations, and at different heights from the ground. Neither was sheltered. The box type trap light (see Fig. 2) was located on a small building, 10 feet above ground, and with no vegetation near. The funnel trap light, located at the east Insectary, which is on a lower elevation, hung four feet above the ground.

There was some vegetation near this location. The two lights were interchanged on July 14, 1932.

The gas light was operated 70 evenings, and the electric light was operated 83 evenings. The total number of evenings was 94. They were both operated from dusk until 11:30 p.m., such a period being time enough to catch representative numbers of the moths active at that time. The electric light was turned off at the proper time by means of a switch connected to an alarm clock. The gas lantern had its fuel measured according to the approximate number of hours it was to be run. The amount of fuel needed to operate this lantern from dusk until 11:30 p.m. was determined by experimentation.

The insects caught were collected each morning after the lights had been run. They were counted, recorded as to number and species, and preserved in boxes. Specimens were pinned for the college collection, and some were sent to Doctor W.T.M. Forbes and other specialists for identification.

Records of temperature and humidity were obtained by means of a hygrothermograph operated by the Department of Entomology at the east insectary. The amount of precipitation was obtained from the experiment station records. Lunar data were obtained from the World Almanac, and wind records were made from personal observation.

EXPERIMENTAL DATA

The two light traps were operated from April 1 to October 16, 1932, and from April 8 to July 1, 1933. The data on which this discussion is based are given in full in Table I for 1932 and in Table II for 1933. The light traps were not operated from August 24 to September 12, because of the author's absence. The periods, April 1 to 13, April 27 to May 1, June 30 to July 25, and August 20 to October 17 are incomplete as far as temperature and humidity are concerned, because of a shortage of hygrothermograph supplies. The classification of wind velocity in Tables I and II is to be interpreted as follows: (1) calm, less than one mile per hour, (2) slight breeze, four to seven miles per hour, (3) breeze, eight to twelve miles per hour and (4) wind, 12 to 25 miles per hour. The moon phases presented in column ten include the date of full moon and time of rising.

DISCUSSION OF DATA

The year 1932 was the driest year known in Kansas since 1917, and the summer temperatures were extreme. Rainfall during the spring of 1933 was below normal and June was one of the hottest months in years.

Table I. Total Catch of Twenty-five Species of Moths at the Two Trap Lights, April to November, 1932, With Meteorological and Lunar Data.

Date	No. traps	Total moths	Moths: Electric light	Moths: Gas light	Temperature, degrees F. Afternoon 6	8	10	12	Ave.	Humidity, per cent Afternoon 6	8	10	12	Ave.	Precipitation days and amount	Wind	Moon: Date	Moon-phase	Moon rises
April															April		April		P. M.
1	1	7		7											.01(7)				
2	1	2		2											.08(16)				
4	2	7	3	4											.12(17)				
8	1	2		2											.22(19)		5	New Moon	
13	2	4		4	76	70	60	50	65.5	45	50	60	69	56.0	1.00(20)		13	1st Quart.	
14	2	14	13	1	66	64	58	53	60.2	53	60	67	70	62.5	.07(21)				
18	1	12		12	63	61	59	56	59.7	75	95	95	100	91.2	.12(23)				
20	2	15	2	13	66	65	63	62	64.0	92	93	100	99	96.0	.17(24)	Calm	20	Full Moon	6:53
21	2	17	1	16	76	74	71	68	72.2	99	99	98	96	98.0	.10(25)	B	21		
22	2	45	37	8	72	71	69	68	70.0	90	91	95	100	94.0	.02(28)	Calm			
27	1	3	1	2											T(29)	S B	27	Last Quart.	
28	1															S B			
May															May		May		
1	2	104	52	52	67	65	61	59	63.0	62	74	74	73	70.7	.09(3)	Calm			
2	1	4		4	65	64	62	60	62.7	89	90	94	95	92.0	.03(6)	W			
3	1	4		4	82	78	73	70	75.7	60	61	62	76	64.7	.67(7)	W			
4	2	17	6	11	79	75	71	69	73.5	63	66	75	82	71.5	.09(8)	S B	5	New Moon	
11	2	11	8	3	74	73	66	61	68.5	62	77	84	90	78.2	.36(9)	S B			
12	2	6	6	0	82	78	71	66	74.2	62	70	78	88	74.5	.05(16)	S B	13	1st Quart.	
23	2	24	17	7	69	65	60	55	62.3	74	83	88	88	78.2	.81(26)	S B	20	Full Moon	8:23
24	1	22	22		84	82	77	74	79.2	67	76	80	85	77.0	.27(29)	B			
26	1	14		14	67	65	62	59	63.2	85	88	88	89	87.5	.30(31)	S B	26	Last Quart.	
30	2	72	66	6															
June															June		June		
3	2	181	166	15	79	78	74	71	75.5	95	100	100	96	97.7	.73(3)	S B			
5	1	38		38	83	81	79	77	80.0	78	77	94	96	86.2	T(4)	Calm	4	New Moon	
6	2	388	353	35	85	84	80	76	81.2	73	83	88	91	83.7		Calm			
9	2	169	135	34	75	73	71	69	72.0	92	94	95	100	95.2		Calm			
10	2	49	38	11	80	79	74	71	76.0	78	83	88	91	85.0	.20(12)	Calm	11	1st Quart.	
13	2	60	40	20	72	72	72	78	73.5	90	85	79	75	82.2	.80(13)	Calm			
14	1	41		41	65	67	72	75	69.7	85	80	75	72	78.0		S B			
15	1	21	21		85	84	78	73	80.0	70	85	91	91	84.2		Calm			
17	1	29	29		17	96	90	83	80.0	77	80	87	94	84.5	.94(19)	Calm	18	Full Moon	8:17
20	2	289	251	38	75	74	72	71	73.0	95	96	98	98	96.7	1.44(20)	Calm			
21	2	241	215	26	82	81	76	72	77.7	86	93	94	95	92.0	.14(26)	Calm			
23	2	115	115	0	85	82	81	80	82.2	83	86	93	96	89.5	.63(27)	Calm			
24	1				82	81	79	87	82.1	97	100	100	100	99.2		S B			
27	2	46	38	8	81	81	77	75	78.0	85	93	93	93	91.0		Calm	25	Last Quart.	
28	2	25	19	6	84	83	79	75	80.2	81	89	93	93	89.0		Calm			
30	1	5		5	92	91	86	81	87.5	80	79	79	73	77.7		S B			
July															July		July		
5	2	784	750	34	82	82	79	76	79.7	95	97	97	100	97.2	T(4)	Calm	3	New Moon	
7	1	481	481	0	88	86	80	76	82.5	83	90	92	95	90.0	.71(5)	Calm			
8	1	166	166	0	86	83	81	79	82.2	98	97	97	98	97.5	.01(8)	Calm			
11	2	13	8	5	91	90	85	82	87.0	78	85	89	92	86.0	.18(9)	S B	10	1st Quart.	
14	2	5	5	0	95	92	87	85	89.7	65	70	74	79	72.0	.06(24)	S B			
15	2	60	58	2	99	95	90	86	92.5	63	75	85	88	77.7	.15(25)	Calm			
18	1	121	121	0	94	91	87	84	89.0	65	72	75	78	72.5	.04(26)	Calm	17	Full Moon	7.46
22	1	101	101	0	99	95	90	86	92.5	69	80	81	88	79.2	.73(30)	Calm			
25	1	239	239	0												S B	25	Last Quart.	
26	2	206	194	12	93	89	85	81	87.0	78	80	86	89	83.2	.03(31)	S B			
Aug.															Aug.		Aug.		
3	2	766	708	58	88	85	81	77	82.7	87	92	93	93	91.2	1.10(2)	Calm	2	New Moon	
8	2	0			87	85	79	76	81.7	65	73	73	92	75.7	.02(3)	W			
															.40(7)				
9	2	468	462	6	91	90	85	81	86.2	84	87	87	87	86.2	.23(9)	Calm	9	1st Quart.	
10	2	13	11	2	93	91	87	84	88.8	72	75	83	86	79.0	.41(12)	S B	16	Full Moon	7:19
															.71(13)				
20	2	40	40	0											.08(14)	W	24	Last Quart.	
															.24(26)				
23	2	26	26	0											.92(31)	S B	31	New Moon	
Sept.															Sept.		Sept.		
13	1	28	28	0											.80(1)	Calm	7	1st Quart.	
															.02(11)				
14	2	55	20	35											.33(12)	Calm	14	Full Moon	6:07
															.77(20)				
26	1	38	38	0											.16(21)	Calm	22	Last Quart.	
															1.52(22)				
27	2	201	186	15											.43(27)	Calm	30	New Moon	
Oct.															Oct.		Oct.		
12	2	6	6	0											.13(9)	S B	6	1st Quart.	
13	2	10	10	0											.09(10)	S B			
16	1	11	11	0											.21(15)	S B	8	Full Moon	5:14
Total		5941	5323	618															

Table II. Total Catch of Twenty-five Species of Moths at the Two Trap Lights, April to July, 1933, With Meteorological and Lunar Data

			Moths		Temperature					Humidity					Precipitation		Moon		
					Afternoon					Afternoon					days and amount				
Date	No. traps	Total moths	Electric light	Gas light	6	8	10	12	Ave.	6	8	10	12	Ave.		Wind	Date	Moon-phase	Moon Rises
April															April		April		P. M.
8	1	38	38	0	79	72	66	64	70.1	55	61	66	100	70.5	.02(3)	S B	3	1st Quart.	
16	2	13	12	1	68	65	52	50	58.8	48	55	65	96	66	.01(9)	S B	10	Full Moon	7:05
17	2	1	1	0	68	64	59	55	61.5	77	100	100	99	94	.04(13)	S B	16	Last Quart.	
24	2	35	32	3											.30(19)	S B	24	New Moon	
27	2	0	0	0	69	68	62	60	64.8	59	69	75	87	72.5	.71(20)	W			
28	2	4	1	3	78	76	71	69	73.5	60	94	96	98	87	1.77(21)	B			
May															May		May		
8	2	18	17	1	80	75	70	66	72.7	67	72	77	83	77.2	.73(5)	B	2	1st Quart.	
14	2	7	3	4	74	71	66	61	68	54	75	85	92	76.5	.06(11)	W	9	Full Moon	7:16
15	2	12	7	5	77	74	67	63	70.2	56	71	84	89	75	.01(12)	W			
16	2	10	7	3	85	81	77	74	79.2	55	67	80	83	71.2	.	S B	16	Last Quart.	
17	1	23	23	0	78	76	74	73	75.2	96	91	91	90	92		B			
19	2	222	217	5	92	89	85	82	87	67	76	84	92	79.7	.03(18)	S B			
20	2	409	391	18	82	81	78	75	79	100	100	100	99	99.7		S B			
21	1	283	283	0	81	80	77	76	78.5	100	100	100	100	100	.05(21)	S B			
24	1	143	143	0	80	72	67	65	71	100	100	100	100	100	.54(23)	S B	24	New Moon	
25	2	163	149	14	72	70	67	63	68	92	96	96	98	95.5		S B			
29	2	60	48	12	80	82	77	71	77.5	51	57	73	87	67	.15(28)	B			
31	1	19	19	0	87	85	83	78	83.2	62	69	80	84	73.7		Calm			
June															June		June		
1	2	14	14	0	88	86	82	79	83.7	68	74	79	83	76		Calm	1	1st Quart.	
2	2	10	6	4	87	86	82	79	83.2	70	79	84	91	81		B			
4	2	42	38	4	99	100	96	68	95.7	50	57	79	88	68.5		S B			
6	1	2	2	0	100	95	90	85	92.5	55	64	70	83	68		W			
8	2	55	41	14	92	88	82	80	85.5	55	63	69	77	66		S B	8	Full Moon	8:35
11	2	61	43	18	99	98	91	87	93.7	55	63	72	73	65.7		Calm	9		
13	2	18	18	0	78	78	72	65	74.5	53	58	67	74	63	T(13)	S B			
14	2	22	12	10	85	83	77	73	79.2	54	59	63	66	60.5		B	14	Last Quart.	
15	2	4	3	1	90	88	83	78	84.7	54	58	64	66	60.5		W			
19	1	2	2	0	97	94	90	85	91.5	59	66	68	67	65		S B			
20	1	15	15	0	93	90	86	83	88	55	58	60	65	59.5		S B			
21	2	262	255	7	96	95	89	83	90.7	66	71	77	81	73.7		Calm			
22	2	222	207	15	94	93	91	88	90.7	63	68	70	74	68.7	.42(26)	S B	22	New Moon	
25	1	571	571	0	89	89	87	84	87.2	84	90	95	95	91	.03(27)	Calm			
26	1	55	55	0	93	91	87	85	89	74	76	79	96	81.2	.15(28)	S B			
29	2	7	7	0	104	100	96	87	96.7	53	63	76	90	70.5	.09(30)	W	30	Last Quart.	
Total		2822	2680	142															

A comparative study of weather conditions at the time of the large catches of moths and of small catches recorded in Tables I and II, shows that temperature and humidity have a considerable influence on the size of the catches. The effects may be somewhat obscured, because the light traps were generally operated on apparently favorable evenings. The fluctuation in the size of the catches can not be closely correlated with either the temperature or the humidity, but the catches apparently tend to increase with rise in temperature until the optimum is reached, after which the catches tend to decrease. The optimum temperature and humidity for the largest catch during 1932 was temperature 79° F. and humidity 97 per cent, with evening clear and calm. The optimum temperature and humidity for the largest catch during 1933 was temperature 84° F. and humidity 91 per cent, with evening calm and cloudy. When the temperatures were above the optimum, the number of moths caught greatly decreased but when the humidity ranged above the optimum, there was little effect on the number of moths caught.

The total catch of insects decreased as either humidity or temperature deviated very far below or above the optimum. For example on night of June 4 the electric light trap was run all night. The total number of moths caught before midnight was smaller than the total number moths caught after twelve P. M. At twelve P. M. the temperature had dropped to 87° F. or lower which would indicate that extremely high temperatures reduce activities of moths. Then as the temperature nears the optimum and the humidity increases, moth activity is increased. The weather from June 1 to June 21 was warm and dry and catches at the lights were small. This dry period was followed by a more humid period with the same temperature range. During this period the catch increased in size. This indicates that the larger number of moths appear to be flying on warm humid nights following warm dry nights. Also it appears that such conditions are more favorable for the emerging of moths. Small catches were made on cool, dry, breezy evenings as May 8, 14, 15, 16, and 17, 1933. Larger catches were made on warm humid evenings such as May 19, 20, 21, and 24, 1933.

Wind is one of the most important factors studied. If other weather factors, such as temperature and humidity, are at their respective optima, many moths may be captured. But if there was no wind the number caught would be greatly increased. On windy evenings such as May 2, May 3, and August 8, few or no moths were caught. The light traps were not operated on very many windy evenings, as the author knew by experience that such evenings were not favorable for moth flight.

The influence of the moon on the size of the catches was not very evident, although on the evening of April 20, 1932, the moon was full and the catch was smaller than on the following evenings. Full moonlight tends to reduce the number of insects which may be active. Such factors as temperature, humidity, wind, and cloudiness must be considered when studying moonlight and its effect on moth flight.

The funnel type trap and the box type trap have been operated at both locations. The box trap was operated at the east insectary from April 1 to July 4, 1932. The total moths taken by the box type trap to July 1 of this period was 457 and total number of moths taken by the funnel type trap from April 8 to July 1, 1933, at the east insectary was 142. Since the moths were approximately equally plentiful both seasons, these results indicate that the box type trap was more efficient in capturing moths.

In comparing the total catches of the electric light and gasoline light traps in Tables II and III, it is apparent that the 500 watt electric light attracted the largest number of moths to the trap. The larger catches are due to the greater intensity of the 500 watt electric light trap. Up to a certain point, moths are positively phototropic. At much greater light intensities as in sunshine the moths are negatively phototropic.

The greatest number of Sparganothus sulfureana Clem. was taken at the east insectary light trap. However, more of each of the other 24 species was taken at the other light trap. More of the strong flying Lepidoptera were captured at the light trap north of the Engineering Building than at the east insectary trap, but more of the micro-lepidoptera were taken at the latter.

The vegetation around the east insectary light appeared to influence the type of insects caught. The catches there included the leaf feeder, such as leafhoppers, June beetles, and moths of the cocklebur stalk borer. While the catches at the light trap north of the Engineering Building included insects which were able to fly farther from vegetation.

A large number of other insects were taken at the lights, in addition to the Lepidoptera. Some of these were: the corn seed beetles, of which over 1000 were taken during one evening; Caddice flies of which over 1500 were taken in one evening; leafhoppers of which over 3000 were taken in one evening; and blister beetles of which over 200 were captured in one evening. The small number of June beetles this year and the large number last year present at the lights indicate that 1932 was the June beetle year.

The following gives the seasonal records of 25 moths from Tables III and IV;

Caenurgia erechtea Cramer. (The forage looper). The total number taken during the two seasons was 222. According to Smith (1924) there are three full broods each year at Manhattan, and the insect overwinters as a pupa in the ground. The light trap catches for the season of 1932 indicated that there were three generations, the peak of the first brood occurring on April 21, the peak of the second brood on June 20, and the peak of the third in August or September. The earliest moths in the spring are undersized. The moths from the second, and third broods were larger, and may be easily confused with C. crassiuscula. The forage looper is one of the most common Noctuids attracted to lights. It was the most regularly present moth coming to the lights during the season of 1932. The catches for 1933 corresponded quite closely to the catches for 1932, except that the peak of the first brood was a few days earlier.

Crambodes talidiformis Guenee. The total number of this species taken during the two seasons was 30. To the author's knowledge, there is no literature published on the habits or life history of this moth. Holland (1903) stated that the larvae feed on verbena, and that the adults are freely attracted to lights. There are no pinned specimens

Table III. Twenty-five Species of Lepidoptera Taken at Two Trap Lights, Manhattan, Kansas, 1932.

Species	April												May									
	1	2	4	8	13	14	18	20	21	22	27	28	1	2	3	4	11	12	23	24	26	30
Caenurgia erechtea	7	2	5	2	4	12	10	14	16	4	0	0	3	0	0	2	0	1	0	0	0	0
Crambodes talidiformis																						
Neleucania albilinea								1		16			33	2		4						
Abrostola urentis														1		4			3	1		
Feltia venerabilis																						
Feltia gladiaria																						
Chorizagrotis axiliaris															3	3			5	9	4	40
Leucania unipuncta			2			2				12	1				1	2						
Cirphis phragmatidicola														1								4
Mamestra renigera																					1	2
Plusia brassicae																						
Tarache aprica																			2			
Galgula partita											1		1				1			4		1
Catabena lineolata																						
Autographa falcifera									1	13			7				1					1
Feltia subgothica																						
Datana perspicua																				8		5
Plathypena scabra																						
Chloridea obsoleta																	1					
Malacosoma americana																						
Loxostege commixtalis													54			1	4	1	10		3	4
Loxostege similalis																					4	13
Nomophila noctuella											1		6			1	3	4	3		2	2
Spargonothus sulfureana																	1		1			
Datana integerrima																						

Species	June															
	3	5	6	9	10	13	14	15	17	20	21	23	24	27	28	30
Caenurgia erechtea	0	0	1	0	1	6	6	0	1	12	7	7	0	2	2	0
Crambodes talidiformis						1		2		4	3	4			1	1
Neleucania albilinea																
Abrostola urentis	3		1			3	1			20	22	26		6	4	
Feltia venerabilis																
Feltia gladiaria																
Chorizagrotis axiliaris	1		1	2												
Leucania unipuncta										12	7	5		5		
Cirphis phragmatidicola	1		4	2	1	1	1			3		2		1		
Mamestra renigera	3		3		2	1										
Plusia brassicae					1	2				12	3			1		
Tarache aprica	6	6	13	6	2	2		5		5	2			4		
Galgula partita			1	1	6		1	3		7		11				
Catabena lineolata									2	1	3	4			1	
Autographa falcifera			1	1			1									
Feltia subgothica																
Datana perspicua	29	2	11	13						4		2				
Plathypena scabra								2		2	9	3		1		
Chloridea obsoleta											1					
Malacosoma americana		2	2	6		1										
Loxostege commixtalis	22	7	30	12	6	2	1	2	1	2	2					
Loxostege similalis	113	16	308	106	26	30	12	7	25	131	142	46		11	10	2
Nomophila noctuella		3	8		2	2				18	9	5		5	1	1
Spargonothus sulfureana		1	1	16	1	9	18			56	30			10	6	1
Datana integerrima	3	1	2	4	1						1					

Species	July										August						September				October			Total
	5	7	8	11	14	15	18	22	25	26	3	8	9	10	20	23	13	14	26	28	12	13	16	
Caenurgia erechtea	0	2	1	0	1	0	1	0	1	1	0	0	0	0	2	1	3	1	0	3	0	1	0	145
Crambodes talidiformis	2	2		2			2	1	1															26
Neleucania albilinea													2		3				1					62
Abrostola urentis	11	8	3					2																119
Feltia venerabilis																				3	3	3	2	11
Feltia gladiaria																			5	14	1	1		21
Chorizagrotis axiliaris																			1			1		70
Leucania unipuncta	2				1						1		2	1										56
Cirphis phragmatidicola						1					1		2	1		1								27
Mamestra renigera																								12
Plusia brassicae	2	2				1		1	1				4											30
Tarache aprica		1							5						10	3				2				74
Galgula partita		3		2	1	6	14		9	4			1					1						79
Catabena lineolata	2						1	1	2				1											18
Autographa falcifera											2		1											29
Feltia subgothica																	7	25	7	13	1	1	2	56
Datana perspicua									2		3		5		7	8								99
Plathypena scabra		2		1			3	6	2	5			4					1						41
Chloridea obsoleta													1		1		7	3	11	7	1	3	5	41
Malacosoma americana																								11
Loxostege commixtalis			1	1													7	3	2	145			1	324
Loxostege similalis	755	461	160	5	1	52	100	90	216	192	730		432	10	16	10		3	2	4				4241
Nomophila noctuella	2				1						1		2	1	1	3								84
Spargonothus sulfureana	8			2						4	28		11				4	18	9	10				245
Datana integerrima			1																					13

Table IV. Twenty-five Species of Lepidoptera Taken at Two Light Traps, Manhattan, Kansas, 1933.

Species	April						May												June																Total
	8	16	17	24	27	28	8	14	15	16	17	19	20	21	24	25	29	31	1	2	4	6	8	11	13	14	15	19	20	21	22	25	26	29	
Caenurgia erechtea	14	3		7			1					7	3	2	1		1				5		3	1	1	1			1	3	6		7		67
Crambodes talidiformis							2														2														4
Neleucania albilinea	4			7		2							1																	1		1		1	17
Abrostola urentis								1																						1	1			1	4
Feltia venerabilis																																			--
Feltia gladiaria																																			--
Chorizagrotis axiliaris									1	7	20	117	348	255	23	22	27	8	8	5	6	2	5	2					1						857
Leucania unipuncta	1	1	1	2		1	6																												12
Cirphis phragmatidicola												5	11	6	1			1	3		3		31	23	1	5	3			1					94
Mamestra renigera													4	6		10	9	2	2	3	4		3	5	2										50
Plusia brassicae							2				1	4	4	1	1	1	2	1			1			1					2	2	1	1	1	1	27
Tarache aprica												2	8	3		7	2	2	1		2		1	2						3	3	3	1		40
Galgula partita							2	1				2				1							2							2		2			12
Catabena lineolata																																			--
Autographa falcifera				5																															5
Feltia subgothica																																			--
Datana perspicua																	2	2																	4
Plathypena scabra																										1					2	2			5
Chloridea obsoleta											2				1														2					1	6
Malacosoma americana																		1			4			1		1									7
Loxostege commixtalis	9	8		5				3	9	3		63	6		100	82							4	3		3			3	2	4	5	3	1	316
Loxostege similalis												20	18	10		24	14				10		2	20	2	4		2	6	232	185	50	35	2	636
Nomophila noctuella	10	1		9		1	5	2	2			1	6		15	11	3			2	1				12	1				11	14	55	8		180
Spargonothus sulfureana																					2		4	3		6	1			4	6	2			28
Datana integerrima												1			1	1	1	2			2					1									9

in the Kansas State College collection. Apparently the moth is not common at Manhattan. The light trap catches indicate that there was only one generation for the season of 1932, with the peak of the flight occurring June 20 to 23. The size of the catches for 1933 was smaller. The first moth emerged in May, 1933, which was about 30 days earlier than the date of the emergence of the first moth in 1932.

Neleucania albilinea Hubner (wheat headed army worm). The total number of this species taken was 79. Webster (1911) stated that there were two generations per year, and that the insect overwintered as a pupa in the soil. Farther south than Kansas he reported three full generations. The light trap captures substantiated his statements as to broods. The peak of the first brood occurred May 1, and of the second on August 20. According to the literature, the second brood is the larger. The peak of the first brood in 1933 was on April 7 which was a little later than the peak for 1932. Three stragglers which were captured the latter part of May was probably due to the late emergence of the first brood. The trap light catches indicated that either this insect is not very common at Manhattan, or it is not strongly attracted to lights.

Abrostola urentis Guenee. The total number of this insect taken during the two seasons was 123. There is no published literature on the habits and life history of this moth. There were no specimens from Kansas in the college collection, which would indicate that it is not common in the vicinity of Manhattan. Holland (1903) stated that it is not a common insect. The size of the catches indicates that it is freely attracted to lights. The period of flight was from May 2 to July 22, with the heaviest flight occurring during June and the climax on June 23, 1932. Apparently there was only one generation for 1932. The 1933 catches were very small and scattered. The first moth was caught later in 1933 than in 1932.

Feltia venerabilis Walker (the dusky cutworm). The total number of these moths taken during 1932 was 11. None was taken in 1933 because operation of the light traps ceased before their emergence. Crumb (1929) stated that Kansas was near the southern limit of distribution of this insect, therefore, one would not expect the insect to be very abundant here. He also stated that there was one brood each year, and that they overwintered as larvae in the soil. The larvae pass through a long aestivation period, pupating in August, and emerge in September, October, and November. Catches at the light traps showed only one generation for

1932, which corresponded to the statements of Crumb. The moth flight at the lights began the last of September and continued through October. This species was the least abundant of the genus Feltia taken during 1932.

Feltia gladiaria Morrison (the clay back cutworm). The total number of this species taken during 1932 was 21. No moths were taken in 1933 because the first moths did not appear until fall. Crumb (1929) stated that there was only one generation each year, and that they overwintered as larvae in the first and second instar. All larvae go into aestivation by the middle of May, and the main emergence occurred from October 1 to October 10. Crumb stated, however, that they may continue to emerge until the middle of October. The light trap showed one flight of moths during the season, indicating that there was one brood in 1932. The flight occurred from September 26 to October 13, which shows that the moths emerged earlier at Manhattan than in Kentucky. The range for this insect is north of Kansas, so the moth is not very abundant at Manhattan.

Chorizagrotis auxiliaris Grote (the army cutworm). The total number taken during the two seasons was 926. Cooley and Parker (1916) stated that larvae of this species seldom are seen in the fall, but are readily observed in the spring. They overwinter as half-grown larvae. The moths emerge from June to August, the main emergence occurring early in July. He says that the adults are long-lived and do not lay eggs until September and October. Catches at the light traps indicated one brood. The largest flight in both 1932 and 1933 was in May. Two moths taken in September and in October probably indicate that they lived a long time, or that they emerged late. The moths emerge about two months earlier in Manhattan than in Montana, according to the results obtained in these experiments. The results also show that they remain alive during the summer and appear in September and October to lay their eggs. The moths may be brownish or grayish in color, which leads one to think they are two different species. They were captured in large numbers at the lights in May but fewer were taken in June, although the shrubbery appeared to be sheltering many moths. Outbreaks of this cutworm occurred in the eastern and southern parts of Kansas during 1933.

Leucania unipuncta Haworth (the common army worm). The total number of this species of moth taken during the two seasons was 68. Walton (1916) stated that there were three broods each year in northern United States and that they overwintered as larvae or adults whereas in the southern states there are as many as six generations and the moths usually overwinter. He said they were freely attracted to lights. The captures at the lights showed that there were three broods during 1932. The peak of the first flight occurred on April 22, the peak of the second on June 20, and the peak of the third about August 9. Some of the first moths of the first flight in April gave indication that they had overwintered as adults because they were badly rubbed when taken at the lights. No moths were active during June of 1933 and the first flight in April was small. The hot weather during June of 1933 may have delayed the emergence of the second brood of moths somewhat. This insect is apparently not very common at Manhattan, as shown by the small catches.

Cirphis phragmatidicola Guenee. The total number of this species of moth taken during both seasons was 119. There is nothing published on the life history of this insect. The catches at the trap lights last season indicated two generations with the peak of the first flight on May 30 and June 6, and the peak of the second on August 9. The catches for 1933 were taken during May and June with the climax on June 8. The catches for 1933 indicated that this insect was more plentiful during this season. This species resembles Leucania unipuncta except that C. phragmatidicola is lighter in color and has dark lines on the first pair of wings. There were several specimens in the college collection. It is apparently not common at Manhattan although it is freely attracted to lights.

Mamestra renigera Stephens. The total number of this species of moth taken during the two seasons was 62. There is no literature available on the life history of this insect. It is probably not of economic importance. Catches at the light traps indicated that there was one generation for 1932. The moths were active during May and June, with the climax from June 3 to June 6. The 1933 flight was larger and the peak of the flight occurred on May 25. There were no pinned specimens in the college collection, so the moth is apparently not very common at Manhattan.

Plusia brassicae Riley (the cabbage looper). The total number of this species taken during the two seasons was 57. Howard and Chittenden (1902) stated that this insect passed the winter in the pupal stage and that there were three or more broods each year. Webster's (1915) notes showed that there were three generations in Iowa. Catches at the lights indicated only two generations in 1932, the peak of the first flight occurring on about June 20 and the peak of the second on August 9. The first flight which according to literature should have occurred in May was not taken at the lights. Catches during 1933 indicated that the first brood peak occurred on May 20. If this season's operations had been continued until October, there would probably have been obtained evidence of three generations. The insect apparently is not very common at Manhattan because of the small catches. The author noticed that the species was strongly attracted to the lights.

Tarache aprica Hubner. The total number taken during the seasons was 114. This moth was of interest to the author because of its striking color pattern. There is no literature available on the life history or habits of this moth. The catches at the trap lights gave indications of two generations for 1932 the first brood peak occurring on June 6 and the peak of the second brood was on August 20. The peak of the first brood during 1933 was on May 20. The number of pinned specimens in the college collection indicates that this species is fairly common at Manhattan. The number taken indicates that it comes freely to lights.

Galgula partita Guenee. The total number of this species taken at the light traps was 92. This Noctuid is the smallest in size of the group considered in this study. The Kansas State College collection contains only one pinned specimen. It is apparently not very common, but it came to the lights readily. This Noctuid has two forms - a light and a dark one. The flight during 1932 continued from April 27 to September 15. The flight had two peaks, the first on June 23 and the second on July 18. The heaviest flights occurred during June and July after which numbers gradually decreased. Catches during May and June of 1933 were small and scattered. The moths appear to come to the lights in pairs.

Catabena lineolata Walker. The total number taken during 1932 was 18. The Kansas State collection contained no pinned specimens of this moth. It is apparently not common in the vicinity of Manhattan. Holland (1903) stated that the larvae fed on verbena. Catches at the lights indicated that there was one generation in 1932. The moths were active during June and July, the climax of flight occurring on June 23. No specimens of this Noctuid were taken in 1933.

Autographa falcifera Kelly (the celery looper). The total number taken was 34. The several publications written on this insect do not give a detailed life history of this pest. Chittenden (1902) says that this species overwinters as a half-grown larva in the soil or in sheltered places. He stated that there were three generations each year. This insect closely resembles the cabbage looper in all respects. Two distinct flights of moths came to the traps, the peak of the first occurring on April 22 and of the second on August 2, making two broods for 1932. Only five moths were taken in 1933, all in April. This insect is actually abundant at Manhattan so it is apparently not strongly attracted to the lights.

Feltia subgothica Haworth (the dingy cutworm). The total moths of this species taken during 1932 was 56. This insect was not taken in 1933 because it does not appear until after trap light operations ceased. Crumb (1929) stated that the larvae of *F. ducens* and *F. subgothica* are difficult to separate and they are readily confused. He also stated that there was one brood each year and that larvae, which are remarkedly hardy, overwintered in the third and fourth instar. The larvae go through an aestivation period from May to August 15. The moths emerged from the middle of August to the end of October. Of the three species taken of the genus Feltia, *F. subgothica* was the most common. The flight of this species occurred during September and October, thus showing but one generation per year at Manhattan. These results correspond with those of Crumb. The peak of the flight was on September 14. If the flight of this moth began in August, some of the flight may have been missed as the traps were not in operation from August 28 to September 13.

<u>Datana perspicua</u> Grote and Robinson. The total number of this species taken during the two seasons was 103. This Datana came to the lights more abundantly than <u>D. integerrima</u>. As far as the author knows nothing has been published on the life history of this moth. Two well marked flights occurred during 1932, indicating two broods. The peak of the first occurred on June 3, and the peak of the second on August 23. Only four moths were taken in 1933, probably because of a decrease in the numbers of this insect. They appeared to be readily attracted to light, as the writer has observed that they did not hesitate to enter the light trap.

<u>Plathypena scabra</u> Fabricius (the green clover worm). The total number of this species of moth taken during the two seasons was 41. Hill (1925) said that the adults may hibernate through the winter in barns and haystacks or the insect may overwinter as a pupa. Two or three generations occur in the northern part of United States. Both males and females are attracted to lights. The catches at the trap lights indicated three generations for 1932 at Manhattan, which confirms rearing studies. Flight at the trap lights first occurred during June and July, with the peak on June 21. The flight of the second brood occurred during July with the peak on July 22. Moths flying during August and

September were from the third brood. The author has noticed that these moths appeared to be not strongly attracted to light, but that they would rather sit in the rays of the light than enter the trap.

Chloridea obsoleta Fabricius (the corn ear worm). The total number taken during the two seasons was 41. Phillips and King (1923) stated that this insect overwintered as a pupa, and the moths first appeared about the first of June, the second brood during the first part of July, and those of the third about the last of August in the latitude of Kansas. Catches at the trap lights for 1932 were as follows: one specimen of the first brood was caught on May 11, one of the second brood on June 21, and several of the third during August, September, and October. The number of moths caught increased as the number of generations increased. Phillips and King (1923) stated that the corn ear worm moths were not strongly attracted to lights which agrees with the writer's observations. The catches for 1933 up to July were as follows: two moths of the second on June 20, and one on June 29. Apparently the broods of this moth appear about two weeks earlier at Manhattan than Phillips and King stated for Kansas in their investigations.

Malacosoma americana Fabricius (the apple tree tent caterpillar). The total number of this species of moth taken was 18. Lowe (1899) stated that this insect overwintered in egg masses which hatch in early spring of the following year. The moths appear in June, and there is only one generation each year. It is commonly believed that this insect is on the increase in Kansas. The catches at the trap lights indicated that there was but one brood both years, the peak of the 1932 generation occurred on June 9. The first moths captured at the lights in 1933 was a few days earlier than the first caught in 1932. They were more abundant at the light traps in 1932. They are either not abundant at Manhattan, or they are not strongly attracted to light. The author's results correspond to those of Lowe (1899).

Loxostege commixtalis Walker (the alfalfa webworm). The total number of this species of moth taken was 640. This insect appears to be more abundant at Manhattan than was formerly thought. This moth was freely attracted to lights, as large swarms were seen around the lights. The main catches during 1932 were taken during May, June, and September. The life history of this insect has not been completely worked out. The catches for 1932 indicated three brood peaks, the first on May first, the second on

June 6, and the third on September 28. During July only 2 moths were taken, and in August none was taken. There appears to be no reason for this gap in the flight. Catches for 1933 started April 8, indicating that this insect probably overwinters as pupae.

Loxostege similalis Guenee (the garden webworm). The total number of this species of moth taken during the two seasons was 4877. This moth was taken in the largest numbers of any of the moths. They were strongly attracted to lights and were often seen circling about the lights. Kelly and Wilson (1918) stated that they overwintered as pupa in the soil and that there are four generations each year in Kansas and Oklahoma. They stated that the first moths appeared about May 1, the second brood about July 10, the third about August 10, and the fourth about September 10. They also stated that they were strongly attracted to lights. Catches at the lights indicated four broods, the peak of the first on June 6, the peak of the second on July 5, the third peak on August 3, and the fourth peak on September 28. Catches during 1933 indicated a brood in May with a peak on May 25, and a second brood with its peak on June 21. If the experiment were continued until October, there would probably have been two more broods.

Nomophila noctuella Denis and Schiffermüller (the celery stalk borer). The total number of this species of moth taken was 264. Ellis (1925) stated that field observations in New England during 1920 and 1921, supported by insectary rearings, showed that this insect has two generations per year and that it overwinters as larvae in refuse. Felt stated that there are three broods in New York. Ellis said that at Arlington, Massachusetts, the first brood appears the last week of May and the second brood appears from July 7 to July 22. Catches at the light traps were made from April 27 to August 23. Apparently the first brood occurred in April and May, the second in June and July and a partial third in August. The flight during 1933 was evenly distributed through April, May, and June. This moth is not freely attracted to light, as the writer finds many of them sitting in the lighted zone and not entering the light trap.

Sparganothus sulfureana Clemens. The total number of moths of this species taken during the season was 254. This moth belongs to the group of bud moths and leaf rollers. Unpublished observations at the Kansas Experiment Station indicate that the insect overwinters as a pupa, and that there are two generations each year occurring during the early and late summer. The first brood reached its peak about June 20, the second reached on August 3, with its flight extending into September. This moth was present at the lights from May 11 to October 1, 1932, thus the two flights were not very distinct. This rather common insect appears to be readily attracted to lights.

Datana integerrima Grote and Robinson (the walnut worm). The total number of moths of this species taken during the season was 22. Houser (1918) states that the caterpillars pupate in late summer and the moths do not emerge until May or June of the next year. Only one generation is said to occur. The catches at the light traps indicated only one brood, the flight occurring during June and with one straggler in July. The flight of this insect during 1933 occurred in May and June. In the year 1932, the walnut datana reached its peak of abundance. Most of the walnut trees throughout Kansas were partly or wholly defoliated. The small numbers taken at the lights would indicate that it is not freely attracted to the light otherwise the catches would have been larger. The defoliation of the walnut trees is not always noticeable. This species is known to be strongly parasitized.

SUMMARY

1. Few moths were caught on evenings when the temperature was 60° F. or lower and relative humidity was 59 per

cent or lower.

2. At temperatures above 90° F. the catches were reduced in size. Comparatively large catches were made when the humidity was 90 to 100 per cent. The catches tended to decrease as either humidity or temperature deviated very far above or below the optium.

3. The largest catch for 1932 was made when the temperature was 79° F. and humidity 97 per cent with the evening clear and calm. The largest catch for 1933 was made when the temperature was 84 and the humidity was 91, with the evening calm and cloudy. These two and other large catches indicate that warm nights and high humidity are most favorable for moth activities.

4. Warm, humid, calm and cloudy evenings following unfavorable evenings characterized by cool, dry, and windy weather are most favorable for large catches.

5. Wind was the most important climatic factor studied. The catches were always larger on calm evenings when other factors were at or near their respective optima, than on windy evenings.

6. The catches were smaller on bright moonlight nights than on dark nights.

7. The electric light trap caught more insects than the gasoline light trap did, apparently because of the greater intensity of the light.

8. The box trap was more efficient in retaining the insects which were caught than the funnel trap was.

9. The light trap near the ground and close to dense vegetation caught by far the smallest number of insects.

10. The light traps provide a good method of catching the first and the last emerging moths during a season and of determining the number of broods any species of moth may have in a season.

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