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### LACHNOSTERNA RECORDS IN WISCONSIN

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By means of a special fund granted by the Wisconsin legislature of 1913, experiments were carried out in 1914 and 1915 with regard to the serious white grub pests of the genus *Lachnosterna*, which have caused heavy losses during recent years. Several factors to be considered included: the determination of conditions; crops most seriously damaged with and without rotation; the species present and their habits, life-history, distribution and means of control.

It was decided that lantern traps be used as a means of collecting large numbers of the beetles for the purpose of determining the species to be found in the lower portion of the state, their attractiveness to lights with regard to sex, and the possibility of economic control in this manner. Some interesting information as to the number of species concerned and their relative abundance and distribution was secured. Some of the results are briefly outlined here.

The forty trap-lights used consisted of the Coleman gasoline arc lantern (Fig. 10), furnishing 300 to 400 candle power, set into large, galvanized refrigerator pans, five inches deep and about twenty-four inches in diameter. These pans were filled about two-thirds full of water, and one-half pint of kerosene was poured on the water and renewed when necessary. Perforated skimmers were used to remove the captured insects.

The five stations (Fig. 11) in the southern third of the state were located as follows: at Lancaster in the southwestern corner of the state, fifteen miles from the Mississippi river and twenty-five miles from the Illinois state line; at Dodgeville, thirty miles east and slightly north of Lancaster; at Madison, thirty-five miles east and north of Dodgeville; at Baraboo, forty miles northeast of Dodgeville and thirty-five miles northwest of Madison; and at Ripon, fifty miles northeast of Baraboo. With the exception of Madison, the stations were situated in a line running northeast from Lancaster, 120 miles to Ripon.

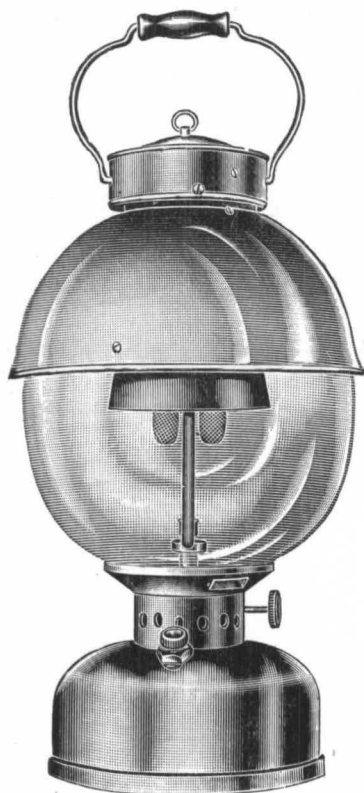


Fig. 10. Coleman Gasoline Arc Lantern (300-400 candle power) used in trapping experiments. [Cut furnished by the Coleman Lamp Co., Wichita, Kans.]

imate total of one million thirty-six thousand four hundred (1,036,400) beetles.

Some striking results were obtained with regard to the distribution of species in this comparatively limited area, the optimum temperatures for flights, favorable location and arrangement of light traps. A mere summary of important results seems most desirable in this paper.

#### TEMPERATURE AN IMPORTANT FLIGHT FACTOR

With 7 p. m. temperatures much below 66° Fahrenheit, flights were very small and almost ceased at 62°. Results show that 99.6

Generally speaking, Lancaster and Dodgeville are located similarly in a high rolling plateau region. Madison is on a lower level of black soil to the east of a hilly region. Baraboo is in a distinct region north of the Wisconsin river valley, featured by bold granite hills and higher plateaus. Ripon is in a lower rolling region of black soil. The latter two stations record slightly lower temperatures.

The forty light traps were operated from the time of the first flights in early May until late in June, and succeeded in catching an approx-

per cent of the entire catch of over 110,000 beetles at Baraboo and 99.1 per cent of the 14,500 at Ripon were made at 66° and upward. With higher temperatures, however, the volume of the flight did not always increase to a maximum at the highest degrees. Other weather conditions, such as cloudiness or moonlight, appeared to have less effect than is usually attributed to them.

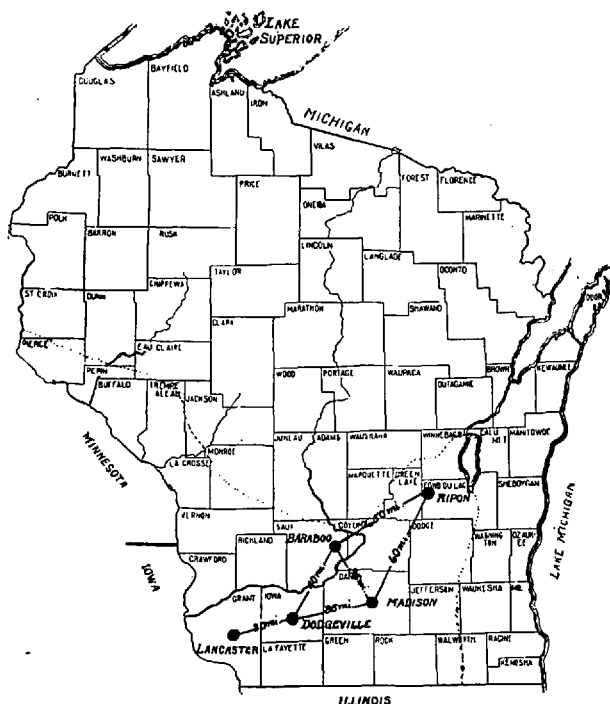


Fig. 11. Map of Wisconsin, showing trap-light stations and intervening distances. Dotted line bounds area of white grub damage.

The following table is a typical record from Baraboo:

DATE	WEATHER CONDITIONS	TEMP. 8.00 P. M.	NO. BEETLES
May 14.....	Clear and calm	54°	0
May 15.....	Clear and calm	57°	0
May 16.....	Clear and calm	61°	135
May 17.....	Clear and calm	64°	154
May 18.....	Clear, light south wind	69°	1,250
May 19.....	Clear, light south wind	70°	1,902
May 20.....	Cloudy, light south wind	73°	3,156
May 21.....	Clear and calm	62°	155
May 26.....	Cloudy, warm south wind	80°	22,700

## DISTRIBUTION OF SPECIES

## SPECIES OF LACHNOSTERNA CAPTURED AT TRAP LIGHTS

## A Comparative Table on a Basis of 10,000 Beetles

	Lan- caster	30 mi... Dodge- ville	40 mi... 35 mi... Madison	Bara- boo	50 mi... Ripon
No. beetles caught...	440,000	271,600	?	110,285	14,519
No. beetles identified	12,246	16,268	10,839	16,847	14,519
<i>L. fusca</i> .....	9,669	9,328	3,903	934	1,290
<i>L. rugosa</i> .....	0	1	5,967	8,483	7,628
<i>L. grandis</i> .....	83	4	59	12	959
<i>L. dubia</i> .....	20	6	7	547	111
<i>L. hirticula</i> .....	25	225	0	4	4
<i>L. gibbosa</i> .....	47	251	4	2	0
<i>L. ilicis</i> .....	33	173	19	10	0
<i>L. balia</i> .....	52	1	0	1	0
<i>L. tristis</i> .....	29	0	0	0	2
<i>L. nitida</i> .....	15	4	7	1	2
<i>L. implicita</i> .....	19	0	0	0	1
<i>L. marginalis</i> .....	3	1	30	0	0
Other species.....	5	6	4	6	3

(*L. vehemens*, *nova*, *prunina*, *inversa*, *villifrons*)

As will be seen by the accompanying table, there is a remarkable variation in distribution of species within a short distance of thirty or forty miles. Seventeen of the nineteen species known to occur in Wisconsin were taken in these traps. Mr. J. J. Davis adds *L. hornii* and *L. crenulata*<sup>1</sup>, collected at Baraboo June 2, 1914, and a specimen of *L. crenulata* from Milwaukee County is also in the Milwaukee Museum. Not less than 10,839 specimens were determined for any station, ranging upward to 16,847—at Baraboo. The entire catch at Ripon has been determined specifically.<sup>2</sup>

In this comparative table computed on a basis of 10,000 beetles, it is seen that *L. fusca* is more cosmopolitan than any other species and is dominant at Lancaster and Dodgeville. *L. rugosa* did not appear at Lancaster, the southwest station, but is dominant at the three northeasterly stations.

*L. implicita*, which was found most abundant by Dr. S. A. Forbes in Illinois in 1906, is rare at Lancaster and did not appear elsewhere except a lone specimen out of 14,519 determined from Ripon.

Only males of *L. gibbosa* and *L. nitida* were attracted to our lantern traps, and *L. tristis* also is but slightly attracted.

<sup>1</sup> After this paper was sent to the editor three specimens of *L. crenulata* were found in the trap collections from Baraboo.

<sup>2</sup> Much praise is due Mr. Neale F. Howard, now assistant at the Ohio State University, Mr. Stewart Chandler and Mr. T. T. Haack for their great care and painstaking efforts in determining all but a few of these specimens. The rarer species have been passed upon by Mr. J. J. Davis.

It will be noticed that several species almost disappear at the stations farther northeast, although *L. rugosa*, *dubia*, and *grandis* gain in numbers. An interesting record is the capture of *L. dubia* at Dodgeville, only previous to May 21, although the traps were run for another month. At Baraboo we took 92 per cent of the catch (377) of this species before the same date, thus indicating unusually early emergence.

#### LARGE TRAP PANS DESIRABLE

By surrounding the central pan, below the gas lantern, with six similar pans, it was found that 76.4 per cent of the beetles attracted to the light at Ripon, missed the central pan and were caught in the adjacent pans. It was found, also, that a pan placed on the side of the central pan toward the origin of flight caught twice as many beetles as a pan placed behind the light. The desirability of using as large a pan as possible is evident. There appeared to be no relative difference of sexes in the several pans.

An ordinary barn lantern used for the trap was found to be practically worthless when used less than 100 yards distant from one of the gasoline lights, but when used alone at some considerable distance caught a fair amount of beetles approximating 30 to 35 per cent of the efficiency of the gasoline light.

At the Lancaster station the direction of flight was always from the northwest toward the southeast. This phenomenon can possibly be explained by the fact that the flight seemed to be directed up a valley at the head of which was a fair-sized grove of trees, principally oak, ash and walnut. Another small valley diverging from the first was treeless and there the catch was very light, whereas in the adjoining small valley with trees available the catch was many times larger. Traps near the margin of woods or close to a fringe of trees were in all cases most successful and doubly efficient.

#### ECONOMIC RESULTS

Any attempt to draw close conclusions on the beneficial results of the capture of these large numbers of beetles in 1914 would be undesirable and the resulting judgment inaccurate, owing to the nature of the season the following year. The heavy and frequent rains of 1915, accompanied by exceptionally low temperatures, resulted in retarded and weak crops.

Mr. W. A. Johnson, who was in immediate charge of the lanterns at Lancaster, states he feels certain, after constant observation throughout the summer of 1915, that the destruction of more than 440,000 beetles on his farm has served as considerable protection for his

crops. He reports that his corn was not noticeably injured, although a few grubs were present in the soil, while many of his neighbors' corn-fields were severely damaged. The only loss which he noted was on a far side of the farm where potatoes were injured somewhat. Too much emphasis must not be laid on this fairly accurate observation, because the grubs were destroyed in considerable numbers by diseases, aided by the damp weather. Had this summer been a normal season, we feel that a fair estimate of value of the experiments could have been made.

At Lancaster, where fifteen light traps were running, it is estimated that under ordinary farm conditions where help is comparatively cheap, the total cost of operation of the lights, exclusive of the initial expense of lights and pans, would not exceed twenty-five or thirty cents a day for the entire period. It is further evident with the knowledge that we have of the small flights of beetles in temperatures under 66° F., the cost of operation could be materially reduced by omitting the lights on nights of low temperature.

#### THE PROPORTION OF SEXES

Altogether our records show that the numbers of males caught greatly exceed the females, it is possible that some other reason may be attributed to this fact rather than the smaller degree of attractiveness to lights in the females. It may be possible that normally there are larger numbers of males than females.

It may be argued that the catch of such a small proportion of females would militate against the success of light traps in economic control, but again, if the beetles are polyandrous, as has been suggested by some entomologists, there may be an unexpected advantage in catching such a large number of the males.

Our records further show that with the more common species the females form a larger percentage of the catch in the earlier part of the season.

On the whole, this question of possible control of the white grub pest by trapping of the adult beetles must receive much further attention and consideration before any definite recommendations can be made.

#### BIOLOGICAL EXPERIMENTS

The following experiments were undertaken in order to learn as much of the normal life of white grubs as possible. No investigations seem to have been made heretofore on the activities of any underground animals in their natural environment. For this reason the only control measures which have been suggested in the past are

partially empirical and partially based on very meagre information. This report is preliminary and the more promising lines of work will be continued. Attempts will also be made, where possible, to apply the results in a practical way.

In these experiments we tried to find out whether white grubs had daily or seasonal habits, such as those of cutworms, what was their relation to temperature and to moisture, what foods they would eat, and what part of the plants they preferred. Efforts were also made to control them by stomach poisons, contact insecticides, and repellents. No work was done with fumigants as this phase of the subject has been carefully studied by previous workers.

Two forms of cages were used, most of the work being done with ordinary flower pots. In working with this type of cage, which Davis has found to be most satisfactory for rearing the grubs, it is necessary to empty the flower pot at each examination. In all cases where continuous observations seemed desirable, glass cages (Fig. 12) were used in which the earth was placed between two vertical glass plates less than one-half inch apart. Opaque shields were used to keep out the light except at the moment the grubs were examined. It was found possible to regulate the distance between the glass plates so that any size of grub could be seen from at least one side at any time and still leave sufficient freedom for the grubs to move actively back and forth. When young corn plants were placed in the soil between the plates, the roots were readily eaten and usually completely destroyed.

The experiments may be divided into seven groups, all the important results so far secured being given below:

1. It was found that grubs have no daily migration, such as cutworms. They were never observed either eating or active late in the evening, early in the morning, or on cold days. Their movements reached the maximum during the heat of the day. There does not seem to be a vertical migration in relation to temperature changes, the larvæ in sod usually remaining close to the surface of the soil at all times but moving about and feeding only during warm weather.

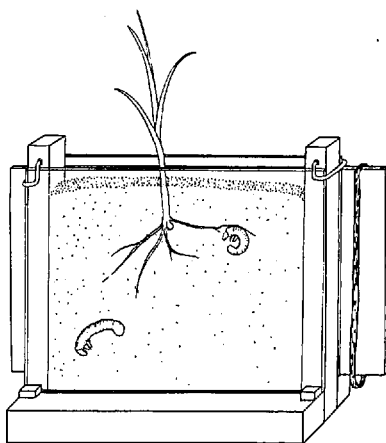


Fig. 12. Cage for Biological Studies of White Grubs.



The effective temperature of the soil seemed to be between 60° and 65° F., for when it was colder than this they did not move in the soil, did not feed, and scarcely made any resistance to handling.

2. Their food was found to consist, so far as observed, of the roots of plants only, or the fragments of these roots. They were never seen eating or manifesting any interest in any form of sweetened bran, dough or flour paste. In sprouting seed they uniformly ate the radicle and left the caulicle unharmed. This is also apparently true in the case of strawberries in the field, even when they have been planted so deeply as to cover the petioles of the leaves. In the case of grass it is more difficult to be certain of this habit.

3. Grubs were reared in flower pots containing moist garden soil with no apparent food from May 5 to July 18; the soil was then allowed to dry and on the 22d of October two larvæ were still found emaciated but alive and active in soil almost completely desiccated. The grubs then succeeded in living on minute root fragments and other humus in the soil for five and one-half months, of which the last three were passed in almost bone-dry surroundings. Under these circumstances, starvation methods of controlling them are proven impracticable.

4. Poison bran mash was found to be valueless against the grubs whether drilled into the earth above or below the larvæ or placed on its surface. This is, of course, due to the fact that they will not eat the bran.

5. In several experiments, including about forty grubs, grass roots were shaken free from earth, dipped in various arsenicals, and planted, in an attempt at poisoning the grubs. The use of sodium arsenite in this way, in the proportion of five pounds to fifty-four gallons of water, resulted in killing six larvæ out of a total of twenty-seven subject to poisoning, a mortality of 22.2 per cent in four days. No injury to the grass was observed. Attempts to accomplish the same results with lead arsenate in the proportion of five pounds of the paste to fifty gallons of water were unsuccessful. Corrosive sublimate used in the same way on a small corn plant caused a mortality of 50 per cent, but not in time to save the plant, as the roots were entirely eaten away by the grubs.

6. Kerosene emulsion and Black Leaf "40," in their ordinary strengths, did not affect the larvæ in the least when the soil was saturated with these solutions.

7. Professor H. T. Fernald a few years ago reported the successful use for two seasons of a repellant of tar on seed corn in preventing the attack of wireworms. Several repellants were tried in the experiments here being reported, but the only one which did not injure the



plant was creosote. Grubs apparently avoided the region where corn seed which had been dipped in creosote had been planted and did not attack the young corn which sprouted from it. These results, however, had not been anticipated and have not yet been followed up.

In connection with the insecticide experiments it should be stated that of the sixty-three larvæ which were reared in the flower pots, but on which no experiments were tried, ten died of bacterial or other diseases within forty days. This gives an average mortality in the check pots of 15.9 per cent for the six weeks.

In conclusion, it may be stated that the results in connection with temperature and the nature of the food supply seemed most significant. It is also of interest to note that white grubs are not immune from arsenical poisoning as wireworms have been said to be, and that there is a possibility that repellants will prove of some value in controlling them.

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## A PROGRESS REPORT ON WHITE GRUB INVESTIGATIONS<sup>1</sup>

By JOHN J. DAVIS, *U. S. Bureau of Entomology, West Lafayette, Indiana*

The white grub (*Lachnosterna*) investigation was begun at the Lafayette Station of the federal Bureau of Entomology in 1911 and has been one of the major problems of this station continuously since that date. The report herewith presented is very brief and but an outline of some of the more important studies made by the writer or under his direction and is given at this time as a guide for those in the federal Bureau as well as station and state entomologists who are coöperating with us in this large problem and for others who are or may have occasion in the near future to take up this problem.

The plan and scope of our studies are comprehensive in the broadest sense, including not only life-histories and habits of the different species of *Lachnosterna* and means of control in this section of the United States but studies in the embryology, the distribution of species in all parts of the country in relation to soil, timber, farming methods and other environmental conditions, destructive broods of different species, systematics, etc., as well as thorough studies of the related genera, with especial reference to the economic importance and life-history of these related genera and means of distinguishing the larvæ of the different genera and of the different species in each genus. It is hoped eventually to have worked out the life-history and habits of every species of *Lachnosterna* and species of related genera for the various localities where each may occur.

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<sup>1</sup> Published by permission of the Chief of the U. S. Bureau of Entomology.