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A STUDY OF THE ECOLOGY AND REACTIONS
OF FOUR SPECIES OF ACRIDIDAE

BY

HARRY LEE ANDREWS
A.B. University of Illinois, 1916

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

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IN

THE GRADUATE SCHOOL

OF THE

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1918

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THE GRADUATE SCHOOL

Dec. 15 1917.

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-
VISION BY Harry Lee Andrews.

ENTITLED A Study of the Ecology and Reactions
of Four Species of Acrididae.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
DEGREE OF Master of Arts.

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	page
I. INTRODUCTION - - - - -	5
II. LOCALITIES STUDIED - - - - -	6
1. Brook Margin Association - - - - -	5
2. Clay-Band Association- - - - -	5
3. Sweet Clover Association - - - - -	7
4. Temporary Marsh Association- - - - -	8
III. OBSERVATIONS IN ENVIRONMENT- - - - -	8
IV. EXPERIMENTAL RESULTS - - - - -	11
1. Reactions to Light - - - - -	11
(a) Intensity and Direction- - - - -	14
(b) to Colors- - - - -	17
2. Reactions to Surface - - - - -	18
3. Reactions to Temperature - - - - -	20
4. Reactions to Gravity - - - - -	22
(a) Orientation- - - - -	22
5. Experiments in Evaporating	
Power of Air - - - - -	24
V. CONCLUSIONS - - - - -	26
VI. ACKNOWLEDGMENTS AND BIBLIOGRAPHY - - - - -	28

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A STUDY OF THE ECOLOGY AND
REACTIONS OF FOUR SPECIES
OF ACRIDIDAE.

I. INTRODUCTION.

The material here presented is based on field observations and laboratory study during the past two summers on four species of Acrididae. In an attempt to make a census of the animal population of a plot of ground, my attention was called to the predominance of Orthopteran life. Field observations revealed not only variety in species and predominance in number of individuals of this order, but also a tendency towards segregation of species into associations.

Many attempts have been made in connection with taxonomic papers to list Orthoptera according to the vegetation upon which they are found, and to explain their distribution as due to the distribution of their food plants.

It is the purpose of this paper to call attention to some environmental relations of greater ecological importance than food, thus accounting for the formation of associations in terms of behavior.

The first part of the history of the
people of the world is the history of the
creation of the world and the
creation of man. The second part
is the history of the world from the
creation of man to the present time.
The third part is the history of the
world from the present time to the
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future.

II. LOCALITIES STUDIED.

The area studied is located one mile north of Urbana along a drainage ditch. The soil is clay having been placed there in the digging of the ditch. Four distinct stations were studied.

First, the brook margin or a narrow strip of land bordering the creek supported a luxuriant growth of willows, smart-weed, cockle-burrs and water grass.

Second, the clay bank which consisted of a rather steep slope at the base of which was a regular incline adjoining the brook margin. The vegetation here was sparse. An occasional wild lettuce plant, a scrubby growth of rag-weed, and now and then a small patch of rather dwarfed white clover struggled for existence. Near the top of the steep slope was overhanging sod and an occasional piece had moved down the bank by slumping.

Third, the top of the bluff or the sweet clover association was almost level. On the ground stratum was largely blue-grass supporting also a rank upper growth of sweet clover, wild lettuce, burdocks and thistles.

Fourth, farther down at a turn in the stream was a temporary marsh or mud bank exposed only at low water, and hence supporting no vegetation except water grass. Here much debris and sediment had been deposited by occasional floods.

1. Brook Margin Association.

Each region had its predominating specie. On the brook margin were found nymphs of all sizes and adults of Melanoplus differentialis. Besides M. differentialis was an occasional M. bivittatus, a few forked tailed katydids (Scudderia furcata), a few short horned locusts (Orphuella speciosa), and the short winged green locust (Dichromorpha viridis). The dense growth and moist ground formed a cool habitat. The M. differentialis were by far in the majority in numbers. The above named varieties were found occasionally while M. differentialis were on every stem. The nymphs chose the ground stratum and flat leaf surfaces, while the adults were perched on the largest stems. When frightened they moved to the opposite side of the stems, usually flying to another stem about three or four feet away then dropping into the tall grass soon becoming concealed. They are poor flyers usually moving by combination of jump and flight.

2. Clay-Bank Association.

The clay bank had its distinctive population. Dissosteira carolina predominated. A few locusts (Psiniidia fenestralis) were observed in this habitat. Their yellowish color closely resembling the clay back-ground afforded excellent protection. D. carolina seem to collect in small groups. While

catching them for study in the laboratory, I found that from three to five, sometimes eight were usually near together. When one flew up on my approach, the others seemed to take warning, the others following closely the flight of the first to a distance sometimes ten feet away or further. When in groups they do not fly such great distances when pursued as when alone. The females are more solitary than the males. Observing several of these small groups, I found them to contain all males. This and other observations, I am inclined to believe that the males are somewhat more gregarious.

When any object approaches they fly up alighting only a few feet away with head pointing toward the approaching danger. If danger follows they fly greater distances, each time flying higher alighting a much greater distance away. D. Carolina make much less resistance when captured than the other forms. They seldom emit the so called "tobacco juice."

I observed one male making a rather spectacular flight. It flew upwards about six feet and rapidly vibrating its wings it was able to remain almost stationary for a few seconds. I observed others in such flights but were unable to capture them in order to determine whether the movements were made by both males and females.

Dissosteira carolina have very good eyesight for seeing objects ahead or at the side. They are able to distinguish objects approaching at a distance of ten or twelve feet. On one occasion a large burdock quite concealed me from the locusts view. I approached sufficiently close to have captured it with

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my hand. Another instance one alighted in a gully, alighting head downward on the slope. I was able to approach within two feet without being seen.

3. Sweet Clover Association.

In the sweet clover association nymphs and adults of Melanoplus femur rubrum were in excess. A sweep of the net would capture an occasional cone-head (Conecephalus robustus), and a few forked-tailed katydids (Scudderia furcata). I also found one oblong winged katydid (Amblycorpha oblongifolia). M. femur rubrum were in great majority. The nymphs by hundreds populated the ground and lower strata. Medium sized nymphs were more venturesome and were usually found on plants that were one-half to a foot high. They were most numerous on the broad leaves of the thistle. The adults were usually on the stems in the very tall sweet clover plants. They were very timid, and upon approach took the opposite side of the stems. Testing them with crude devices in the field, I am inclined to believe that M. femur rubrum depend much upon eyesight rather than hearing to tell the approach of danger. If approached directly from the side or above, they fly when one is within four or five feet, but when approached from below it is an easy matter to collect them by hand.

It is interesting to watch their methods of alluring their pursuers. Frequently, they will jump and proceed by flying a yard or two to another plant. They at once try to conceal themselves by crawling to the opposite side of the stem. Many times they will drop to the ground and by crawling a short distance in

the grass are safely concealed. In case they are discovered in this hiding place, it is interesting to note how easily they are captured. They seldom make any attempt to escape, and remain quiet until picked up. As soon as danger has passed, they crawl to the nearest plant and are soon in their former positions.

When danger approaches the flight of one grass-hopper seems to warn others. I have counted fifteen to twenty grass-hoppers in retreat. In all cases observed, I am sure the retreating followers were sufficiently far away that they did not detect my approach. They always follow in the direction of the first.

4. Temporary Marsh Association.

On the temporary marsh were found many Tetrix granulata. They inhabit the ground stratum. They are poor fliers usually escaping their pursuers by a hop combined with flight. They hop only a short distance, perhaps a foot. Their close resemblance to the ground and by crawling under the debris, they are not easily observed.

III. OBSERVATIONS IN ENVIRONMENT.

Grasshoppers have their enemies and diseases. During the early part of my observations, I found several grasshoppers affected with fungus disease. They had usually crawled to the tops of plants taking a firm grasp and were found hanging where they had died. Many of the specimens kept in the cage in the

1870	Jan 1	1000
1871	Feb 1	1000
1872	Mar 1	1000
1873	Apr 1	1000
1874	May 1	1000
1875	Jun 1	1000
1876	Jul 1	1000
1877	Aug 1	1000
1878	Sep 1	1000
1879	Oct 1	1000
1880	Nov 1	1000
1881	Dec 1	1000
1882	Jan 1	1000
1883	Feb 1	1000
1884	Mar 1	1000
1885	Apr 1	1000
1886	May 1	1000
1887	Jun 1	1000
1888	Jul 1	1000
1889	Aug 1	1000
1890	Sep 1	1000
1891	Oct 1	1000
1892	Nov 1	1000
1893	Dec 1	1000
1894	Jan 1	1000
1895	Feb 1	1000
1896	Mar 1	1000
1897	Apr 1	1000
1898	May 1	1000
1899	Jun 1	1000
1900	Jul 1	1000

laboratory died similarly. Sometimes a grasshopper in random flight will become entangled in a spider web. I noticed many cases where spiders seemed to lay in waiting in their beautifully constructed webs, for such accidental happenings to take place, rushing out on the trespasser and proceeding to entangle him further. M. femur rubrum meet this death frequently. I have also found large M. diffidentalis and M. bivittatus entangled.

I found wasps capturing nymphs, and carrying them away. Locusts are also victims of Diptera parasites. While keeping some live specimens in vials for identification two large Dipterus larvae crawled out of the posterior end of a M. diffidentalis. The locust seemed very sluggish when I placed it in the vial and died soon after the larvae had left the body.

Moulting is an interesting process and very easily observed both in the field and in the laboratory cages. It is a much easier and a more rapid process in the large sized nymphs than in the small nymphs. One small nymph became very sluggish during an experiment. As its actions were not normal, it was removed from the experiment pan. It soon began moulting which process was long and tedious. It worked and struggled for one and one-half hours. Later observation showed that it had not been able to extricate itself but had died in the process. Large nymphs observed moulting in the field attach the claws of the third pair of legs to a twig and hanging head downward, the process soon begins and is completed in about twenty minutes. The observed extremes were eight and thirty-two minutes.

The observation that certain species of insects are

commonly found in the same associations as certain plants, does not justify the conclusion that the insects are there because they feed upon the plants. Looking into the habitat, we find nymphs and adults choosing different strata, different positions, different food plants. Such observations have led to experimental work in order to interpret the relation of animals in their normal environments in terms of their physiological constitutions.

No.	Name	Age	Sex
1	John Smith	25	M
2	Mary Jones	22	F
3	James Brown	30	M
4	Elizabeth White	28	F
5	Robert Black	35	M
6	Sarah Green	20	F
7	William Grey	40	M
8	Anna Lee	24	F
9	Thomas King	32	M
10	Jane Hall	26	F
11	Charles Adams	38	M
12	Elizabeth Clark	21	F
13	George Baker	33	M
14	Margaret Wilson	29	F
15	Richard Scott	31	M
16	Ann Taylor	23	F
17	Henry Moore	36	M
18	Rebecca Hill	27	F
19	Samuel Young	34	M
20	Jessie King	25	F
21	Benjamin Hall	39	M
22	Lucy Adams	22	F
23	Edward Clark	37	M
24	Frances Baker	20	F
25	John Wilson	41	M
26	Mary Scott	28	F
27	Robert Taylor	35	M
28	Sarah Moore	24	F
29	William Hill	32	M
30	Anna Young	26	F
31	Thomas King	30	M
32	Jane Hall	23	F
33	Charles Adams	38	M
34	Elizabeth Clark	21	F
35	George Baker	33	M
36	Margaret Wilson	29	F
37	Richard Scott	31	M
38	Ann Taylor	23	F
39	Henry Moore	36	M
40	Rebecca Hill	27	F
41	Samuel Young	34	M
42	Jessie King	25	F
43	Benjamin Hall	39	M
44	Lucy Adams	22	F
45	Edward Clark	37	M
46	Frances Baker	20	F
47	John Wilson	41	M
48	Mary Scott	28	F
49	Robert Taylor	35	M
50	Sarah Moore	24	F
51	William Hill	32	M
52	Anna Young	26	F
53	Thomas King	30	M
54	Jane Hall	23	F
55	Charles Adams	38	M
56	Elizabeth Clark	21	F
57	George Baker	33	M
58	Margaret Wilson	29	F
59	Richard Scott	31	M
60	Ann Taylor	23	F
61	Henry Moore	36	M
62	Rebecca Hill	27	F
63	Samuel Young	34	M
64	Jessie King	25	F
65	Benjamin Hall	39	M
66	Lucy Adams	22	F
67	Edward Clark	37	M
68	Frances Baker	20	F
69	John Wilson	41	M
70	Mary Scott	28	F
71	Robert Taylor	35	M
72	Sarah Moore	24	F
73	William Hill	32	M
74	Anna Young	26	F
75	Thomas King	30	M
76	Jane Hall	23	F
77	Charles Adams	38	M
78	Elizabeth Clark	21	F
79	George Baker	33	M
80	Margaret Wilson	29	F
81	Richard Scott	31	M
82	Ann Taylor	23	F
83	Henry Moore	36	M
84	Rebecca Hill	27	F
85	Samuel Young	34	M
86	Jessie King	25	F
87	Benjamin Hall	39	M
88	Lucy Adams	22	F
89	Edward Clark	37	M
90	Frances Baker	20	F
91	John Wilson	41	M
92	Mary Scott	28	F
93	Robert Taylor	35	M
94	Sarah Moore	24	F
95	William Hill	32	M
96	Anna Young	26	F
97	Thomas King	30	M
98	Jane Hall	23	F
99	Charles Adams	38	M
100	Elizabeth Clark	21	F

IV. EXPERIMENTAL RESULTS.

1. Reactions to Light.

A great number of experiments were carried on in the field and laboratory in studying light and its effects. The apparatus used has been described by Shelford ('17). It consists of pans 10x30 centimeters at the bottom with slightly larger tops and about 7 cm. deep, painted black. Glass tubes with hemispherical ends and caps were used for containers. One third of the inside circumference which is placed downward is painted black. A cover with an adjustable slit was used to allow bright light, medium light, and shade divisions to strike the container.

In the experiments usually five or ten grasshoppers were used. Readings were recorded every five minutes until twenty had been taken. In cases where data did not seem conclusive five experiments were run and averages made. In other cases only the most representative data will be given.

Experiments in phototaxis show that grasshoppers do not all exhibit the same responses. One species may respond in one way, another in another manner. nymphs may react very differently than the adults of the same species. In tests with adults of Melanoplus femur rubrum, Diosostiera carolina, and Melanoplus differentialis, D. carolina and M. femur rubrum were positive to light while M. differentialis was negative.

<u>D. carolina</u>		<u>M. femur rubrum</u>		<u>M. differentialis</u>	
Light	Dark	Light	Dark	Light	Dark
69%	31%	66%	34%	32%	68%

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It is noticeable that the nymphs of M. femur rubrum and D. carolina do not respond to light as do the adults, but in both species the adults are found to be positive and the nymphs negative.

Adult M. femur rubrum

Light	Dark
66%	34%

Nymphs of M. femur rubrum

Light	Dark
38%	62%

Adult D. carolina

Light	Dark
72%	28%

Nymphs of D. carolina

Light	Dark
40%	60%

It is significant that the difference in reaction between the nymphs and adults of these two species corresponds with the difference in light conditions in the localities in which the two stages are found. Thus the adults of M. femur rubrum were usually exposed to light on the tops of the stalks of sweet clover, while the nymphs were hidden on the under sides of the leaves of plants of the low growth or among the grasses. Similarly the adults of D. carolina were found on the bare clay banks exposed to the direct rays of the sun. While the nymphs were invariably found in the partially protected situations formed by sparse growth of clovers, rag-weed, and similar vegetation near the foot of the clay bank.

In contrast to the above two species, the nymphs and adults of M. differentialis are alike in their response to light both being negative.

Adult M. differentialis

Light	Dark
42%	58%

Nymphs of M. differentialis.

Light	Dark.
30%	70%

Here again the responses under experimental conditions are what would be expected from the character of their habitat for both nymphs and adults are confined to conditions of moisture and shade.

Experiments in direct light when heat becomes a factor as was the case of some experiments run at noon, show a negative reaction toward light in all species tested except Dissostiera carolina. When heat became intense the adults of this species died. None of the nymphs died. (This would indicate that the nymphs were able to stand greater temperatures than the adults.

Name	Age	Sex	Occupation
John Smith	25	Male	Farmer
Mary Jones	22	Female	Homemaker
Robert Brown	30	Male	Teacher
Elizabeth White	28	Female	Nurse
James Wilson	35	Male	Engineer
Sarah Davis	20	Female	Student
Thomas Miller	40	Male	Doctor
Anna Taylor	24	Female	Artist
Charles Moore	32	Male	Lawyer
Margaret Clark	26	Female	Writer
William Lewis	38	Male	Scientist
Jennifer Adams	18	Female	Student
Michael Baker	27	Male	Musician
Lisa Green	23	Female	Designer
David King	33	Male	Historian
Michelle Scott	21	Female	Student
Christopher Hill	31	Male	Architect
Amanda Young	29	Female	Translator
Daniel Allen	36	Male	Economist
Nicole Evans	25	Female	Journalist

(3) Intensity and Direction.-- Experiments in intensity and direction were performed in the dark room in the Vivarium with the Yerkes light grader, (described by Shelford '14). It was found that in some cases the nymphs and adults of a species react alike, while in others the reactions are reversed. The number of grasshoppers used and readings taken were the same as in former light experiments.

<u>Melanoplus femur rubrum</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Very small nymphs	40	60	42	58
Second & third stage	54	66	40	60
Last stage	72	28	76	24
Adults	64	36	62	38

Small nymphs of M. femur rubrum are negative to direction and intensity. Adults are positive to direction and intensity.

<u>Melanoplus differentialis</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Very small nymphs	44	56	24	76
Second & third stage	38	62	28	72
Last stage	54	66	48	52
Adult	32	68	46	54

Nymphs and adults of M. differentialis are negative to direction and intensity. Adults are less negative to direction, nymphs are less negative to intensity.

<u>Dissosteira carolina</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Nymphs	88%	12%	76%	24%
Adults	64%	36%	66%	34%

Both nymphs and adults of D. carolina are strongly positive to both intensity and direction.

<u>Tetrix granulata</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Adults	51%	- 49%	25% - 75%	

Tetrix granulata is somewhat indifferent to direction but negative to intensity.

No experiments were performed with nymphs of Tetrix granulata because the early stages of this form were not available at the time this work was in progress.

Here, again as in case of the experiments on phototaxis, we find an exact correlation between the reaction of the insects and the conditions in the habitat in which they occur.

1870	Jan 1	1870	1870
1871	Jan 1	1871	1871
1872	Jan 1	1872	1872
1873	Jan 1	1873	1873
1874	Jan 1	1874	1874
1875	Jan 1	1875	1875
1876	Jan 1	1876	1876
1877	Jan 1	1877	1877
1878	Jan 1	1878	1878
1879	Jan 1	1879	1879
1880	Jan 1	1880	1880
1881	Jan 1	1881	1881
1882	Jan 1	1882	1882
1883	Jan 1	1883	1883
1884	Jan 1	1884	1884
1885	Jan 1	1885	1885
1886	Jan 1	1886	1886
1887	Jan 1	1887	1887
1888	Jan 1	1888	1888
1889	Jan 1	1889	1889
1890	Jan 1	1890	1890
1891	Jan 1	1891	1891
1892	Jan 1	1892	1892
1893	Jan 1	1893	1893
1894	Jan 1	1894	1894
1895	Jan 1	1895	1895

(b) Reactions to Colors.-- An attempt was made to find out reactions of grasshoppers to the different colors of the spectrum in order of phototropic power. A cover for the container was made from colored gellatine sheets and arranged in the order,-- violet, blue, green, yellow, orange, and red. The light was furnished by a forty watt Mazda.

COLOR TESTS.

	Adults						Nymphs					
	V.	B.	G.	Y.	O.	R.	V.	B.	G.	Y.	O.	R.
<u>Melanoplus femur rubrum</u>	0	7	28	46	2	17	5	7	29	24	16	19
<u>Melanoplus differentialis</u>	12	12	15	19	16	28	1	10	19	12	33	25
<u>Dissosteira carolina</u>	12	10	50	26	13	9	17	13	39	13	12	6

There is a general preference for green and yellow in both nymphs and adults of Melanoplus femur rubrum and Dissosteira carolina. The nymphs and adults of Melanoplus differentialis prefer orange and red. This is in agreement with other light reactions in which insects prefer shade or darkness.

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<p>Printed by</p> <p>W. L. G. & Co.</p> <p>1861</p>	<p>Price</p> <p>10s</p>

2. Reactions to Surface

Field observations show that grasshoppers vary in the kinds of resting places which they choose. There is a distinct difference in the species as well as a difference in adults and nymphs of a species. For example, Dissosteira carolina alights on the bare ground, Melanoplus differentialis usually on stems. The nymphs of M. differentialis or M. femur rubrum are usually found on leaf surfaces, while the adults prefer stems. Experiments testing this point were carried on using the apparatus described by Shelford '17. As stimuli I used square sticks of mint, round stems of plants, strips of corrugated paper, rice, pebbles, quartz, and sand. The readings were taken as in the light tests.

<u>D. carolina</u>		<u>M. femur rubrum</u>		<u>M. differentialis</u>	
Smooth surface	Sticks	Smooth surface	Sticks	Smooth surface	Sticks
78%	22%	44%	56%	32%	68%

D. carolina showed no preference for the sticks. They crawled over the sticks, always taking the smooth surface of the pan in preference to crawling on the sticks. Femur rubrum always followed the sticks after coming in contact with them. In very few cases did M. femur rubrum walk on the smooth surfaces of the pan. M. differentialis also showed a decided preference for the

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sticks. In experiments in which I used large, small, and square sticks, M. differentialis seemed very active when on sticks of small circumference, but became very quiet when on sticks of larger circumference.

In experiments with nymphs and adults of M. femur rubrum in which mica was used as a stimulus, I found that the adults showed a preference for the bits of mica. They would crawl from the bits of mica to the smooth surface, immediately turn around and become quiet on the rough surfaces of the mica. The nymphs seemed to show little preference for the mica.

Adults M. femur rubrum

Mica smooth surface

72% 24%

Nymphs M. femur rubrum

Mica smooth surface

56% 44%

I next tested nymphs and adults with sticks of corrugated paper, square stems of mint, and triangular sticks of wood.

Adults M. femur rubrum

Sticks smooth surface

34% 36%

Nymphs M. femur rubrum

Sticks smooth surface

52% 66%

The adults prefer the round surfaces, the nymphs the flat.

3. Reactions to Temperature.

Temperature plays an important part in the life of a grasshopper--some choosing cool shaded habitats, others dry barren places.

In the experiments gradients were established and maintained by placing two pans on the water table and allowing hot water to flow into one, cold into the other. A third pan was set across these two so as to allow the water to come in contact with the cold at one end and the hot at the other, (Shelford '17). Sand and black dirt were used as a floor in the pan. Temperatures of 50° C. (hot) and 25° C. (cold) were maintained.

Adults M. femur rubrum

hot 50° cold 25°

57%

25%

Nymphs M. femur rubrum

hot 50° cold 25°

46%

54%

The nymphs were very inactive and were easily contented in either temperature. All experiments showed a slight preference for cool temperatures. Nymphs of Differentialis were most negative to heat.

I next subjected adults to the same temperatures.

Name		Age		Sex		Occupation		Address		Remarks	
John	Smith	25	18	M	F	Farmer	Teacher	123 Main St.	456 Oak St.		
James	Johnson	30	22	M	F	Merchant	Physician	789 Elm St.	321 Pine St.		
William	Williams	40	35	M	F	Engineer	Lawyer	567 Cedar St.	210 Birch St.		
Robert	Roberts	20	15	M	F	Student	Student	987 Maple St.	654 Spruce St.		
Thomas	Thomas	50	45	M	F	Minister	Minister	135 Willow St.	876 Poplar St.		
Charles	Clark	35	30	M	F	Artist	Artist	246 Hickory St.	789 Ash St.		
Edward	Edwards	28	23	M	F	Writer	Writer	345 Sycamore St.	123 Walnut St.		
George	Green	45	40	M	F	Doctor	Doctor	456 Chestnut St.	567 Elm St.		
Henry	Harris	38	33	M	F	Engineer	Engineer	678 Maple St.	901 Oak St.		
John	Hunter	22	17	M	F	Student	Student	890 Pine St.	234 Birch St.		
William	Hyatt	55	50	M	F	Minister	Minister	101 Cedar St.	321 Spruce St.		
Robert	Hubbard	32	27	M	F	Artist	Artist	432 Elm St.	654 Ash St.		
Thomas	Hughes	27	22	M	F	Writer	Writer	543 Maple St.	765 Walnut St.		
Charles	Hicks	42	37	M	F	Doctor	Doctor	654 Cedar St.	876 Elm St.		
Edward	Hill	37	32	M	F	Engineer	Engineer	765 Maple St.	987 Oak St.		
George	Holmes	23	18	M	F	Student	Student	876 Pine St.	123 Birch St.		
Henry	Holmes	52	47	M	F	Minister	Minister	987 Cedar St.	234 Spruce St.		
John	Holmes	33	28	M	F	Artist	Artist	101 Elm St.	321 Ash St.		
William	Holmes	28	23	M	F	Writer	Writer	212 Maple St.	432 Walnut St.		
Robert	Holmes	43	38	M	F	Doctor	Doctor	323 Cedar St.	543 Elm St.		
Thomas	Holmes	38	33	M	F	Engineer	Engineer	434 Maple St.	654 Oak St.		
Charles	Holmes	23	18	M	F	Student	Student	545 Pine St.	765 Birch St.		
Edward	Holmes	53	48	M	F	Minister	Minister	656 Cedar St.	876 Spruce St.		
George	Holmes	33	28	M	F	Artist	Artist	767 Elm St.	987 Ash St.		
Henry	Holmes	28	23	M	F	Writer	Writer	878 Maple St.	123 Walnut St.		
John	Holmes	43	38	M	F	Doctor	Doctor	989 Cedar St.	234 Elm St.		
William	Holmes	38	33	M	F	Engineer	Engineer	100 Maple St.	321 Oak St.		
Robert	Holmes	23	18	M	F	Student	Student	211 Pine St.	432 Birch St.		
Thomas	Holmes	53	48	M	F	Minister	Minister	322 Cedar St.	543 Spruce St.		
Charles	Holmes	33	28	M	F	Artist	Artist	433 Elm St.	654 Ash St.		
Edward	Holmes	28	23	M	F	Writer	Writer	544 Maple St.	765 Walnut St.		
George	Holmes	43	38	M	F	Doctor	Doctor	655 Cedar St.	876 Elm St.		
Henry	Holmes	38	33	M	F	Engineer	Engineer	766 Maple St.	987 Oak St.		
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William	Holmes	53	48	M	F	Minister	Minister	988 Cedar St.	234 Spruce St.		
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Henry	Holmes	28	23	M	F	Writer	Writer	212 Maple St.	432 Walnut St.		
John	Holmes	43	38	M	F						

<u>D. carolina</u>		<u>M. femur rubrum</u>		<u>M. differentialis</u>	
Hot 50°C.	cold 25°C.	Hot 50°C.	cold 25°C.	Hot 50°C.	cold 25°C.
84%	10%	60%	40%	28%	72%

D. carolina moved out of the cool region in the pan and became inactive in the warm area. M. differentialis was much agitated upon coming into the warm area. They would either turn directly around moving to the cool area, or jump ahead into the warm sand moving about actively, finally finding their way out or jumping to the cool area. M. femur rubrum were not so active as either D. carolina or M. differentialis. They are slightly positive to heat. Adult specimens of M. femur rubrum when subjected to high temperatures die much before the nymphs seem to show any signs of agitation.

4. Reactions to Gravity.

Experiments in geotaxis did not show very decided results. M. femur rubrum and M. differentialis are undoubtedly negatively geotactic. Phototactic stimuli seem to be greater in effect, consequently altering the grasshoppers response to gravity.

M. femur rubrum and M. differentialis crawl up the stems and upon reaching the top they jump usually alighting on the ground sometimes on a stem that is nearer the surface than the former position. They then proceed to crawl up again. Tests in which I used D. carolina indicate a decided positive geotactic response. This species which in nature is found on the ground remain on the floor of the container.

(a) Orientation.-- Grasshoppers usually orient head upward on the stem. I placed M. femur rubrum in a cylindrical wire cage. Laying the cage on the side, the grasshopper took a position on the end of the cylinder with the head upward. As the cage rotated, the grasshopper moved, always walking in a circle and always keeping the head upward. When the cage was moved faster than the grasshopper's rate of movement, it would jump to another position in the cage. The test was made in several specimens, all of which responded in the same way, always moving in a circle and moving in the direction that the cage was rotated.

<p>THE</p> <p>LIBRARY</p> <p>OF THE</p> <p>UNIVERSITY OF</p> <p>CHICAGO</p>		<p>1891</p> <p>1892</p> <p>1893</p> <p>1894</p> <p>1895</p> <p>1896</p> <p>1897</p> <p>1898</p> <p>1899</p> <p>1900</p> <p>1901</p> <p>1902</p> <p>1903</p> <p>1904</p> <p>1905</p> <p>1906</p> <p>1907</p> <p>1908</p> <p>1909</p> <p>1910</p> <p>1911</p> <p>1912</p> <p>1913</p> <p>1914</p> <p>1915</p> <p>1916</p> <p>1917</p> <p>1918</p> <p>1919</p> <p>1920</p> <p>1921</p> <p>1922</p> <p>1923</p> <p>1924</p> <p>1925</p> <p>1926</p> <p>1927</p> <p>1928</p> <p>1929</p> <p>1930</p> <p>1931</p> <p>1932</p> <p>1933</p> <p>1934</p> <p>1935</p> <p>1936</p> <p>1937</p> <p>1938</p> <p>1939</p> <p>1940</p> <p>1941</p> <p>1942</p> <p>1943</p> <p>1944</p> <p>1945</p> <p>1946</p> <p>1947</p> <p>1948</p> <p>1949</p> <p>1950</p> <p>1951</p> <p>1952</p> <p>1953</p> <p>1954</p> <p>1955</p> <p>1956</p> <p>1957</p> <p>1958</p> <p>1959</p> <p>1960</p> <p>1961</p> <p>1962</p> <p>1963</p> <p>1964</p> <p>1965</p> <p>1966</p> <p>1967</p> <p>1968</p> <p>1969</p> <p>1970</p> <p>1971</p> <p>1972</p> <p>1973</p> <p>1974</p> <p>1975</p> <p>1976</p> <p>1977</p> <p>1978</p> <p>1979</p> <p>1980</p> <p>1981</p> <p>1982</p> <p>1983</p> <p>1984</p> <p>1985</p> <p>1986</p> <p>1987</p> <p>1988</p> <p>1989</p> <p>1990</p> <p>1991</p> <p>1992</p> <p>1993</p> <p>1994</p> <p>1995</p> <p>1996</p> <p>1997</p> <p>1998</p> <p>1999</p> <p>2000</p> <p>2001</p> <p>2002</p> <p>2003</p> <p>2004</p> <p>2005</p> <p>2006</p> <p>2007</p> <p>2008</p> <p>2009</p> <p>2010</p> <p>2011</p> <p>2012</p> <p>2013</p> <p>2014</p> <p>2015</p> <p>2016</p> <p>2017</p> <p>2018</p> <p>2019</p> <p>2020</p> <p>2021</p> <p>2022</p> <p>2023</p> <p>2024</p> <p>2025</p>	
<p>1891</p> <p>1892</p> <p>1893</p> <p>1894</p> <p>1895</p> <p>1896</p> <p>1897</p> <p>1898</p> <p>1899</p> <p>1900</p> <p>1901</p> <p>1902</p> <p>1903</p> <p>1904</p> <p>1905</p> <p>1906</p> <p>1907</p> <p>1908</p> <p>1909</p> <p>1910</p> <p>1911</p> <p>1912</p> <p>1913</p> <p>1914</p> <p>1915</p> <p>1916</p> <p>1917</p> <p>1918</p> <p>1919</p> <p>1920</p> <p>1921</p> <p>1922</p> <p>1923</p> <p>1924</p> <p>1925</p> <p>1926</p> <p>1927</p> <p>1928</p> <p>1929</p> <p>1930</p> <p>1931</p> <p>1932</p> <p>1933</p> <p>1934</p> <p>1935</p> <p>1936</p> <p>1937</p> <p>1938</p> <p>1939</p> <p>1940</p> <p>1941</p> <p>1942</p> <p>1943</p> <p>1944</p> <p>1945</p> <p>1946</p> <p>1947</p> <p>1948</p> <p>1949</p> <p>1950</p> <p>1951</p> <p>1952</p> <p>1953</p> <p>1954</p> <p>1955</p> <p>1956</p> <p>1957</p> <p>1958</p> <p>1959</p> <p>1960</p> <p>1961</p> <p>1962</p> <p>1963</p> <p>1964</p> <p>1965</p> <p>1966</p> <p>1967</p> <p>1968</p> <p>1969</p> <p>1970</p> <p>1971</p> <p>1972</p> <p>1973</p> <p>1974</p> <p>1975</p> <p>1976</p> <p>1977</p> <p>1978</p> <p>1979</p> <p>1980</p> <p>1981</p> <p>1982</p> <p>1983</p> <p>1984</p> <p>1985</p> <p>1986</p> <p>1987</p> <p>1988</p> <p>1989</p> <p>1990</p> <p>1991</p> <p>1992</p> <p>1993</p> <p>1994</p> <p>1995</p> <p>1996</p> <p>1997</p> <p>1998</p> <p>1999</p> <p>2000</p> <p>2001</p> <p>2002</p> <p>2003</p> <p>2004</p> <p>2005</p> <p>2006</p> <p>2007</p> <p>2008</p> <p>2009</p> <p>2010</p> <p>2011</p> <p>2012</p> <p>2013</p> <p>2014</p> <p>2015</p> <p>2016</p> <p>2017</p> <p>2018</p> <p>2019</p> <p>2020</p> <p>2021</p> <p>2022</p> <p>2023</p> <p>2024</p> <p>2025</p>		<p>1891</p> <p>1892</p> <p>1893</p> <p>1894</p> <p>1895</p> <p>1896</p> <p>1897</p> <p>1898</p> <p>1899</p> <p>1900</p> <p>1901</p> <p>1902</p> <p>1903</p> <p>1904</p> <p>1905</p> <p>1906</p> <p>1907</p> <p>1908</p> <p>1909</p> <p>1910</p> <p>1911</p> <p>1912</p> <p>1913</p> <p>1914</p> <p>1915</p> <p>1916</p> <p>1917</p> <p>1918</p> <p>1919</p> <p>1920</p> <p>1921</p> <p>1922</p> <p>1923</p> <p>1924</p> <p>1925</p> <p>1926</p> <p>1927</p> <p>1928</p> <p>1929</p> <p>1930</p> <p>1931</p> <p>1932</p> <p>1933</p> <p>1934</p> <p>1935</p> <p>1936</p> <p>1937</p> <p>1938</p> <p>1939</p> <p>1940</p> <p>1941</p> <p>1942</p> <p>1943</p> <p>1944</p> <p>1945</p> <p>1946</p> <p>1947</p> <p>1948</p> <p>1949</p> <p>1950</p> <p>1951</p> <p>1952</p> <p>1953</p> <p>1954</p> <p>1955</p> <p>1956</p> <p>1957</p> <p>1958</p> <p>1959</p> <p>1960</p> <p>1961</p> <p>1962</p> <p>1963</p> <p>1964</p> <p>1965</p> <p>1966</p> <p>1967</p> <p>1968</p> <p>1969</p> <p>1970</p> <p>1971</p> <p>1972</p> <p>1973</p> <p>1974</p> <p>1975</p> <p>1976</p> <p>1977</p> <p>1978</p> <p>1979</p> <p>1980</p> <p>1981</p> <p>1982</p> <p>1983</p> <p>1984</p> <p>1985</p> <p>1986</p> <p>1987</p> <p>1988</p> <p>1989</p> <p>1990</p> <p>1991</p> <p>1992</p> <p>1993</p> <p>1994</p> <p>1995</p> <p>1996</p> <p>1997</p> <p>1998</p> <p>1999</p> <p>2000</p> <p>2001</p> <p>2002</p> <p>2003</p> <p>2004</p> <p>2005</p> <p>2006</p> <p>2007</p> <p>2008</p> <p>2009</p> <p>2010</p> <p>2011</p> <p>2012</p> <p>2013</p> <p>2014</p> <p>2015</p> <p>2016</p> <p>2017</p> <p>2018</p> <p>2019</p> <p>2020</p> <p>2021</p> <p>2022</p> <p>2023</p> <p>2024</p> <p>2025</p>	

I next placed the cage on the side rotating it slowly. This time the grasshopper was on the side of the cage. I turned the cage about fifteen degrees so that the grasshopper would be on the side of the cage but with the head downward. At once it walked forward. Rotating the cage I was able to keep it relatively in the same position. After a time, being unable to walk to a position where it would be normally oriented, it jumped taking a position head upward. This experiment was repeated with the same results.

I next placed the grasshopper on the bottom of the cage, this time slanting the cage at an angle of fifteen degrees. It traveled upward in a spiral path arriving at the top at about fifteen degrees from the former position. If the cage was slanted at a greater angle the path traveled became greater forming a greater angle.

X - First position of the grasshopper.

X' - Position taken by the grasshopper.

No.		Date		Description		Amount	
1		1880	Jan 1	Balance		100.00	
2		1880	Feb 1	Interest		1.00	
3		1880	Mar 1	Interest		1.00	
4		1880	Apr 1	Interest		1.00	
5		1880	May 1	Interest		1.00	
6		1880	Jun 1	Interest		1.00	
7		1880	Jul 1	Interest		1.00	
8		1880	Aug 1	Interest		1.00	
9		1880	Sep 1	Interest		1.00	
10		1880	Oct 1	Interest		1.00	
11		1880	Nov 1	Interest		1.00	
12		1880	Dec 1	Interest		1.00	
13		1880	Jan 1	Interest		1.00	
14		1880	Feb 1	Interest		1.00	
15		1880	Mar 1	Interest		1.00	
16		1880	Apr 1	Interest		1.00	
17		1880	May 1	Interest		1.00	
18		1880	Jun 1	Interest		1.00	
19		1880	Jul 1	Interest		1.00	
20		1880	Aug 1	Interest		1.00	
21		1880	Sep 1	Interest		1.00	
22		1880	Oct 1	Interest		1.00	
23		1880	Nov 1	Interest		1.00	
24		1880	Dec 1	Interest		1.00	
25		1880	Jan 1	Interest		1.00	
26		1880	Feb 1	Interest		1.00	
27		1880	Mar 1	Interest		1.00	
28		1880	Apr 1	Interest		1.00	
29		1880	May 1	Interest		1.00	
30		1880	Jun 1	Interest		1.00	
31		1880	Jul 1	Interest		1.00	
32		1880	Aug 1	Interest		1.00	
33		1880	Sep 1	Interest		1.00	
34		1880	Oct 1	Interest		1.00	
35		1880	Nov 1	Interest		1.00	
36		1880	Dec 1	Interest		1.00	
37		1880	Jan 1	Interest		1.00	
38		1880	Feb 1	Interest		1.00	
39		1880	Mar 1	Interest		1.00	
40		1880	Apr 1	Interest		1.00	
41		1880	May 1	Interest		1.00	
42		1880	Jun 1	Interest		1.00	
43		1880	Jul 1	Interest		1.00	
44		1880	Aug 1	Interest		1.00	
45		1880	Sep 1	Interest		1.00	
46		1880	Oct 1	Interest		1.00	
47		1880	Nov 1	Interest		1.00	
48		1880	Dec 1	Interest		1.00	
49		1880	Jan 1	Interest		1.00	
50		1880	Feb 1	Interest		1.00	
51		1880	Mar 1	Interest		1.00	
52		1880	Apr 1	Interest		1.00	
53		1880	May 1	Interest		1.00	
54		1880	Jun 1	Interest		1.00	
55		1880	Jul 1	Interest		1.00	
56		1880	Aug 1	Interest		1.00	
57		1880	Sep 1	Interest		1.00	
58		1880	Oct 1	Interest		1.00	
59		1880	Nov 1	Interest		1.00	
60		1880	Dec 1	Interest		1.00	
61		1880	Jan 1	Interest		1.00	
62		1880	Feb 1	Interest		1.00	
63		1880	Mar 1	Interest		1.00	
64		1880	Apr 1	Interest		1.00	
65		1880	May 1	Interest		1.00	
66		1880	Jun 1	Interest		1.00	
67		1880	Jul 1	Interest		1.00	
68		1880	Aug 1	Interest		1.00	
69		1880	Sep 1	Interest		1.00	
70		1880	Oct 1	Interest		1.00	
71		1880	Nov 1	Interest		1.00	
72		1880	Dec 1	Interest		1.00	
73		1880	Jan 1	Interest		1.00	
74		1880	Feb 1	Interest		1.00	
75		1880	Mar 1	Interest		1.00	
76		1880	Apr 1	Interest		1.00	
77		1880	May 1	Interest		1.00	
78		1880	Jun 1	Interest		1.00	
79		1880	Jul 1	Interest		1.00	
80		1880	Aug 1	Interest		1.00	
81		1880	Sep 1	Interest		1.00	
82		1880	Oct 1	Interest		1.00	
83		1880	Nov 1	Interest		1.00	
84		1880	Dec 1	Interest		1.00	
85		1880	Jan 1	Interest		1.00	
86		1880	Feb 1	Interest		1.00	
87		1880	Mar 1	Interest		1.00	
88		1880	Apr 1	Interest		1.00	
89		1880	May 1	Interest		1.00	
90		1880	Jun 1	Interest		1.00	
91		1880	Jul 1	Interest		1.00	
92		1880	Aug 1	Interest		1.00	
93		1880	Sep 1	Interest		1.00	
94		1880	Oct 1	Interest		1.00	
95		1880	Nov 1	Interest		1.00	
96		1880	Dec 1	Interest		1.00	
97		1880	Jan 1	Interest		1.00	
98		1880	Feb 1	Interest		1.00	
99		1880	Mar 1	Interest		1.00	
100		1880	Apr 1	Interest		1.00	

5. Experiments in Evaporating Power of Air.

Experiments were performed to determine the reactions of the grasshoppers to air of different evaporating powers. The apparatus used was essentially the apparatus described by Shelford and Deere (1913), Hamilton ('17), and Weese ('17). The experiments covered a period of forty minutes, readings being taken every two minutes. Five animals were used.

The grasshoppers show a dislike for either moist or dry air currents. When first placed in the gradient cage they are very active. Finally they arrange themselves on the wire screen opposite the entrance of the air currents and become quiet. If they come to rest on the floor of the cage, they orient with the head away from the currents of air. This would show them to be negatively anemotropic.

The data given below was taken on L. femur rubrum nymphs and adults. In all species there is a tendency to show a preference for dry air, nymphs showing a greater preference than adults. The data given is typical for all species studied.

Date	Description	Debit	Credit	Balance
1890	Jan 1			100.00
Feb 1	Paid for rent	20.00		80.00
Mar 1	Received from John		50.00	130.00
Apr 1	Paid for groceries	15.00		115.00
May 1	Received from Mary		30.00	145.00
Jun 1	Paid for fuel	10.00		135.00
Jul 1	Received from Peter		40.00	175.00
Aug 1	Paid for insurance	25.00		150.00
Sep 1	Received from Robert		60.00	210.00
Oct 1	Paid for repairs	12.00		198.00
Nov 1	Received from Susan		20.00	218.00
Dec 1	Paid for taxes	30.00		188.00
Total		132.00	180.00	256.00

Adults.

Minutes	Humidity		
	80	55	25
1	3	1	1
2	1	3	1
4	3	1	1
6	2	1	2
8	2	1	2
10	0	5	0
12	2	2	1
14	3	1	1
16	2	2	1
18	2	2	1
20	2	0	2
22	0	2	3
24	0	3	2
26	1	2	2
28	1	2	2
30	1	1	3
32	0	2	3
34	0	2	3
36	0	2	3
38	0	3	2
	25%	38%	37%

Nymphs.

Humidity		
80	55	25
0	2	3
1	2	2
1	2	2
2	2	1
1	1	3
1	0	4
2	0	3
2	0	3
2	0	3
1	0	4
2	0	3
2	1	2
3	0	2
1	2	2
1	0	4
1	0	4
1	0	4
1	0	4
1	0	4
27%	12%	61%

V. CONCLUSIONS.

Grasshoppers tend to form associations. This habit is little affected by choice of food, but rather according to response to light, surface contact, temperature, gravity, and the evaporating power of air.

Nymphs and adults select somewhat different habitats and show a corresponding difference in their reactions to environmental stimuli. Thus, nymphs choose broad, flat leaf surfaces of the lower strata, adults take positions on the stems.

Four stations were studied: the brook margin, clay bank, sweet clover, and temporary marsh. Each station has its distinctive species. Melanoplus differentialis is found in the brook margins; Dissosticta carolina on the clay bank; Melanoplus femur rubrum in the sweet clover; Petrix granulata on the temporary marsh.

The following table briefly summarizes the reactions of the grasshoppers to the various factors of their environments. These reactions as has been repeatedly pointed out are correlated with the differences in the habitats chosen by the various species and stages of development as observed in the field and may be regarded as explaining the distribution of the grasshoppers in their natural environment.

No.		Date		Description		Amount	
1		1890	Jan 1	Balance forward			
2		1890	Jan 15	Received from John Doe		100	
3		1890	Jan 20	Received from John Doe		50	
4		1890	Jan 25	Received from John Doe		25	
5		1890	Jan 30	Received from John Doe		125	
6		1890	Feb 5	Received from John Doe		75	
7		1890	Feb 10	Received from John Doe		150	
8		1890	Feb 15	Received from John Doe		100	
9		1890	Feb 20	Received from John Doe		50	
10		1890	Feb 25	Received from John Doe		25	
11		1890	Feb 28	Received from John Doe		125	
12		1890	Mar 5	Received from John Doe		75	
13		1890	Mar 10	Received from John Doe		150	
14		1890	Mar 15	Received from John Doe		100	
15		1890	Mar 20	Received from John Doe		50	
16		1890	Mar 25	Received from John Doe		25	
17		1890	Mar 28	Received from John Doe		125	
18		1890	Mar 31	Received from John Doe		75	
19		1890	Apr 5	Received from John Doe		150	
20		1890	Apr 10	Received from John Doe		100	
21		1890	Apr 15	Received from John Doe		50	
22		1890	Apr 20	Received from John Doe		25	
23		1890	Apr 25	Received from John Doe		125	
24		1890	Apr 28	Received from John Doe		75	
25		1890	Apr 30	Received from John Doe		150	
26		1890	May 5	Received from John Doe		100	
27		1890	May 10	Received from John Doe		50	
28		1890	May 15	Received from John Doe		25	
29		1890	May 20	Received from John Doe		125	
30		1890	May 25	Received from John Doe		75	
31		1890	May 28	Received from John Doe		150	
32		1890	May 31	Received from John Doe		100	
33		1890	Jun 5	Received from John Doe		50	
34		1890	Jun 10	Received from John Doe		25	
35		1890	Jun 15	Received from John Doe		125	
36		1890	Jun 20	Received from John Doe		75	
37		1890	Jun 25	Received from John Doe		150	
38		1890	Jun 28	Received from John Doe		100	
39		1890	Jun 30	Received from John Doe		50	
40		1890	Jul 5	Received from John Doe		25	
41		1890	Jul 10	Received from John Doe		125	
42		1890	Jul 15	Received from John Doe		75	
43		1890	Jul 20	Received from John Doe		150	
44		1890	Jul 25	Received from John Doe		100	
45		1890	Jul 28	Received from John Doe		50	
46		1890	Jul 31	Received from John Doe		25	
47		1890	Aug 5	Received from John Doe		125	
48		1890	Aug 10	Received from John Doe		75	
49		1890	Aug 15	Received from John Doe		150	
50		1890	Aug 20	Received from John Doe		100	
51		1890	Aug 25	Received from John Doe		50	
52		1890	Aug 28	Received from John Doe		25	
53		1890	Aug 31	Received from John Doe		125	
54		1890	Sep 5	Received from John Doe		75	
55		1890	Sep 10	Received from John Doe		150	
56		1890	Sep 15	Received from John Doe		100	
57		1890	Sep 20	Received from John Doe		50	
58		1890	Sep 25	Received from John Doe		25	
59		1890	Sep 28	Received from John Doe		125	
60		1890	Sep 30	Received from John Doe		75	
61		1890	Oct 5	Received from John Doe		150	
62		1890	Oct 10	Received from John Doe		100	
63		1890	Oct 15	Received from John Doe		50	
64		1890	Oct 20	Received from John Doe		25	
65		1890	Oct 25	Received from John Doe		125	
66		1890	Oct 28	Received from John Doe		75	
67		1890	Oct 31	Received from John Doe		150	
68		1890	Nov 5	Received from John Doe		100	
69		1890	Nov 10	Received from John Doe		50	
70		1890	Nov 15	Received from John Doe		25	
71		1890	Nov 20	Received from John Doe		125	
72		1890	Nov 25	Received from John Doe		75	
73		1890	Nov 28	Received from John Doe		150	
74		1890	Nov 30	Received from John Doe		100	
75		1890	Dec 5	Received from John Doe		50	
76		1890	Dec 10	Received from John Doe		25	
77		1890	Dec 15	Received from John Doe		125	
78		1890	Dec 20	Received from John Doe		75	
79		1890	Dec 25	Received from John Doe		150	
80		1890	Dec 28	Received from John Doe		100	
81		1890	Dec 31	Received from John Doe		50	
82		1890	Jan 1	Balance forward			

Table showing Reactions to Environmental Stimuli.

Stimuli	<i>M. differentialis</i> Brook margin		<i>M. femur rubrum</i> Sweet clover		<i>D. carolina</i> Clay bank		<i>A. granulata</i> Marsh
	adults	nymphs	adults	nymphs	adults	nymphs	adults.
Light	N	N	P	N	P	N	I
Intensity	N	N	P	N	P	P	I
Direction	N	N	P	N	P	P	N
Colors	(Orange & red)		(Green & yellow)		(Same)		(Same)
Rough surface	P	N	P (slightly)	N	N	N	N
Temperature	N (To warm)	N	P (To warm)	I	P (To warm)	I	N (To warm)
Gravity	I	N	P	N	N	N	N
Preference for dry air	P (Slight)	P (Slight)	P (Very)	P	P (Very)	I	I

Explanation of symbols:-

P- Positive

N- Negative

I- Indifferent.

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Adams, C. C.

- 1913 Guide to the Study of Animal Ecology. New York.

Cameron, Alfred E.

- 1916 The Insect Association of Local Environmental Complex
in the District of Holmes Chapel, Cheshire.
Transactions of the Royal Society of Edinburgh Vol.
LII. Part 1. (No. 2). pp 37-77.

Fox, Henry

- 1914 Data on the Orthoptera Faunistics of Eastern Penn-
sylvania and Southern New Jersey.
Acad. Nat. Sci. of Phila. June 1914.

Shelford, V. E.

- 1911 Physiological Animal Geography. Jour. Morph.,
Vol. 22; pp 552-618.
- 1912 Ecological Succession. V. Aspects of Physiological
Classification. Biol. Bull., Vol. XLIII., pp 331-370.
- 1913a. Animal Communities in Temperate America. Chicago.
- 1913d. The Reactions of Certain Animals to Gradients of
Evaporating Power of Air. A Study in Experimental
Ecology. Biol. Bull. Vol. XLV. pp. 79-120.
- 1914a. Modification of the Behavior of Land Animals by
Contact with Air of High Evaporating Power. Jour.
An. Behavior., Vol. 4, No. 1, pp. 31-49.
- 1914b. The Significance of Evaporation in Animal Geography.
Ann. Assn. Am. Geog. Vol. III. pp. 29-42.

Name	Age	Sex
John Smith	25	Male
Mary Jones	22	Female
Robert Brown	30	Male
Elizabeth White	28	Female
James Wilson	20	Male
Sarah Davis	24	Female
Thomas Miller	27	Male
Anna Taylor	21	Female
George Clark	23	Male
Charlotte Adams	26	Female
William Baker	29	Male
Margaret Green	20	Female
Richard King	24	Male
Susan Hill	22	Female
Daniel Scott	27	Male
Rebecca Young	21	Female
Benjamin Hall	25	Male

- 1915 Shelford, V. L. and Deere, E. O.
A Method of Establishing Gradients.
- 1917 Shelford, V. L.
Suggestions as to Field and Laboratory Instruction
in the Behavior and Ecology of Animals with Descriptions of Equipment.
School Science and Mathematics. Vol. XVII, No. 5,
pp. 388-409.

Vestal, Arthur C.

- 1914 Internal Relations of Terrestrial Associations.
American Naturalist Vol. XLVIII. cc. 413-444.
- 1913b. An Associational Study of Illinois Sand Prairie.
Bull. III. State Lab. Nat. Hist. 10: 1-96.

Wesse, A. C.

1917. An Experimental Study of the Reactions of the Horned
Lizard, *Phrynosoma modestum* Gir., A Reptile of the
Semi-Desert.

Woodsdalek, J. E.

- 1912 The Formation of Associations in May-fly Nymphs. II.
Interunctata.
Jour. En. Beh. Vol. II., No. 1.

Diagram 1.-- Diagramatic profile of the stations studied.

A-B, The Sweet Clover Association.

B-C, The Clay Bank Association.

C-D, The Brock Margin Association.

E- , The Temporary Marsh Association.

Diagrammatic Profile of Stations Studied.

A-B... Sweet Clover Association..

B-C... Clay-Bank "

C-D... Stream Margin "

E- Marsh "

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Explanation of Plate 1.

Fig. 1 - The Clay Bank, a type of situation selected by Lissosteira carolina.

Fig. 2 - A view showing a dry, barren path. At the right is the edge of the Black Margin Association. The vegetation at the upper left corner belongs to the Sweet Clover Association.

1

2

Explanation of Plate II.

Fig. 3 - Is a detailed view of the Sweet Clover Association, the habitat of Melanoplus femur rubrum.

Fig. 4 - Is a detailed view of the Brook Margin Association showing a growth of grass and smart weed shaded by willows. A typical habitat chosen by Melanoplus differentialis.

Fig. 5 - Is a detailed view of the temporary marsh, typical habitat of Tettix granulata.

3

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