PRELIMINARY EXPERIMENTS ON THE JUMPING REACTIONS OF MELANOPLUS DIFFERENTIALIS UHLER

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The problem was to determine the environmental factors affecting the jumping reaction of *Melanoplus differentialis* Uhler, the Differential Locust. Specimens were secured in the fields of the vicinity of the Ohio State University, where the experiments were conducted in the summer of 1925. No one factor was worked to the exclusion of the others, but light seemed to be the strongest stimulus. Owing to the lack of adequate apparatus and the short period of time in which the hoppers were available, no definite conclusions can be drawn at this time. This report is made public now in order to make available the methods used and the results obtained to others who might be interested in this problem.

These experiments were conducted under the direction of Dr. W. M. Barrows, of the Department of Zoology and Entomology, Ohio State University, to whom I am indebted for criticisms and suggestions. A large amount of time was spent in assembling and designing the apparatus and correcting it to offset several difficulties.

The apparatus consisted of two main divisions, the jump recording apparatus and the time recording apparatus. The former consisted of a cone of white cardboard, about two feet high, (I), (see diagram of apparatus), open at the top, which was covered with a piece of clear celluloid, (J). The base was tightly closed and light-proof, and was fastened to the platform of a scale used for weighing letters, (H). (This type of scale was used because of it's high degree of sensitiveness). To the pointer of the scale was attached an arm, about 18″ long, (G), which had a pin fixed through the free end. This pin recorded the jumps on the paper, blackened over a coal oil lamp flame, on the rotating cylinder of the recording instrument, (F). This cylinder was revolved by clockwork making a complete revolution every 18 hours. The timing apparatus consisted of a dry cell battery, a clock, with the crystal removed, a ringstand, and an electro-magnet. The negative wire from

the battery, (A), was grounded to the clock, (B). The positive wire was connected to the insulated post on the electro-magnet. From the other post on the electro-magnet a wire was connected to the clamp, (E), which was supported on the same ring-stand, (D), as the electro-magnet. This clamp held a piece of stiff flexible wire, tilted at an angle upward so that the minute hand of the clock would make a contact with it on the hour, closing the circuit, and after a few minutes would force the wire up and break the circuit, the wire returning to its former position. A small pointer on the electro-magnet was moved when the circuit was closed, thus recording the hours on a line on the rotating cylinder just above the line on which the jumps were recorded.

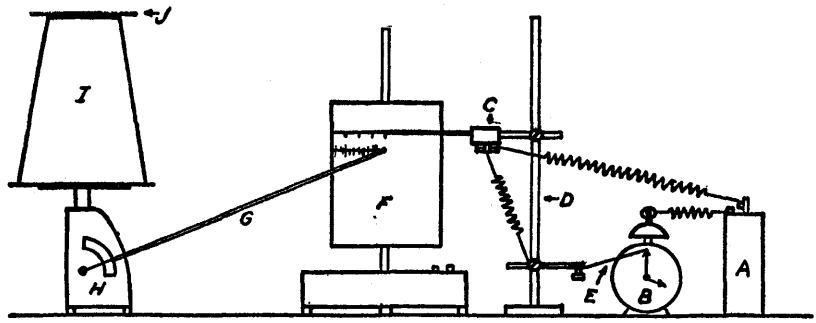

DIAGRAM OF APPARATUS

In all these experiments only one hopper was used at a time, and none were used for two successive periods. After 24 hours without food in the apparatus they were allowed a period of 24 hours for feeding and recuperation. Large cages were necessary as the grasshoppers confined in small ones were attacked and killed by the lawn ant, Lasius niger americana Em.

There were three types of experiments. First the insects were exposed to the diffused daylight in a room with an eastern exposure, about four feet from the window. No direct sunlight struck the insect. In this room there was a maximum variation of temperature of 12°F. occuring in the morning when the sun shone through the window. The humidity was rather constant, ranging from 43° to 50°F. in steps of 1°. The

following table shows the number of jumps per hour, correlated with the average temperature and average relative humidity, and light.

TABLE 1.

		P. M.												A. M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
4 Grasshoppers	Light	Diffused Daylight											Dark									Diffused Daylight			
	Jumps	7	12	3	6	10	15	27	46	3	1	1	6	2	1	0	0	1	2	4	11	19	16	18	17
	Av.e Hum.	43	43	44	44	44	44	45	46	46	47	48	48	48	48	48	49	49	49	49	50	50	50	49	49	49
	Av.e Temp.	76	76	75	75	75	75	75	75	75	74	74	74	74	74	74	74	74	73	73	73	74	74	85	77	75

The second type of experiment was run in the Department greenhouse, where there was a wide range of temperature and humidity, but the light was bright from 6:30 A. M. to 7 P. M. with perhaps a half hour of diffused light immediately preceding and following those hours. The changes in temperature were rather sudden, ranging from 89°F. to 62°F. Very little if any direct sunlight struck the insect or container as the glass was whitewashed to prevent destructive high temperatures. Table 2 shows the results obtained.

TABLE 2.

		P. M.												A. M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
3 Grasshoppers	Light	Bright Daylight						Diffused Daylight					Dark						Diffused Daylight	Bright Daylight					
	Jumps	15	15	16	4	3	0	4	7	3	1	1	1	3	0	0	0	0	0	0	0	0	0	3	7
	Av.e Hum.	49	43	46	48	50	53	57	62	66	68	69	69	69	69	70	71	71	71	73	74	75	67	50	45
	Av.e Temp.	80	80	82	80	78	76	75	73	71	70	69	68	67	66	65	65	63	63	64	64	65	70	77	82

The third type of experiment was conducted in a dark room where the temperature did not vary more than two degrees during any one period of 24 hours. However the

humidity was more variable, ranging from a variation of 4% in one experiment to 10% in the other. The light was supplied by a 40-watt Mazda lamp and was continuous. A record was kept of the sexes of the tested grasshoppers. Table 3 gives a comparison of the two sexes correlated with the temperature and relative humidity. The greater activity shown by the male does not necessarily indicate a difference in the activity of the two sexes as not enough of each sex were tested. It is natural to suppose that a greater activity would exist in

TABLE 3.

		P.M.												A.M											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Light		40 Watt Mazda Lamp - Continuous																							
3♂ Grasshoppers	No. Jumps	17	23	24	23	16	19	12	10	19	10	13	18	12	7	17	14	12	10	8	8	1	7	0	0
	Av. Hum.	60	60	58	57	57	57	58	59	59	59	59	60	60	60	60	59	59	60	60	60	59	58	57	56
	Av. Temp.	75	75	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	77
3♀ Grasshoppers	No. Jumps	0	0	8	15	6	8	6	5	9	0	0	1	1	0	0	1	4	7	3	14	11	8	2	4
	Av. Hum.	53	54	57	57	58	57	57	57	57	57	58	58	58	58	58	58	58	58	58	58	58	59	63	65
	Av. Temp.	68	68	68	68	68	68	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69

the male sex, if there was any difference at all. Many studies of animal life, where the sexes are differentiated into two separate individuals, shows a decided difference of habits and a greater activity on the part of the male, which is the aggressor. Further experiments may proove that this is also true of the saltatorial reactions of the grasshopper.

One variation of the above experiment was tried. Two different intensities and qualities of light source were used. In both cases the light was continuous for a period of 24 hours. Table 4 shows the results, with the temperatures and relative humidity recorded.

There seems to be little if any difference with the two different lights. Jumping is almost continuous throughout the

experiments, with the exception of one hour. With the lower-powered light the activity is greater and the jumps are more evenly distributed throughout the entire period. This corresponds with the results recorded in Table 1, where the period of greatest activity occurs when the light is at a minimum intensity, just preceding sunrise and following sunset. The conflicting results in Table 2 may be due to the modifying action of the temperature and humidity. Further experimentation is necessary to prove or disprove this theory.

TABLE 4.

		P. M.												A. M.									
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
4 Grasshoppers	Light	40 Watt Mazda Lamp - Continuous																							
	Jumps	17	23	32	39	33	33	19	18	29	11	14	24	18	11	21	17	17	19	14	26	17	22	8	14
	Av.° Hum.	53	53	54	53	54	53	54	55	55	55	56	57	57	57	57	57	57	57	57	57	57	57	58	59
	Av.° Temp.	71	71	78	78	79	79	72	72	72	72	72	72	72	72	72	72	76	76	76	71	76	76	76	75
4 Grasshoppers	Light	125 Watt Nitrogen Daylight Lamp - Continuous																							
	Jumps	24	22	22	10	16	16	14	18	24	14	18	38	8	14	20	10	6	6	0	16	16	8	14	16
	Av.° Hum.	65	64	65	66	66	66	67	67	67	68	68	68	68	68	68	67	67	67	63	61	61	62	64	65
	Av.° Temp.	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	73	73	73	73	73	73

Table 5 shows the comparison of the reactions of the grasshoppers to natural daylight and those tested with artificial light. The average temperatures and average relative humidity are also recorded. The variation of jumps per hour is much greater under natural light than under artificial light, which is to be expected as there is a greater variation of the former during the different hours of the day, especially toward night and early in the morning. The rays at these periods are more or less horizontal and must penetrate more of the atmosphere, which tends to change the quality and intensity of light by filtering out some of the rays. It would be interesting

to test out the different colors of the spectrum to determine which rays have the greatest effect on the grasshoppers.

SUMMARY

As stated previously no definite conclusions may be drawn from the limited number of experiments performed. However, the results obtained permit of certain deductions.

TABLE 5.

		P.M.												A.M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
8 Grasshoppers	Light	← Daylight →											Dark	←					→	← Daylight →					
	Jumps	22	27	19	10	13	15	34	54	6	2	2	7	5	1	0	0	1	2	4	11	19	16	21	24
	Av.° Hum.	46	43	45	46	47	49	49	54	56	58	59	59	59	59	60	60	60	60	61	62	62	62	50	47
	Av.° Temp.	78	78	78	78	77	76	75	74	73	72	71	71	71	70	69	69	68	68	68	69	69	77	77	78
8 Grasshoppers	Light	← Continuous Light →																							
	Jumps	35	42	54	67	41	46	40	30	50	20	27	46	23	17	34	25	25	26	16	39	26	26	13	17
	Av.° Hum.	58	58	58	58	59	58	59	59	59	60	60	61	61	61	61	60	60	60	59	59	59	59	60	61
	Av.° Temp.	72	72	73	73	73	73	73	73	73	73	73	73	73	73	73	73	74	74	74	72	74	74	74	74

NOTE. All humidities recorded are relative.
All jumps recorded are totals for the individuals tested which tends to balance differences in individualistic behaviour.

1. Light appears to be the strongest stimulus. In Table 5 it will be seen that the hoppers exposed to continuous light showed not only a greater activity, but the jumps were more or less evenly distributed over the entire period of 24 hours. Those exposed to daylight alone showed the period of maximum activity during the daylight hours. Comparison of the hours from 8 P. M. to 6 A. M. gives support to the supposition that jumping is a light response. Casual observation of grasshoppers in their natural habitat also lends support to the theory that light or other visual stimuli are the chief stimuli.

In the evening when the light is less intense a greater activity was observed among the different species of grasshoppers. This may be due to both the intensity and quality of the light, as well as the direction.

2. Heat, in these experiments, does not appear to affect the jumping. In Table 2, as stated before, heat may be responsible for the conflicting results recorded, so modifying the activity that the greater number of jumps were recorded when the light was more intense. In Tables 1 and 3 the greatest activity was shown when the light was less intense.

Work by Geist on the heat sensitive areas of certain grasshoppers showed, in this species, a period of continuous jumping when the surface upon which the grasshopper rested was heated to a temperature high enough to raise the air temperature to 37°C.—about 98°F. This was undoubtedly due to stimulation from the surface upon which they were resting. Whether the same would also be true if only the surrounding air only were heated, is a question to be decided by further experimentation. However, such temperatures do not as a rule occur in the natural habitat of this species of grasshopper.

3. Sex may play an important part in the difference displayed in the activity of different individuals. Table 3 shows a greater number of jumps recorded for the male of the species, as would natuarlly be supposed to be the case.

BIBLIOGRAPHY.

1. GEIST, R. M. The Heat Sensitive Areas of Certain Grasshoppers. Ann. Ent. Soc. Amer. Vol. XXI: 4; pp. 614–619.
2. LOEB, J. Forced Movements, Tropisms, and Animal Conduct. J. B. Lippincott Co.
3. CARPENTER, F. W. The Reactions of the Pomace Fly, (*Drosophila ampelophila* Loew.), to Light, Gravity, and Mechanical Stimulation. Amer. Nat., Vol. 39, pp. 157–171.
4. HERMS, W. B. The Photic Reactions of Sarcophagid Flies, etc. Journ. Exp. Zool., Vol. 10; pp. 167–226.
5. FOLSOM, J. W. Entomology with reference to its Biological and Economical Aspects. pp. 307, 308.