AN ECOLOGICAL STUDY OF TOXOPTERA GRAMINUM IN PAYNE COUNTY

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The green bug (*Toxoptera graminum* Rond.) is a plant louse infesting such farm crops as barley, oats, and wheat. In Oklahoma, infestations develop in the late fall in the form of deadened more or less circular areas in fields of small grains such as wheat. The following spring these areas may enlarge and become confluent, and most of the wheat or barley may be destroyed. Also, millions of winged aphids which have developed in these fields may migrate to fields of spring-planted oats, likewise destroying them. In some years, as in 1941-42, the fields may become invaded by aphids drifting in from infested districts in Texas; and in such years general field infestations develop, rather than the more or less restricted spotty type above described. In other years, certain conditions, not clearly understood, prevent further development of the green bug in the spring and little economic loss results.

The importance of the green bug problem to Oklahoma farmers is shown by the following historical outline, which gives the years of the outbreaks and the extent of the infestations by number of counties infested:

1890—11 counties
1901—6 counties
1907—state-wide except parts or all of 8 counties
1911—eastern Oklahoma
1916—6 counties at least, possibly more
1921—4 counties
1926—4 " (records very incomplete)
1934—7 "
1937—5 "
1938—3 "
1939—34 "
1941—9 "
1942—42 " reported with at least 14 others infested

The 1907 outbreak was the most widespread and destructive. It was estimated by Webster and Phillips (1912)[2] that 50,000,000 bushels of wheat were destroyed in Kansas, Oklahoma, and Texas. In 1939, the estimated financial loss in Oklahoma was $508,704.30 (Fenton and Fisher 1940). Figures for the 1942 outbreak are difficult to obtain and in so far as the wheat crop was concerned seem out of line with the total wheat production for the state. This was because the pest caused very little damage to wheat in the main wheat belt of Oklahoma, where conditions for this crop were unusually favorable. However careful analysis of the state production by districts as outlined by Blood and Hill (1941) indicate a reduction of the wheat crop by 7,189,275 bushels. Losses to oats and barley were much more severe.

At present, the best hope for preventing injury by this pest is in the development of resistant varieties. Tests have shown great differences among varieties of barley in damage caused by the green bug[2] and there

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[2] Special report of variety tests at Lawton, Oklahoma, by R. G. Dahms.

are some indications that this is also true for oats (Fenton and Fisher 1940). Development of resistant varieties would require a long time. Meanwhile, information is badly needed on the ecology of the insect, especially with reference to the effects of parasitization and predation on its multiplication. With this in mind, observations were made in 1939 in selected heavily infested wheat and barley fields in Payne County. The results of this study have been published (Fenton and Fisher 1940); since then two other outbreaks in Payne County have been studied, one during 1941 and the other during 1942.

REVIEW OF PREVIOUS WORK

The biologies of *T. graminum* and that of its principal parasite (*Lysiphlebus testaceipes*) have been carefully studied, as has also the influence of weather on outbreaks of the pest. Webster and Phillips (1912) state "Probably the whole secret of the disastrous outbreaks of *Toxoptera graminum* lies in the fact that this parasite is not active at a temperature much below 56° F while . . . the aphis begins to reproduce in a temperature at or slightly below 40° F. . ." Wadley (1931) found that the green bug could develop at temperatures between 44.6° and 91.4° F but that most rapid development took place at 86° F and maximum reproduction at 71.6° F. Death occurred quickly at 5° and 107.6° F. Hunter and Glenn (1909) noted that at 17° F the parasite in its adult stage was killed, while at 35° F it attempted to sting the bugs in a very feeble manner but apparently without success. The host was parasitized at 38° to 40° F. As the temperature rises above 45° F parasite activity increases and appears normal at 70° F. The conclusion reached by various authorities as a result of these and other studies is that incipient green bug infestations develop rapidly at temperatures sufficiently high for the aphid, yet too low for much parasite activity. When and if a rise in the temperature occurs, the parasite becomes very active and quickly terminates the outbreak.

TECHNIQUE

Infestation data. In 1939, infestation counts were not started until April 13, some time after other records were being taken. The method consisted of taking 50 leaves within each of 5 infested spots in a field and counting the number of leaves with green bugs on them. In each infested spot, leaves were picked from 3 rows in the heaviest or inner part of the spot, 3 rows next to these and then 3 rows beyond them. These rows represented, respectively, the heaviest, medium, and lightest infested portions of each spot. In computing the mean infestation within each spot, the average was taken of leaves picked from all 9 rows. This figure, averaged with similar data for the other spots in the same field examined, gave a picture of the mean infestation for the infested portion of that particular field for that day. Since records were taken from 5 fields, in each one of which 5 spots were sampled, the daily average as listed for 1939 in Table I represents the mean of 25 infested spots in 5 fields. Such a figure obviously does not give a true picture of the infestation for the fields, since the leaves were selected from the infested portions and these might represent only about half of any field, the rest being uninfested. However, the idea was not so much to study the total infestation of the field as it was to evaluate parasitization and predation on the green bug population.

In 1941, the infestation counts were made within the infested spots as in 1939 except that 20 leaves were picked at random from each spot or 100 leaves per field. Data on the intensity of the infestations, i. e., the number of aphids per leaf, were also taken. From 3 to 6 fields were sampled (Table II). Infestation counts in 1942 were taken from 5 points selected at random for the entire field. Twenty leaves were picked at ran-

dom from each point. Since the 1942 infestation was generally due to migratory aphids, the records are a very close approximation of actual field infestation conditions. Five to six fields were sampled (Table III).

Parasitization. During all three years the percentage of parasitization caused by *Lysiphlebus testaceipes* was determined by random sampling of infested leaves within selected spots. Such leaves were placed in alcohol, brought into the laboratory, and examined under a binocular microscope.

Predation. The most common insect predator was *Hippodamia convergens.* The numbers of this species in each spot examined for the three years was determined by counting the larvae, pupae, and adults at two locations in each spot. Each location consisted of 3 linear feet of plants or 30 linear feet per field. Only the larvae and adults were considered as active predators in this study.

RESULTS

It is difficult if not impossible to compare green bug infestations of different years. However, certain trends are definitely shown. In 1939 (Table I) the first counts were made after the infestation had begun to decline, based upon general observations. Torrential rains on April 4 and 5 abruptly checked what was a very rapidly increasing infestation. Following more rain on April 6, there was a period of dry weather during which the green bug began to recover from the devastating effect of these rains. The highest infestation recorded, however, was only 53.2 percent on April 14. The effect of the parasite on the decline in the infestation appears to be secondary. The percentage of parasitization varied considerably in the fields sampled, yet the downward trend of the infestation was about the same in all. *H. convergens* larvae were very numerous early in the period of study; the beetles were abundant later on.

In 1941, the peak of the infestation occurred at or about the time the records were begun (Table II). The infestation dropped very much faster than during the period in 1939 when records were taken. Furthermore, there are important differences in the number and time of appearance of predators and parasites during these two years. There was only one period during which predator activity was marked, namely April 13, as compared with two periods, April 3 and 27, in 1939. The percentage of parasitization was very much higher in 1941 than in 1939 or 1942. It is very evident that parasites and possibly predators were much more important in checking the infestation than in the other two years.

A much more complete picture of the infestation was obtained during 1942 than for the other two years (Table III). There was much more rainfall than in the other two years during the period when observations were made. The percentage of parasitization was lower in 1942 than in either of the other two years, while predators were exceptionally few. The decline and termination of the infestation in 1942 could not possibly have been due in any large degree to the controlling effects of these natural enemies.

DISCUSSION

If we consider the infested spots in 1939 and 1941 as units of study and the entire field in 1942 in the same manner, then it can be said that during all three years we were studying a known aphid-predator-parasite complex. This being the case, it is possible to evaluate the effects of the predator and parasite on the host. Complete figures are available only for the decline in the infestation from its peak during the three years. Such a decline took place in all three years regardless of how

numerous the natural enemies of the aphids were. The decline was most rapid, however, during the year when parasites were most numerous, namely, 1941. Also during this year predators were very active at the peak of the infestation and may have contributed to the control of the aphid. In 1939, parasites became abundant late in the infestation period and helped destroy the remnants of the aphid population. This was likewise true for the predators during 1939. The effect of parasites and especially predators was minor in 1942.

SUMMARY

Three years study of green bug infestations in selected wheat and barley fields in Payne County, Oklahoma, were made to evaluate the effect of parasites and predators on this aphid. In two of the years, one species of predator, *Hippodamia convergens*, was sufficiently numerous to have exerted some pressure on the aphid population, although not enough to check it. In one year, the parasite *Lysiphlebus testaceipes* seemed to have been a very important factor in checking the green bug; in one other year it became abundant only in time to destroy the remnants of aphids late in the period of the infestation. In the two years when biologic control was secondary, heavy rainfall appeared to be the principal factor checking the outbreak and indirectly was involved in terminating the infestation in that it promoted rapid growth of the plants, thereby making conditions more unfavorable for the aphid.

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TABLE I

Average green bug infestation in selected fields, percent of parasitization, and predator population; Payne County, Okla., 1939

Date	No. of fields	Percent of infestation			Percent of parasitization			No. of coccinellids per 3 feet of row [a]		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
4/13	5	27.9	51.2	37.4	2.4	28.9	10.2	1.2	8.3	3.2
14	5	26.9	53.2	37.2	2.7	27.7	10.7	1.3	6.7	3.2
15	5	19.7	33.3	26.9	6.4	33.4	15.0	1.6	4.8	3.0
18	5	8.7	19.7	15.0	4.4	62.0	26.6	1.8	10.1	5.3
19	5	10.8	21.3	16.2	4.2	69.8	24.9	2.7	4.3	3.5
20	5	10.7	20.1	16.2	4.2	57.5	26.4	2.9	5.2	4.2
21	5	8.5	18.7	13.5	7.8	61.5	27.9	2.6	4.5	3.8
23	5	7.1	18.0	12.1	10.8	57.3	28.6	6.1	16.2	8.5
24	5	6.7	18.3	12.3	10.6	50.5	25.7	5.7	8.8	7.9
25	5	6.3	18.5	13.2	10.8	66.9	32.2	6.2	25.5	12.3
26	5	6.0	18.1	12.0	18.7	66.1	36.5	8.2	25.5	13.1
27	5	6.1	17.9	12.5	24.8	62.9	39.2	10.0	17.0	13.0
28	5	2.3	18.0	8.2	31.2	67.7	46.0	6.1	13.3	9.4
30	5	1.2	13.9	6.3	43.2	68.1	53.8	5.5	13.2	8.5
5/1	5	0.3	8.8	3.0	58.3	71.6	64.4	3.3	8.1	5.0
2	5	0.1	4.1	1.4	54.0	65.4	60.2	3.3	7.2	4.7
3	5	0	1.5	0.6	50.0	100	65	1.6	4.0	2.9
5	5	0	0.8	0.3	36.5	100	50.8	1.3	3.3	2.3
8	5	0	0.3	0.1	68.3	100	93.7	0.5	2.3	1.3

[a] Larvae and adults. Peak of larval population, April 7; of adults, April 27.

TABLE II

Average green bug infestation in selected fields, percent of parasitization, and predator population; Payne County, Okla., 1941

Date	No. of fields	Percent of infestation			Percent of parasitization			No. of coccinellids per 3 feet of row [a]		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
4/ 8- 9	6	75	99	92.8	3.6	51	16.5	2.6	14.0	5.4
10-11	6	84	100	94.8	11.0	62	23.7	1.5	28.0	11.3
12-14	5	55	98	87.8	18	80	35.4	11.0	18.9	15.0
15-16	6	0	97	57.5	30	100	57.2	1.5	42.1	14.1
17-18	6	0	93	38.3	46	100	74.7	0.6	19.6	8.1
19-20	6	0	55	17.0	56	100	80.2	1.0	18.6	5.3
21-22	4	4	35	15.3	55	96	76.0	1.5	16.5	7.0
23-25	4	1	3	1.5	85	100	93.4	0.6	11.1	3.8
26-27	5	1	10	4.8	80	97	88.0	0.4	9.1	3.9
30	5	0	9	2.0	82	100	96.0	0.3	6.3	2.2
5/ 1	3	1	4	2.0	80	98	91.3	1.1	4.6	2.4
3	3	0	3	1.3	.....	.....	.....	.....	.....	.....
6	3	0	2	1.0	.....	.....	.....	.....	.....	.....

[a] Larvae and adults.

TABLE III

Average green bug infestation in selected fields, percent of parasitization, and predator population; Payne County, Okla., 1942

Date	No. of fields	Percent of infestation			Percent of parasitization			No. of coccinellids per 3 feet of row [a]		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
3/26-27	6	19	60	35.5	2.9	14.2	8.6	0	0.1	0.02
28-29	6	15	52	30.2	6.1	12.7	9.2	0	0.1	0.03
30-31	6	21	78	49	2.3	14.1	7.9	0	0	0
4/1-2	6	27	70	55.2	4.5	14.8	9.2	0	0.1	0.05
3-4	6	39	88	64	4.9	31.3	13.5	0	2.3	0.5
5-6	6	64	84	71.7	4.9	35.0	19.1	0	2.9	1.5
7-10	6	42	98	72.2	4.6	49.2	22.4	0.1	4.0	0.9
11-12	6	33	93	69.2	8.3	34.8	19.6	0.6	4.0	1.8
13-14	6	44	94	71.7	7.1	48.7	23.9	1.0	2.5	1.6
15-16	6	21	94	61.3	8.6	59.5	32.1	0.3	3.2	1.4
22	5	1	80	31.2	16.6	38.0	27.5 [b]	0	0.8	0.2
25-26	5	0	27	10.8	26.9	61.8	44.4 [c]	0	1.0	0.3
27-28	5	0	4	1.8	.....	.....	.....	0	0.3	0.1
29-30	6	0	10	3.5	.....	.....	.....	0	0.7	0.3
5/1-3	6	0	6	3.7	.....	.....	.....	0	0.5	0.3

[a] Larvae and adults.
[b] 3 fields.
[c] 2 fields.