CERTAIN ASPECTS OF THE HOST-PARASITE RELATIONSHIP BETWEEN THE GREENBUG APHID AND LYSIPHLEBUS TESTACEIPES (CRESSON)

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PREFACE

Because of the increasing development and use of mathematical models in applied entomology, it has become necessary to investigate more closely the relationships that exist between insect pests and their natural enemies. A better knowledge of such relationships can serve in the development of more realistic models for simulating field conditions and determining control strategies.

Studies dealing with the relationship between the greenbug and a native parasite, Lysiphlebus testaceipes (Cresson), were conducted under laboratory conditions. The results of these studies are presented herein.

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CHAPTER I

INTRODUCTION

The increased emphasis in recent years on past management strategies has resulted in much research dealing with natural enemies of the greenbug, Schizaphis graminum Rondani. Lysiphlebus testaceipes (Cresson), a braconid parasite of the greenbug, has been recognized for many years as being one of the principle enemies of this pest. Hunter and Glenn (1909), Webster and Phillips (1912), and Fenton and Fisher (1940) all credited L. testaceipes with exhibiting varying degrees of control on greenbug populations in the field.

This parasite has drawn more attention than most aphid parasites because of its wide distribution and its large number of host species. Webster and Phillips (1912) listed 17 known aphid species and 6 unknown aphids from which this parasite had been reared. Schlinger and Hall (1960b) reported it to have been reared from 10 species of aphids in California alone. They also commented that, because of its widespread abundance, this parasite "certainly should be considered a potential aid to any natural control program of pest aphids."

When considering the effect of a parasite such as L. testaceipes on a greenbug population, one needs to know the host-parasite relationships and the mechanisms by which the parasite reduces the host's numbers. Two separate aspects of the host-parasite relationship are discussed in this paper. One aspect considered is the suitability of

very young first-instar greenbugs as hosts to L. testaceipes. The other aspect deals with disruption of greenbug populations by the parasite and the exiting of the disturbed aphids from their host plants.

CHAPTER II

SUITABILITY OF GREENBUGS LESS THAN SIX HOURS OLD AS HOSTS FOR LYSIPHLEBUS TESTACEIPES

When considering the relationship between the greenbug and L. testaceipes, one important aspect is the suitability of various instars of the greenbug in serving as hosts for the parasite. Webster and Phillips (1912) reported that L. testaceipes developing in first and second instars of the greenbug would not reach maturity because such young aphids contained insufficient nourishment to support the parasite larvae. Hight et al. (1972), however, found that percent emergence of adult L. testaceipes was very high from greenbugs parasitized at ages 1 and 2 days. However, information was lacking on the possible difference in host suitability of greenbugs within the first instar. The question arose as to whether a newborn greenbug, only a few minutes old, could survive the ovipositional thrust of the parasite and be as suitable a host as an aphid which had developed for several hours before being parasitized. Therefore, a study was performed to determine the suitability of young greenbugs, ranging in age from several minutes to several hours, in serving as hosts for L. testaceipes.

Methods and Materials

Greenbugs were reared on sorghum in the laboratory and observed for reproduction. When an adult was seen giving birth, the time of parturition was recorded, and the newborn aphid was removed with an artist's brush, which was used throughout the experiment to transfer aphids. The young aphid was then placed on a small cutting of sorghum which was set in wet sand contained in a 1-ounce plastic cup. The cup was capped and set aside until the aphid had attained the desired age for parasitism. Three age groups of aphids were exposed to parasitism: < 15 min., 1 hr. 30 min., and 6 hr. Forty aphids in each age class were exposed, giving a total of 120 observations. Aphids in the < 15 min class were exposed to the parasite immediately following parturition.

Female parasites were taken from laboratory cultures and placed in gelatin capsules with randomly chosen males. After copulation had been observed, the male and female were left in the capsule together for about an hour to give more assurance that they had actually mated. The male was then removed, and the female was considered ready for use in the experiment. Each female was used to parasitize 4 to 5 greenbugs.

Parasitism was achieved by placing the aphid into a gelatin capsule containing a mated, female L. testaceipes. Aphid and parasite were observed through a dissecting microscope until the parasite had delivered two ovipositional thrusts to the aphid. The aphid was then returned to the sorghum cutting where it was observed daily for mummy formation. When mummies formed, they were clipped from

the sorghum and placed in individual gelatin capsules. Then, when parasites emerged, their sex and date of emergence were recorded.

In order to check the fertility of those emerging parasites, two females emerging from each age group were mated with emerging males and placed in individual greenbug cultures containing 20 to 30 aphids. These were checked for mummy formation and emergent parasites.

Results and Discussion

Sixty-five percent of all aphids tested formed mummies which produced viable adult parasites, 22.5% formed mummies which did not emerge, 6.7% died before mummy formation could be observed, and 5.8% lived and matured with no apparent ill effects. This data is presented in Table I (Appendix). Injury resulting from the ovipositional thrust of the parasite or from the brush transferring process could have been responsible for the deaths of those aphids which died before mummy formation could be observed. It is possible that no parasite eggs were deposited in the bodies of those aphids which lived and matured, even though each aphid was struck by a parasite's ovipositor at least twice. Another possibility is that these aphids successfully resisted parasitism, either by encapsulation of the parasite embryo or through humoral reaction (Stary, 1970).

Contingency tables were constructed for data analysis to test for significant differences between age classes. "Lived" and "died" categories in Table I (Appendix) were combined, so that expected frequencies would be at least 5 in all cells, thus making a X^2 test valid (Conover, 1971). The resulting X^2 of 3.56 with 4 d.f. was

not significant at the 0.05 level, which was the level of significance used in all the X^2 tests in this study. Two smaller tables (Tables II and III in Appendix) were constructed from information in Table I. Table II compared the number of aphids forming mummies to the number not forming mummies in each age class. The resulting X^2 value of 3.2 with 2 d.f. was not significant. Table III dealt only with those aphids forming mummies, and compared the number of emergent parasites to the number of non-emergent mummies in each age class. The test gave no significant difference between age classes (X^2, 2 d.f. = 0.38).

When only aphids which formed mummies were considered, the percentages emergence for the < 15 min, 1 hr 30 min, and 6 hr classes were 73, 72, and 78 respectively. Had the mummies not been handled prior to emergence, the figures would probably be higher. Hight et al. (1972) reported that handling of mummies resulted in a reduction in emergence. However, in this study, placing the mummies in gelatin capsules greatly facilitated the handling of emergent adults.

A test for differences in sex ratios between age classes (Table IV in Appendix) showed no significance with a X^2 of 2.22 (2 d.f.). In all age groups, males outnumbered females with an average of 64% ♂ to 36% ♀. This is similar to the findings of Hight et al. (1972).

The emerging parasites tested were found to be fertile and active when placed in their own greenbug cultures. An average of 22 offspring was produced by each female tested, and the sex ratio was approximately 1:1. Further study is needed to compare the fecundity

of parasites developing in young greenbugs to that of parasites developing in later instars.

CHAPTER III

EFFECTIVENESS OF *LYSIPHLEBUS TESTACEIPES* IN CAUSING GREENBUGS TO EXIT FROM THEIR HOST PLANTS

Lysiphlebus testaceipes reduces greenbug populations in several ways. Not only does the aphid eventually die as a result of parasitism, but fecundity of adult greenbugs is also reduced (Hight et al., 1972). Hight also reported that about 40% of the greenbugs left the sorghum plants on which they were feeding as a result of the activity of the parasites. She hypothesized that, under field conditions, many of these aphids would never return to the plant as a result of being killed by high soil temperatures.

These aphid exits from the host plants were attributed to several factors by Hight et al. (1972). Many times, the ovipositional thrust of the parasite was so powerful that the aphid was physically knocked from the plant. Larger aphids would occasionally run from the plant to avoid contact with the parasite. Finally, the kicking behavior of a parasitized aphid, also described by Webster and Phillips (1912), set off a chain reaction of the same behavior among other nonparasitized aphids, causing many of them to fall from the plant. Tamaki et al. (1970) reported that the activity of the hymenopterous parasite

Aphidius smithi Sharma and Subba Rao caused 57% of the pea aphid population to leave the pea plants on which they were feeding, and that 3/4 of those aphids leaving were not parasitized. He said that the parasites disrupted and harassed the aphid population. This behavior on the part of the aphids has since been attributed to the release of an alarm pheromone by the parasitized aphid, which repels nearby aphids from their feeding sites (Nault et al., 1973).

Because of the lack of quantitative data dealing with this aspect of the host-parasite relationship, a study was performed to determine the effectiveness of L. testaceipes in causing greenbugs to exit from their host plants. Age of the greenbugs and their population density were considered in the experiment. A small scale test was also run in the field to determine the fate of aphids which were knocked from plants onto soil exposed to direct sunlight.

Methods and Materials

Small sorghum plants grown in 4-inch pots were infested with various ages and densities of greenbugs. Ages 1, 3, and 5 days were crossclassified with densities 5, 10, and 20 aphids per plant to give 9 treatment combinations. In order to facilitate observation of aphids which had exited from the plants, the soil around the infested plants was covered with a layer of fine, white sand; and, the plants were covered with clear cellulose-nitrate cages. For 5 successive days, 30 infested plants were observed continually for a 4-hour period. Fifteen of the plants received exposure to L. testaceipes while the remaining 15, which served as controls, were not exposed. New plants, aphids, and parasites were used each day.

The 150 sorghum plants required for the experiment were grown in the greenhouse and were selected for uniformity in height (ca. 4 in. tall) and number of leaves (2-3 per plant). Plants which were too tall or had too many leaves were trimmed to meet the specifications.

In order to obtain the desired densities and ages of greenbugs, 300 adult greenbugs were taken from cultures in the laboratory and placed in pairs on individual sorghum cuttings 6 days prior to the start of the experiment. The cuttings were partially submerged in wet sand contained in 1-ounce plastic cups. Then, every morning and evening through the duration of the experiment, the offspring of the adult aphids were removed from the cuttings with the aid of an artist's brush. Those aphids removed in the morning were discarded, and those removed in the evening were placed on large sorghum plants for incubation.

Beginning 11 days before the start of the experiment and continuing for the next 6 days, cultures of L. testaceipes were established on barley plants at the rate of 1 culture per day. This insured that a batch of newly-emerged parasites would be available on each trial day. The use of barley for the parasite cultures facilitated the isolation of individual aphid mummies into gelatin capsules, so that the newly-emerged female parasites had no exposure to either males or live greenbugs prior to the experiment. Only those females less than 12 hours old were used in the experiment.

Each morning of the experiment, the plants to be used on that day were infested with the various age-density combinations of greenbugs. An average of 300 aphids per day were transferred to the

experimental plants. The plants were then covered and labelled according to their treatment combinations. All available female parasites were then mated in the gelatin capsules to males chosen at random. When all pairs of parasites had been observed in copulation, 15 females were chosen at random, and each was placed inside one of the caged pots.

For the next 4 hours, all greenbugs which exited from any of the 30 plants were recorded on data sheets along with the approximate times of the exits. An aphid was considered to have exited from the plant when it no longer had bodily contact with the plant, at which time the aphid was removed from the caged pot with the aid of a brush. The 15 plants exposed to parasites were assigned a particular treatment arrangement, and the same arrangement was assigned to the control plants as well. The experiment was set up in a randomized block design with days as blocks. The treatment arrangements by day are shown in Table V (Appendix).

The total number of plants receiving any particular treatment combination was dependent upon the aphid density in that treatment. Treatments with lower densities would result in greater variances of the responses to those treatments. In order to adjust for this, more replications of the lower density treatments were run, so that any treatments containing a density of 5 were applied to 22 plants over the 5-day period as compared to 16 plants and 12 plants for densities of 10 and 20 respectively.

In order to determine the fate of aphids which would exit from the plant onto soil exposed to direct sunlight, a small scale study was performed. On a sunny day in July, 1973, near the forestry nursery

west of Stillwater, flats of soil were exposed to the sun, and greenbugs were knocked from infested sorghum plants onto the soil with a small artist's brush. Aphids were timed from the moment they hit the soil until they stopped all movement and death was apparent. Surface temperature of the soil was recorded with a Barnes infrared thermometer. The test was performed at about 2:30 p.m., and the air temperature was approximately 85° F.

Results and Discussion

The experiment was originally designed to detect a 15% difference between the plants exposed to parasites and the control plants at $P = 0.05$, thus showing the parasites to be responsible for increasing the incidence of greenbug exits. Only 0.9% of the aphids exited the control plants compared to 41.0% for the exposed plants, so it was obvious that parasite activity on the plants definitely disrupted the greenbug populations. Because the response from the 75 control plants was virtually nill, they were excluded from further analyses, and all aphid exits were assumed to be the result of parasite activity. Aphids ran, jumped, or were knocked from plants as a result of parasite activity, as was reported by Hight et al. (1972).

The alarm reaction caused by a pheromone produced by the parasitized aphids was a very important factor in causing aphids to exit from the plants. Many times, if a group of aphids were clustered on the stem, and one of the aphids was attacked by a parasite, the others would instantly react to the pheromone by springing from the plant onto the sand. Nault et al. (1973) reported this same reaction for the pea aphid, Acyrthosiphon pisum (Harris), and the green peach

aphid, Myzus persicae (Sulzer), when these two aphids were attacked by Nabis americoferus Carayon (Hemiptera: Nabidae). These aphids produce trans-β-farnesene, the same alarm pheromone produced by the greenbug. The pheromone appears in droplet form at the tips of the aphids' cornicles, following attack by a predator or parasite (Nault et al., 1973). Such early greenbug researchers as Webster and Phillips (1912) associated droplets at the tips of cornicles with attack by L. testaceipes. Figure 1 shows a greenbug producing pheromone following attack by L. testaceipes.

Figure 1. Greenbug Producing Pheromone Following Attack by L. testaceipes

Following the introduction of the parasites into the cages, there was tremendous variation in parasite activity from one plant to the next. Some parasites went to work almost immediately, searching the plants and parasitizing greenbugs. Others remained on the sides or tops of the cages for longer periods of time before beginning to search for hosts. In many cases, the parasites never showed any interest whatsoever in searching for hosts throughout the entire 4-hour period. Greenbug exits occurred from all plants with active parasites, but no exits occurred from plants which were exposed to inactive parasites. A total of 26 of the 75 exposed plants received inactive parasites, which caused the percentages of aphids exiting these plants to be 0's.

Because of the large number of 0's in the data, two separate analyses were performed. All data, including the 0 values, were considered in the first analysis, and only non-0 values were considered in the second analysis. Analysis of variance and regression procedures of the Statistical Analysis System (SAS) were used on an IBM 360 computer to analyze the data. The values in the data set, which were in the form of average percentages of aphids exiting plants, were transformed to angles to account for possible inequalities in treatment variances. The arcsine transformation described on pages 327-328 of Snedecor and Cochran (1967) was used. However, a comparison of the analyses of the transformed and untransformed data showed no appreciable differences between the two, so the transformation was not really necessary.

When all data, including 0's, were considered, the overall average percent of aphids exiting plants was 41.0. Table VI

(Appendix) shows the treatment averages in this analysis. Tables VII and IX (Appendix) give the average percentages for aphid ages and densities, respectively, when all data were considered. In this analysis, only the density factor was found to have a significant effect on the percentages of aphids exiting the plants. This effect was linear, as can be seen in Figure 2. Aphid density is represented on the abscissa, and the logarithmic scale is used, to allow for equal spacing of the density values.

Only the non-0 data were considered in the second analysis; and, in this case, the overall average percent of aphids exiting plants was 62.8 (see Table VI in Appendix). This higher percentage was to be expected, however, since the 0 values in the first analysis would obviously pull the averages down. See Tables VIII and X (Appendix) for the average percentages for aphid ages and densities, respectively, for this analysis. When the 0's were excluded from the analysis, the density factor ceased to be of significance. Table X clearly shows that there was almost no difference in the percentages between the three densities in the second analysis.

The significance of the density effect in the first analysis was apparently a result of the distribution of the inactive parasites over the various treatments. A 2×3 contingency table (Table XI in Appendix) was constructed to test for differences in the proportions of active and inactive parasites for the three density levels of aphids. The resulting X^2 value (2 d.f.) of 9.659 was easily significant at $P = 0.01$. It can be seen from the table that the proportion of inactive parasites was inversely related to aphid density. The larger proportion of inactive parasites on plants with a density of 5 aphids

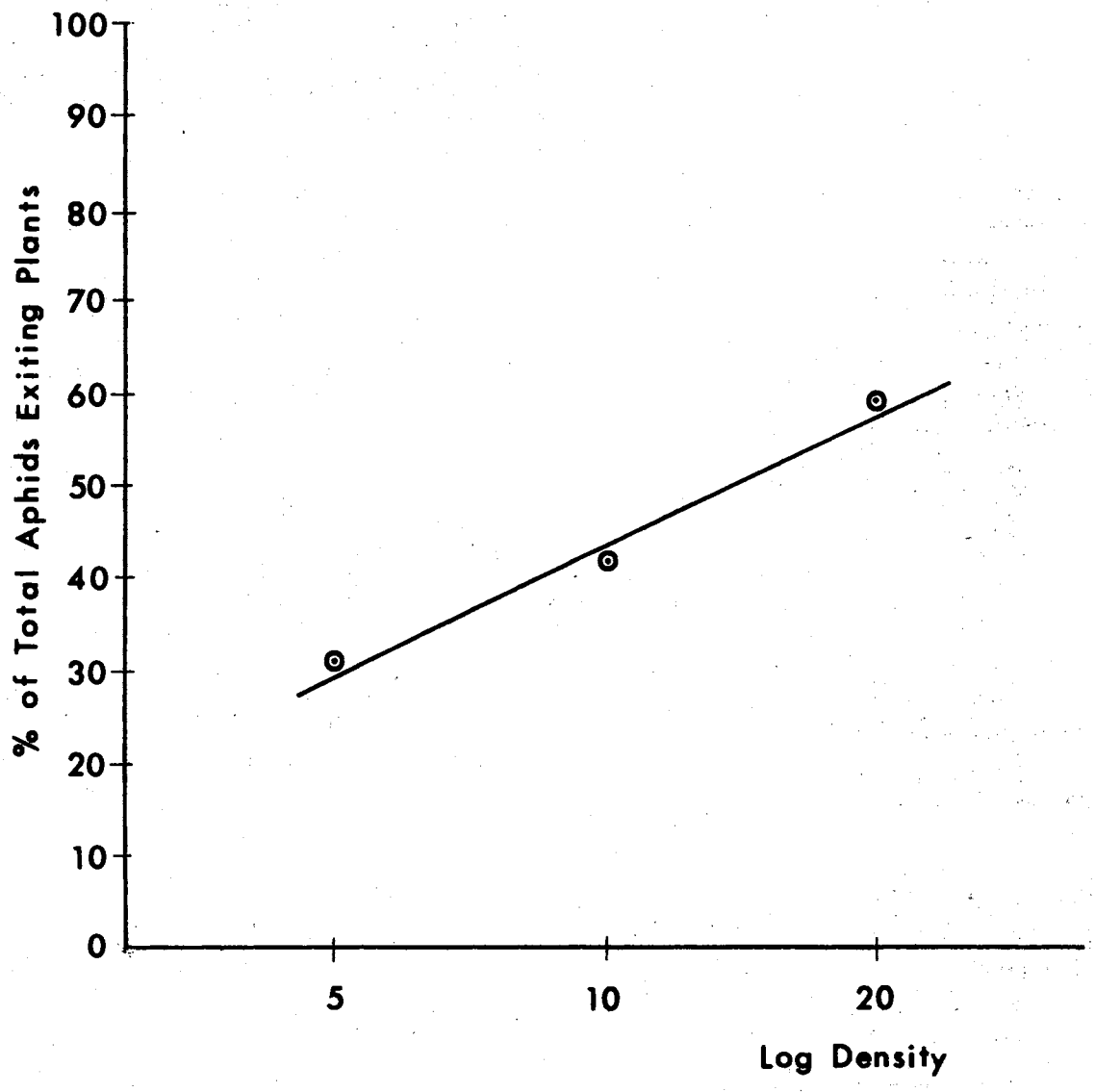

Figure 2. Relationship Between % Aphids Exiting Plants and Log Density of Aphids Per Plant

per plant pulled the average percentages of exits down for these treatments. This resulted in the linear effect of density on the percent of aphid exits (Figure 2).

The parasite inactivity could possibly be attributed simply to the variation between the parasites used in the experiment. Although measures were taken to standardize the parasites with respect to age and exposure to hosts, it was impossible to obtain complete genetic and physiological uniformity among the parasites. However, it is doubtful that parasite variation could be the only factor involved, considering the distinct inverse relationship between aphid density and the number of inactive parasites.

One possible explanation for the inverse relationship between aphid density and parasite activity is that of a general olfactory stimulus to the parasite by the aphids present. Schlinger and Hall (1960a), in reporting on the behavior of Praon palitans Muesbeck, stated that the parasite was not apparently attracted directly to spotted alfalfa aphids by odor, but that ". . . some odor given off by the aphid and/or its honeydew may act as a general attractant." It would seem logical for the strength of such a stimulus to be related to the number of aphids present. If this were the case with the greenbug and L. testaceipes, then the odor given off by 5 greenbugs would probably not be as effective in stimulating the parasite as would the odor given off by 20 greenbugs. This is pure speculation, however, and its verification or rejection would be dependent upon much further research.

Because of the limited number of aphids available to the parasites in the experiment, the parasites would sometimes attack the

same aphids again and again during the 4-hour period, striking them with the ovipositor many times. These aphids were not dissected and examined for parasite eggs, so it cannot be said whether or not superparasitism actually occurred. However, Sekhar (1958) reported superparasitism to occur in his experiments with L. testaceipes and Praon aguti Smith, when only small numbers of aphids were available to the parasites. More aphids were knocked from the plants as a result of the multiple attacks than would have been had they not occurred. Although it may be argued that this does not represent field conditions very well, Spencer (1926) reported, concerning L. testaceipes, that

> . . . when conditions are such that egg laying is vigorous, as on quiet, hot, sunny days, the parasite will attack aphids of any stage and will lay egg after egg in one individual if the supply of aphids is limited.

Conditions such as those described by Spencer (1926) would also be unfavorable for greenbug survival on the surface of soil exposed to direct sunlight. In the small scale test for greenbug survival on soil exposed to direct sunlight, none of the 28 aphids tested lived more than 10 seconds, with the average survival time being 4 seconds. Soil surface temperature ranged from 113° F. to 130° F., the fluctuation resulting from a slight breeze and occasional small clouds blocking the sunlight. This aphid mortality factor would of course be dependent upon such things as relative humidity, dampness of the soil surface, degree of shading by the plant canopy, wind, and cloudiness. However, in a field of young, seedling-stage sorghum plants on a quiet, hot, sunny day, this factor could be quite significant.

CHAPTER IV

SUMMARY

Newborn greenbugs less than 15 minutes old were as suitable hosts of L. testaceipes as were greenbugs which had mstured for $1\frac{1}{2}$ hours and 6 hours before being parasitized. Adult parasites emerging from these young greenbugs proved to be fertile and active when placed in their own greenbug cultures.

L. testaceipes, when active, caused an average of 62.8% of the greenbugs to exit from their host plants. Greenbugs exited by either running, falling, or jumping from the plant. Effects of the aphid alarm pheromone were very important in causing aphids to leave their host plants. Twenty-six of the 75 parasites used in the experiment were inactive, and the incidence of this inactivity was inversely related to aphid density on the plant. The fact that more inactive parasites occurred on plants with lower aphid densities resulted in a significant linear effect of density on the percentage of aphids exiting from plants. However, when the inactive parasites were disregarded, aphid density was no longer significant.

Greenbugs knocked from infested plants onto soil exposed to direct sunlight lived an average of four seconds, indicating that the forcing of greenbugs from their host plants by L. testaceipes could be a very important mortality factor under the proper conditions.

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APPENDIX

TABLE I

A COMPARISON OF RESPONSES OF THREE AGES OF FIRST-INSTAR GREENBUGS TO EXPOSURE TO LYSIPHLEBUS TESTACEIPES

Age of Aphid When Exposed (hr: min)	Results of Exposure to Parasite				Total
	No. Aphids Lived	No. Aphids Died	No. Mummies-- Emerging	No. Mummies-- Not Emerging	
0: 15	1	2	27	10	40
1: 30	3	5	23	9	40
6: 00	3	1	28	8	40
Total	7	8	78	27	120

X^2 (4 d.f.) = 3.56 -- Not significant at P = 0.05 ("Lived" and "Died" categories combined).

TABLE II

NUMBER OF FIRST-INSTAR GREENBUGS FORMING MUMMIES FOLLOWING EXPOSURE TO L. TESTACEIPES

	Aphid Age When Exposed to Parasite (hr: min)			Total
	0: 15	1: 30	6: 00	
Mummy Formed	37	32	36	105
No Mummy	3	8	4	15
Total	40	40	40	120

X^2 (2 d.f.) = 3.2 -- Not significant at P = 0.05

TABLE III

NUMBER OF MUMMIES YIELDING VIABLE ADULT
L. TESTACEIPES FOR THREE AGES OF
FIRST-INSTAR GREENBUGS

	Aphid Age When Exposed to Parasite (hr:min)			Total
	0:15	1:30	6:00	
Mummies Yielding Viable Adult	27	23	28	78
No Viable Adult	10	9	8	27
Total	37	32	36	105

X^2 (2 d.f.) = 0.38 -- Not significant at P = 0.05

TABLE IV

NUMBERS OF MALE AND FEMALE L. TESTACEIPES EMERGING FROM THREE AGES OF PARASITIZED GREENBUGS

Sex of Emerging Parasite	Aphid Age When Parasitized (hr:min)			Total
	0:15	1:30	6:00	
Male	16	13	21	50
Female	11	10	7	28
Total	27	23	28	78

X^2 (2 d.f.) = 2.22 -- Not significant at P = 0.05

TABLE V

NUMBER OF TREATMENT REPLICATIONS PER DAY FOR THE STUDY TO DETERMINE THE EFFECT OF L. TESTACEIPES ON GREENBUG EXITS FROM FEEDING SITES [b]

Treatment Age (a_i) × Density (d_j) [c]	Trial Day					Total
	1	2	3	4	5	
$a_1 d_5$	4	6	6	6	6	22
$a_1 d_{10}$	4	2	4	2	4	16
$a_1 d_{20}$	2	2	2	4	2	12
$a_3 d_5$	4	6	4	4	4	22
$a_3 d_{10}$	4	2	4	2	4	16
$a_3 d_{20}$	2	2	2	4	2	12
$a_5 d_5$	4	6	4	4	4	22
$a_5 d_{10}$	4	2	4	2	4	16
$a_5 d_{20}$	2	2	2	4	2	12
Total	30	30	30	30	30	150

[b] Half of the daily replications were exposed to parasites, and the others served as controls.

[c] i = 1, 3, and 5 days, and j = 5, 10, and 20 aphids per plant.

TABLE VI

AVERAGE PERCENTAGES OF TOTAL GREENBUGS EXITING FROM SORGHUM PLANTS EXPOSED TO ACTIVE AND INACTIVE *LYSIPHLEBUS TESTACEIPES*

Treatment (Age (a_i) × Density (d_j)) [c/]	All Exposed Plants		Exposed Plants -- Active Parasites Only	
	No. of Observations	Avg. % of Aphid Exits	No. of Observations	Avg. % of Aphid Exits
a_1d_5	11	29.1	6	53.3
a_1d_{10}	8	28.8	3	76.7
a_1d_{20}	6	41.7	6	44.7
a_3d_5	11	27.3	5	60.0
a_3d_{10}	8	57.5	7	65.7
a_3d_{20}	6	55.0	5	66.0
a_5d_5	11	36.4	6	66.7
a_5d_{10}	8	38.8	5	62.0
a_5d_{20}	6	79.2	6	79.2
	Total = 75	Grand Avg. = 41.0	Total = 49	Grand Avg. = 62.8

[c/] i = 1, 3, and 5 days, and j = 5, 10, and 20 aphids per plant.

TABLE VII

AVERAGE PERCENTS OF APHIDS EXITING PLANTS WITH RESPECT TO APHID DENSITY FOR ALL PLANTS EXPOSED TO PARASITES

Density (Aphids/Plant)	No. of Plants	Avg. % Aphids Exiting Plants
5	33	30.91
10	24	41.67
20	18	58.61

TABLE VIII

AVERAGE PERCENTS OF APHIDS EXITING PLANTS WITH RESPECT TO APHID DENSITY FOR ONLY THOSE PLANTS EXPOSED TO ACTIVE PARASITES

Density (Aphids/Plant)	No. of Plants	Avg. & Aphids Exiting Plants
5	17	60.00
10	15	66.67
20	17	62.06

TABLE IX

AVERAGE PERCENTS OF APHIDS EXITING PLANTS WITH RESPECT TO APHID AGE FOR ALL PLANTS EXPOSED TO PARASITES

Aphid Age (Days)	No. of Plants	Avg. % Aphids Exiting Plants
1	25	32.00
3	25	43.60
5	25	47.40

TABLE X

AVERAGE PERCENTS OF APHIDS EXITING PLANTS WITH RESPECT TO APHID AGE FOR ONLY THOSE PLANTS EXPOSED TO ACTIVE PARASITES

Aphid Age (Days)	No. of Plants	Avg. % Aphids Exiting Plants
1	15	53.33
3	17	64.12
5	17	69.70

TABLE XI

COMPARISON BETWEEN APHID DENSITY CLASSES OF NUMBERS OF PLANTS EXPOSED TO INACTIVE L. TESTACEIPES

	Aphid Density			
	5	10	20	Total
Plants With Inactive Parasite	16	8	1	25
Plants With Active Parasite	17	16	17	50
Total	33	24	18	75

X^2 (2 d.f.) = 9.659; $P < 0.01$

VITA[2]

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Master of Science

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