DISPERSAL BEHAVIOR OF *RHINONCOMIMUS LATIPES* KOROTYAEV

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Honors Bachelors of Science in Entomology with Distinction.

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ABSTRACT

Mile-a-minute weed weevils, (*Rhinocomimus latipes* Korotyaev) are biological control agents of mile-a-minute weed (*Persicaria perfoliata* (L.) H. Gross), an invasive Asian plant that has spread throughout much of the Mid-Atlantic United States. I set up two types of experiments: a habitat island experiment to look at dispersal of weevils in response to density and whether or not they prefer dispersing to plants with or without other resident weevils; and two distance dispersal experiments to study how far the weevils would disperse in response to a deteriorating habitat and if there were any differences between male and female dispersal behavior. Weevils did not disperse in response to overcrowding, but rather to a deteriorating habitat. They did not disperse at different rates to plants with or without conspecifics. Females tended to disperse farther away from the deteriorating habitat than males; both sexes were probably maximizing their own reproductive success. Males probably remained close to the deteriorating habitat because there was an established weevil population present. This population would provide females with whom the males could mate. Once females have been mated, they do not need to exist near other weevils. Instead, they flew to farther away locations of healthy mile-a-minute weed so that their young would mature in an optimum habitat and have the best chance of survival.

Chapter 1

INTRODUCTION

Mile-a-minute weed (*Persicaria perfoliata* (L.) H. Gross) is an invasive plant species native to China, Japan, Korea, the Philippines, Formosa, and India (Moul 1948). The species was first introduced in the eastern United States in the 1930s to a nursery in York county, Pennsylvania (Moul 1948). From its introduction until the present, mile-a-minute weed has spread as far as Massachusetts, Ohio, and West Virginia (Hough-Goldstein et al. 2008a).

Mile-a-minute weed has a negative effect on native ecosystems in the eastern United States because it germinates early in the spring. This early growth period gives the annual vine an advantage over many native species (Lake 2007). The plants are able to grow over and outcompete other species creating monocultures of mile-a-minute weed. Since this is a non-native plant, native insects that have not coevolved with it are not as able to feed on the plant (Zuefle et al. 2008). As with all invasive species, this lack of predators allows the plants to grow unchecked throughout the season.

Classical biological control programs manage invasive plants and animals with parasites, pathogens, and predators which originated in the pest's native range (Newman et al. 1998). Introduction of biological control agents of plants in the U.S. is regulated by the Animal and Plant Health Inspection Service (APHIS), a subset of the U.S. Department of Agriculture (Harris 1993 and Crutwell-McFayden 1998). Permits from APHIS are required for importation of plant pests by anyone in the U.S. and its territories (USDA-APHIS). Researchers perform host-specificity testing on potential biological control agents in quarantine before they are allowed to be released (DeLoach 1991).

Mile-a-minute weed weevils (*Rhinoncomimus latipes* Korotyaev) were identified as herbivores of mile-a-minute weed (Wu et al. 2002). *R. latipes* is highly host specific; in trials it could not reproduce on any other plant species, even those within the same genus as mile-a-minute weed (Colpetzer et al. 2004a). In 2004, *R. latipes* was approved by the USDA for release and it has been released as a biological control agent in Delaware, Maryland, New Jersey, Pennsylvania, and West Virginia.

Previous research has shown that weevils are effective at controlling mile-a-minute weed. In cage tests, mile-a-minute weed plants that were exposed to 10, 20, or 40 weevils suffered greater mortality and delayed seed production than control plants (Hough-Goldstein et al. 2008b). When feeding damage was simulated in the laboratory, all small mile-a-minute weed plants died (Colpetzer et al. 2004b). Weevils are able to negatively affect mile-a-minute weed plants through mortality and decreased seed production in confined settings. To maximize effectiveness of the control, the weevils must be able to disperse to and colonize new patches of mile-a-minute weed.

In 2005, the first summer and fall following release, the weevils dispersed beyond a tree line and hay fields lacking mile-a-minute weed before colonizing host patches up to 200 m away (Lake 2007). The next year the weevils dispersed up to 760 m from the original release site (Lake 2007). Weevils have been found as far away as 18 miles from the nearest release site (Lake, personal communication). Weevils, in general, are not known to have a defined dispersal or migratory period; long-distance dispersals are probably a result of being blown in the wind (Furniss 2004, Furniss and Kegley 2006, Showler 2006). In terms of short-distance dispersals, another herbivorous host-specific Coleopteran species, *Trirhabda virgata* LeConte, has been shown to disperse with increasing population and defoliation of the host plant (Herzig 1995). Male and female *T. virgata* dispersed to different types, quality and population levels of host patches (Herzig and Root 1996).

To effectively control the mile-a-minute weed invasion, the patterns and methods of weevils' dispersal must be discovered. Researchers and landowners need to know if weevils can find new patches of mile-a-minute weed on their own or if they need to manually take the weevils to all mile-a-minute weed sources for efficient control of an infested area.

The objectives of this study were to determine whether *R. latipes* dispersal occurs in response to a high density of conspecifics; whether dispersing weevils are more likely to find host patches with or without conspecifics; how far weevils were likely to disperse when faced with a declining food source; and whether there were any differences in male vs. female dispersal behavior.

Chapter 2

MATERIAL AND METHODS

Habitat Island Experiment

For the first experiment, twelve habitat islands consisting of circular patches of mile-a-minute weed one meter in diameter were created in White Clay Creek State Park along a tree line bordering a hay field near the nature center. All plant material was removed from a one-meter-wide ring outside each habitat island. Any weevils that were found on the mile-a-minute weed plants in the central island were collected and moved to a different patch of mile-a-minute weed in the park. Mile-a-minute weed plants in each habitat island were counted and equalized to ten plants per island by pulling excess plants. The majority of the mile-a-minute weed plants were small, less than 30 cm in height. Besides mile-a-minute weed, Japanese stilt grass (*Microstegium vimineum* (Trin.) Camus) was the dominant plant in the habitat islands. The plots were created in partial shade; the different blocks had varying amounts of sunshine and shade.

Four replicates of three treatments of weevil density were set up in a randomized complete block design (Figures 1 and 2). The low, medium, and high density treatments had 1, 10, and 20 weevils added respectively to each plant, or 10, 100, and 200 weevils per habitat island. The New Jersey Department of Agriculture

Beneficial Insect Laboratory in Trenton, New Jersey supplied the weevils for the experiment. The weevils were collected such that the male to female ratio was approximately 50:50. Male weevils tend to emerge as adults approximately one to two days prior to females (Colpetzer et al. 2004b). Early and late emerging weevils were combined to help assure equal numbers of each sex. The weevils were shaken in luminous powder (Bioquip Products, Gardena, CA). Low-density weevils were marked with yellow, medium-density weevils with red, and high-density weevils with blue. The purpose of the powder was to distinguish between weevils that were released for this experiment and those which originated elsewhere. The other weevils were recorded as "wild." Within each block, the islands were three to five meters apart. The blocks were five meters apart. Treatments were randomly assigned within each block.

Around each habitat island in the ring where all plant material had been removed, six potted mile-a-minute weed plants, grown from seed in the greenhouse and approximately one month old, were placed equidistant from each other and one meter from the middle of the plot. The six potted plants alternately had 15 weevils or no weevils present (Figure 1). These "resident" weevils were prevented from flying away and were distinguished from dispersers by painting their elytra shut with green enamel paint (The Testor Corporation, Rockford, IL). "Resident" weevils were placed on potted plants in the greenhouse on 21 June, 2008. Potted plants were transported to the field site in plastic garbage bags and marked weevils were added to the habitat islands on 24 June.

Mylar sheets (21.6 x 28 cm) covered with spray-on Tangle-Trap sticky coating (The Tanglefoot Company, Grand Rapids, MI) on both sides were set up on poles between the potted plants, to catch dispersing weevils from the habitat islands that did not land on the trap plants, or weevils dispersing to the habitat islands from outside the plots. There were six poles per island, and each pole had two mylar sheets attached to it, one at 1 meter and one at 2 meters above the ground.

The potted plants were watered and both plants and Mylar sheets were checked daily from 24 June to 1 July, 2008 for weevil migrants. The dispersing weevils were collected each day, returned to the lab, and sexed using external features (Korotyaev 2006) under the microscope. The number of each sex on plants with and without "resident" weevils was recorded.

On 2 July, 2008, the day after the experiment ended, mile-a-minute plants and remaining weevils in each habitat island were counted and percent defoliation was estimated.

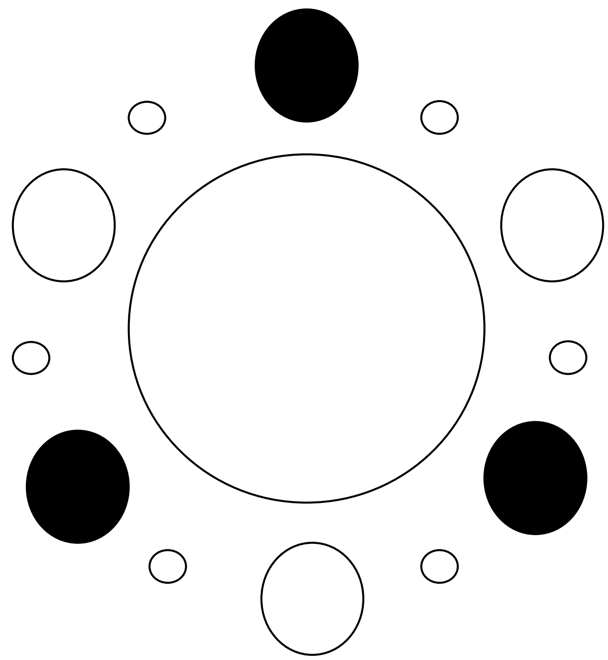


Figure 1. Map of habitat island experiment. The large central circle designates the habitat island. The medium sized circles represent the trap plants. The black circles show trap plants with resident weevils and the white are without conspecifics. The small circles represent poles with mylar sheets.

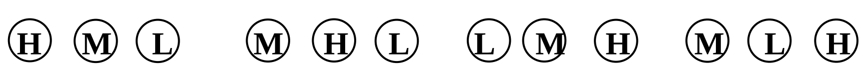


Figure 2. Diagram of habitat island set up. H= high treatments, M = medium treatments, L= low treatments. Distance between treatments in a block ~3 m. Distance between blocks ~5 m.

Distance Dispersal Experiment, 0.5-15.5 m

On 22 July, 2008, 25 one-month-old, potted mile-a-minute weed plants were placed in a hay field bordering a tree line with a substantial mile-a-minute weed population, located approximately 15 meters from the habitat island experiment. The plants were set up five across, with two meters between each plant. The distances away from the mile-a-minute source were: first row 0.5 meter, second row 1.5 meters, third row 3.5 meters, fourth row 7.5 meters, and the fifth row 15.5 meters (Figure 3).

The mile-a-minute weed source had evidence of a substantial existing weevil population including node damage, eggs, feeding damage, and adult weevils. Mile-a-minute plants along an eight-meter-long section nearest to the rows of potted plants were cut as low to the ground as possible so the plants would desiccate, simulating a declining food source. The weevil population was supplemented with approximately 20 additional weevils from a nearby area once per week during the experiment, which ran for 24 days, from 22 July to 14 August. These weevils were collected by cutting other infested mile-a-minute weed foliage and placing it on top of the original mile-a-minute weed source.

Each potted plant was watered and checked daily for weevil migrants. The weevils were collected and sexed in the laboratory, under the microscope using external features (Korotyaev 2006). The number of each sex on the individual plants was recorded.

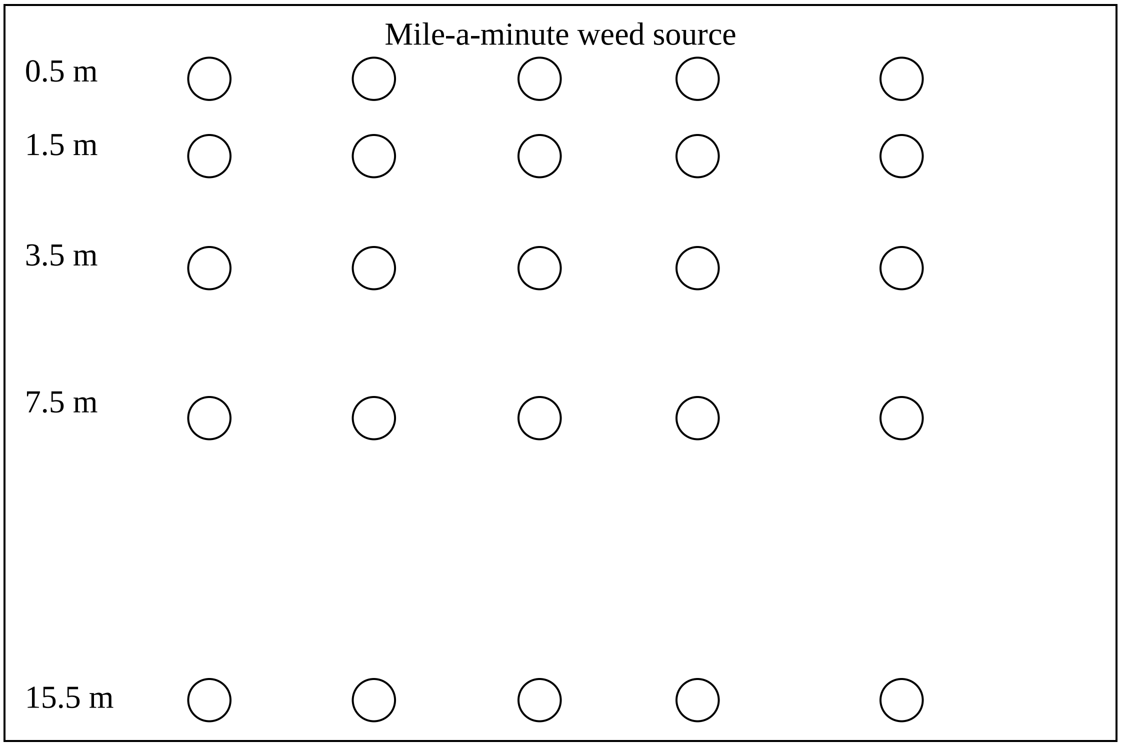


Figure 3. Diagram of distance dispersal experiment, 0.5-15.5 m. Circles represent trap plants.

Distance Dispersal Experiment, 4-28 m

One week after the initial set up of the first distance dispersal experiment, an additional 15 plants were placed in the field adjacent to the original 25, also with a substantial mile-a-minute weed population along the edge of the woods. These potted plants were also in rows of five with 2 meters in between each plant. Their distances away from the mile-a-minute weed source were: first row 4 meters, second row 12 meters, third row 28 meters (Figure 4). Again an eight-meter-long patch of mile-a-minute weed along the tree line nearest to the rows of potted plants was cut at the base of the plants so the weevils would disperse. The weevil population was supplemented with weevils on cut mile-a-minute weed once per week during the experiment, which ran for 17 days, from 29 July to 14 August, 2008. Weevils on these potted plants were also collected daily and sexed in the laboratory as for the first distance dispersal experiment.

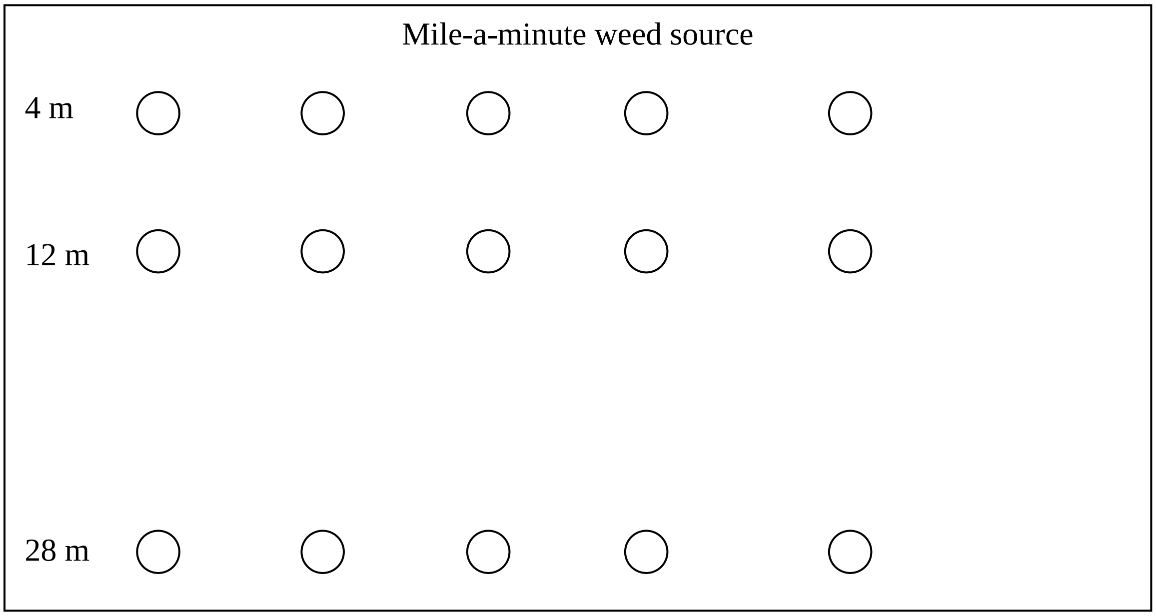


Figure 4. Diagram of distance dispersal experiment, 4-28 m. Circles represent trap plants.

Statistical Analysis

For the habitat island experiment, the average number of weevils collected and the standard error of the mean (SEM) was calculated each day for plants with and without conspecifics, using all treatments (high, medium, and low) and then only with the high and medium treatments. The daily and total numbers collected on plants with and without conspecifics were compared using two-tailed paired t-tests. The average number and percent of weevils along with the SEM dispersing from the high, medium, and low treatments collected on the surrounding potted plants was also calculated. A two-way ANOVA analysis by block and treatment was performed. For the percent data, the numbers were arcsin-square root transformed for analysis. The average number of mile-a-minute weed plants (of 10) remaining in the center islands after eight days, the estimated percent defoliation of these plants, the average number and percent of weevils remaining in the center islands, and the SEM was found for each of the treatments, high, medium, and low. A two-way ANOVA analysis by block and treatment was conducted. The percent values were arcsin-square root transformed for analysis. A regression analysis was conducted between the percent defoliation of the central plants and the percent of weevils that dispersed from these plants onto potted plants. The average number and SEM of males and females that dispersed onto potted plants from medium and high treatments each day and the total that dispersed was found. Two-tailed paired t-tests were performed to compare male and female dispersal.

For the distance dispersal experiments, the daily cumulative number of male and female weevils dispersing to each of the different distances was found. For each day, a two-tailed paired t-test was performed to look for differences between males and females. The average number and SEM of male, female, and total weevils that dispersed to the five potted plants at each distance were determined. A two-way ANOVA and LSD analysis was performed on the data to compare the numbers of weevils collected at the different distances.

Chapter 3

RESULTS

Habitat Island Experiment

Dispersal to trap plants with and without resident weevils

The average number of dispersing weevils collected on plants with and without resident weevils did not differ significantly for any individual day, or for the eight-day totals, whether all 12 plots were analyzed (Table 1), or just the eight that started with high or medium numbers of weevils released (Table 2). Therefore, in subsequent tests, the numbers of weevils on both types of plants were considered together.

Table 1. Average numbers of weevils (mean ± SEM) collected from plants with and without resident weevils

	Day								
	1	2	3	4	5	6	7	8	Total
With Residents	0.5 ± 0.4	0.8 ± 1.2	4.1 ± 1.2	5.7 ± 1.7	0.7 ± 0.2	3.2 ± 0.9	1.7 ± 0.5	3.0 ± 0.9	18.2 ± 5.3
Without Residents	0.7 ± 0.4	1.0 ± 0.3	0.9 ± 0.3	1.2 ± 0.3	0.8 ± 0.2	1.2 ± 0.4	0.6 ± 0.2	2.3 ± 0.7	7.2 ± 2.1
P	0.551	0.894	0.241	0.294	0.438	0.283	0.107	0.116	0.168

N = 12 plots, each with three plants with and three plants without resident weevils. *P* is based on paired, two-tailed t-test for weevils collected each day and for the total number of weevils collected throughout the experiment.

Table 2. Average numbers of weevils (mean ± SEM) collected from plants with and without resident weevils, high and medium treatments only									
Day									
	1	2	3	4	5	6	7	8	Total
With Residents	0.6 ± 0.6	1.1 ± 0.7	2.6 ± 1.7	3.1 ± 2.4	0.5 ± 0.3	3.0 ± 1.3	1.6 ± 0.7	4.1 ± 1.0	16.9 ± 7.2
Without Residents	1.0 ± 0.5	1.3 ± 0.4	0.8 ± 0.4	0.9 ± 0.5	0.8 ± 0.3	1.6 ± 0.4	0.4 ± 0.3	2.1 ± 0.9	9.4 ± 3.3
P	0.351	0.897	0.250	0.305	0.451	0.293	0.106	0.116	0.181

N= 8 plots, each with three plants with and three plants without resident weevils. *P* is based on paired, two-tailed t-test for weevils collected each day and for the total number of weevils collected throughout the experiment. The low treatments were not considered for this analysis because only one weevil was collected from a low treatment plot throughout the duration of the experiment.

<u>Dispersal from plants with high, medium, and low weevil populations</u>

An analysis of the total number of weevils dispersing from the high, medium, and low treatments onto the potted plants during the 8-day experiment revealed that although more weevils dispersed from the high treatment than the low treatment the difference was not significant due to high variation within the treatments (Table 3). There was also no significant difference in the percentage of weevils dispersing from each of the three treatments (Table 3).

Table 3. **Average number and percent of weevils (mean ± SEM) dispersing from plants with high, medium, and low initial densities**		
Treatment	Number	Percent
High (200 weevils added)	32.8 ± 17.4	16.4 ± 8.7
Medium (100 weevils added)	16.3 ± 6.4	16.3 ± 6.4
Low (10 weevils added)	0.3 ± 0.3	2.5 ± 2.5
F value	3.22	2.18
P value	0.1122	0.1850

N= 4 replicates per treatment. Statistical analysis (two-way ANOVA, by block and treatment) on percent conducted on arcsin- transformed values, but original means are shown.

Dispersal from deteriorating host plants

During the eight-day experiment, the average number of mile-a-minute weed plants left in the habitat islands decreased due to plant mortality in all three treatments (Table 4). Individual habitat islands that had few mile-a-minute weed plants remaining following the eight-day experiment, and/or heavy defoliation of those that were left also tended to have high dispersal, i.e. a low percent of weevils remaining in the center and more weevils collected from potted plants surrounding the islands, regardless of the initial weevil densities. The high-density treatment had significantly higher defoliation than the medium and low treatments (Table 4). Although not highly significant (*P*= 0.10), the high density treatment also had a lower percent of weevils remaining in the habitat islands at the end of the experiment. There was a strong correlation (R^2=0.6907) between the percent defoliation of the plants within the habitat islands and the tendency for the weevils to disperse (Figure 5). The tendency to disperse here is based on the percent of weevils collected from the potted plants.

The highest dispersal was found in the medium and high treatments in block three, which also had very high defoliation levels on the central plants (Figure 5).

Table 4. Average (mean ± SEM) number of mile-a-minute weed plants remaining (of 10) after eight days, estimated percent defoliation, number (mean ± SEM) of weevils remaining in the center island, and percent of weevils remaining in the center with initial high, medium, and low densities of weevils

Treatment	Number of plants remaining	Percent defoliation	Number of weevils remaining	Percent of weevils remaining
High (200)	6.7 ± 1.79	63.7 ± 12.14A	9.0 ± 3.76	4.5 ± 1.88
Medium (100)	8.5 ± 1.50	37.5 ± 14.36AB	12.7 ± 3.40	12.7 ± 3.40
Low (10)	8.0 ± 1.41	11.2 ± 3.15B	3.5 ± 1.44	35.0 ± 14.43
F value	0.3300	5.690	2.3300	3.0100
P value	0.7300	0.0253	0.1525	0.1000

N= 4 replicates per treatment. Statistical analysis (two-way ANOVA, by block and treatment) on percent conducted on arcsin- transformed values, but original means are shown. Means followed by same letters are not significantly different (ANOVA, LSD P=0.05)

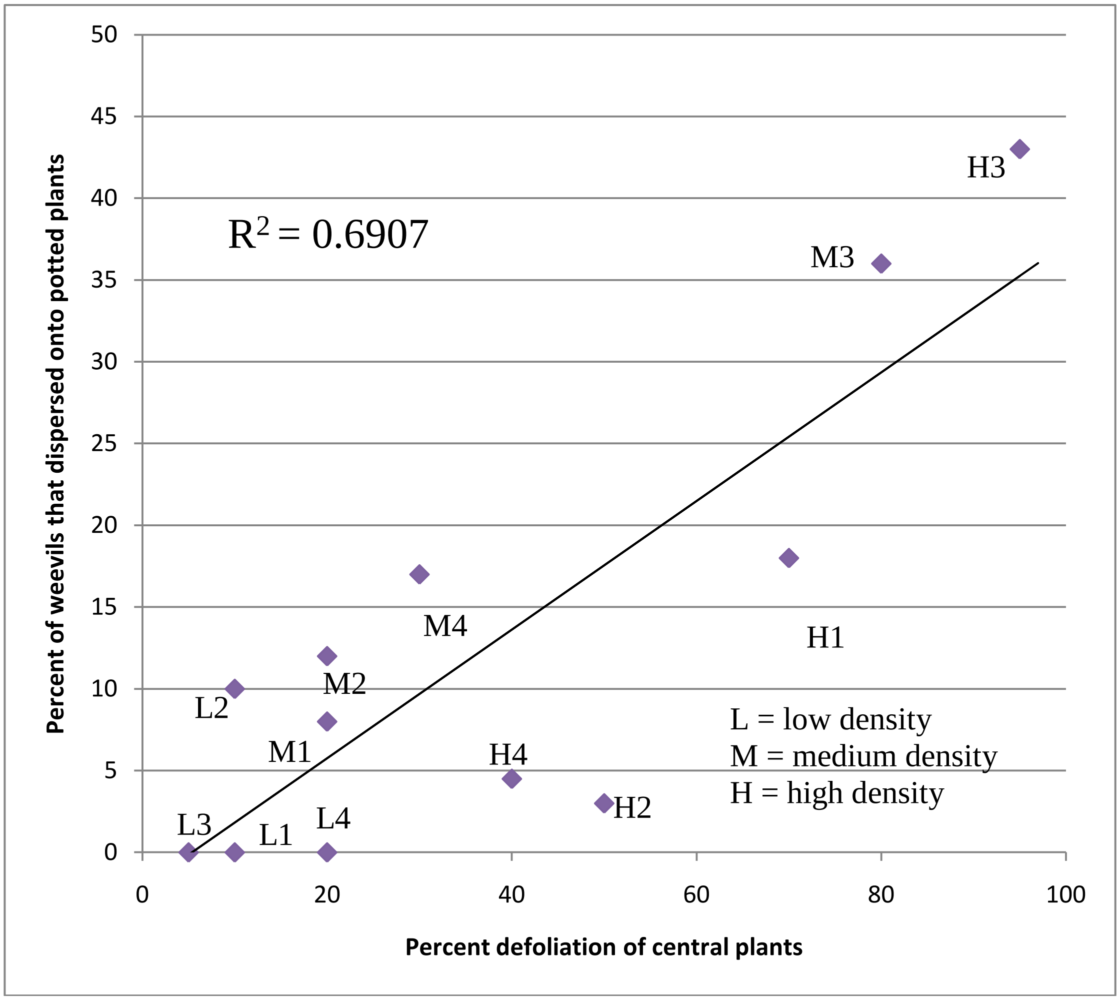


Figure 5. Correlation between plant defoliation and tendency of weevils to disperse

Number of male and female weevils that dispersed

The number of males and females that dispersed each day and the total number of male and female weevils that dispersed over the duration of the experiment onto the potted plants surrounding the islands were compared using two-tailed, paired t-tests. Data from the "low" treatment were not included because only one weevil was collected from the potted plants from this treatment. Significantly more males than females dispersed on days three, six, eight and for the total number of weevils that dispersed (Table 5). More than four times as many males as females were collected on the potted plants over all eight days.

Table 5. Average numbers (mean ± SEM) of males and females that dispersed onto potted plants from medium and high treatments each day, and total.

	Day								
	1	2	3	4	5	6	7	8	Total
Males	1.1 ± 0.3	1.4 ± 0.5	2.3 ± 1.2	3.8 ± 2.3	1.0 ± 0.4	4.1 ± 1.5	1.6 ± 0.7	4.0 ± 1.3	19.8 ± 7.9
Females	0.5 ± 0.4	1.0 ± 0.4	1.1 ± 0.9	0.3 ± 0.2	0.3 ± 0.2	0.4 ± 0.2	0.4 ± 0.2	0.5 ± 0.3	4.4 ± 1.4
P	0.180	0.504	0.015*	0.229	0.111	0.052*	0.106	0.020*	0.052*

Two-tailed paired t-test comparing average numbers of males and females collected from potted plants surrounding medium and high-density plots (N= 8)
*$P \leq 0.05$

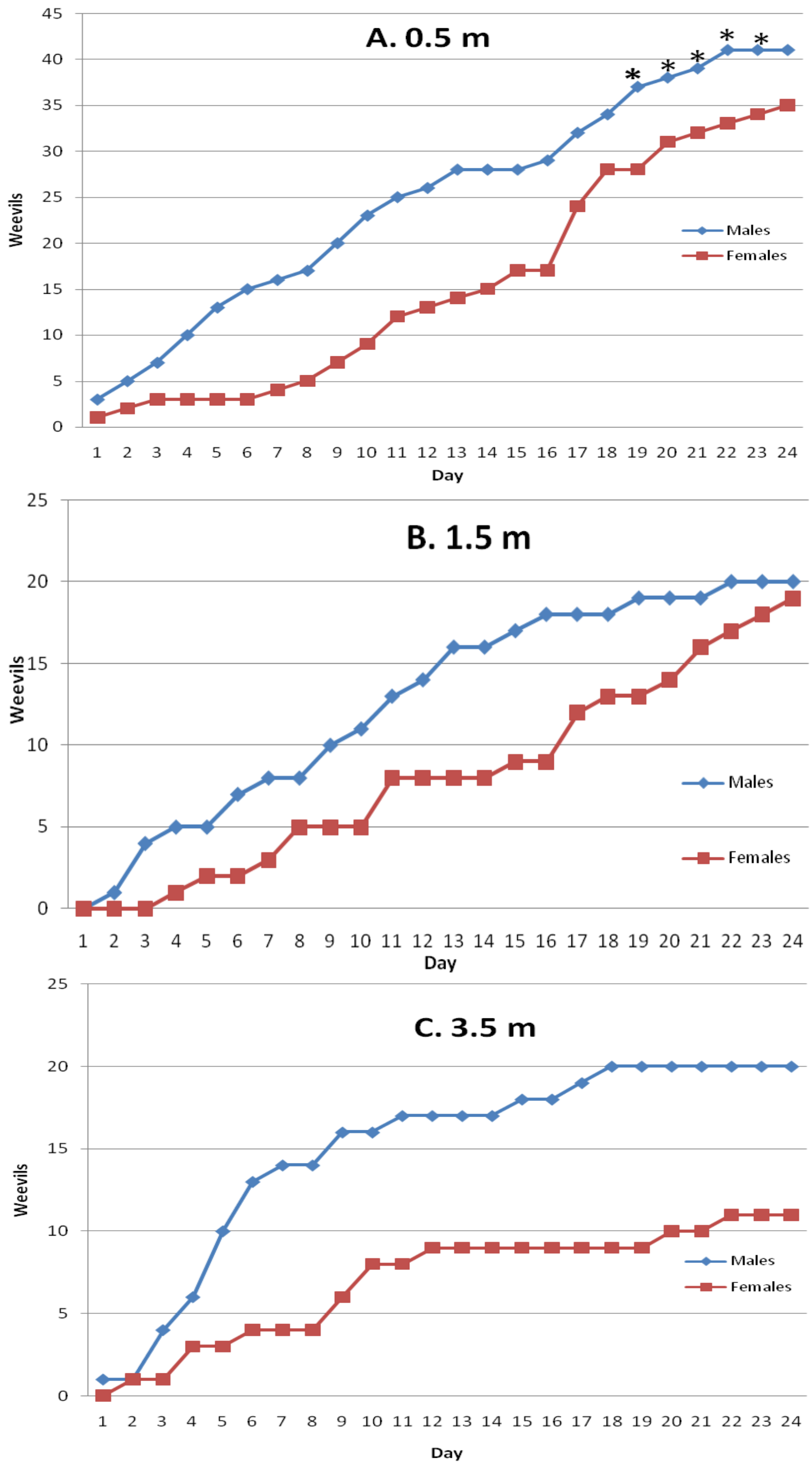
Collection from the mylar sheets

No *R. latipes* adults were collected on the mylar sheets, although other insects of similar and greater size and weight such as *Coccinellidae* and *Buprestidae* beetles were found on the sheets. To become stuck to the mylar sheets, the weevils would have needed to fly straight up and then out. The weevils probably did not fly in this fashion, so the lack of weevils on the mylar sheets was probably due to a design flaw.

Distance Dispersal Experiment, 0.5-15.5 m

Figure 6 shows the cumulative total number of male and female weevils collected from all five potted plants set up at each of the five distances from the source population in the first distance dispersal experiment, ranging from 0.5 to 15.5 m. There was a great discrepancy between males and females in the distance away from the mile-a-minute patch and the time frame in which the weevils dispersed. Male weevils tended to leave the source first and did not travel as far as females. Male weevils were generally more abundant than females on potted plants up to 3.5 m away, although this difference was only significant for the plants 0.5 m from the source on days 18-24 (Figure 6 A-C). Female weevils generally dispersed after at least one day of waiting on the host plant. They tended to travel farther than males, with more females than males found at 7.5 m (Figure 6 D) and only females found at 15.5 m (Figure 6 E).

There were significantly more males on plants closer to the source than those farther away (Table 6). There was no significant difference between the numbers of females dispersing to the different distances (Table 6). The total cumulative numbers collected were greater at the distances closer to the source (Table 6).



A. 0.5 m
B. 1.5 m
C. 3.5 m
Weevils
Day
Males
Females
*
0
5
10
15
20
25
30
35
40
45
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

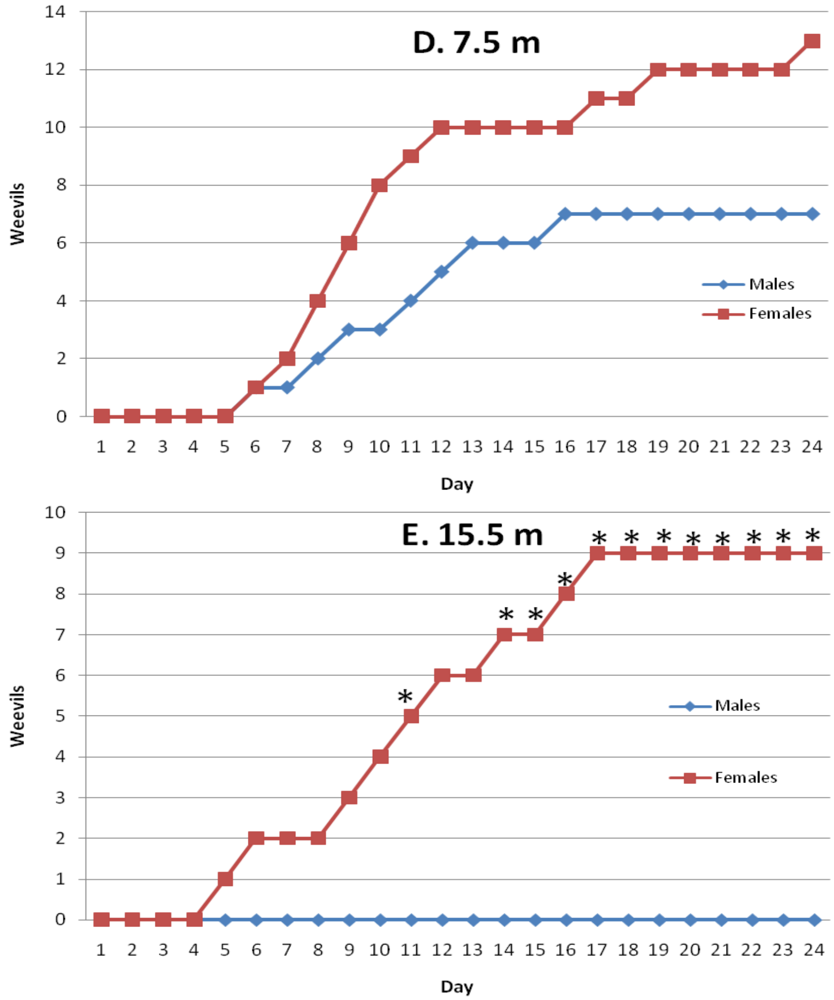


Figure 6. Cumulative number of male and female weevils dispersing A. 0.5 m, B. 1.5 m, C. 3.5 m, D. 7.5 m, E. 15.5 m. *, significant difference in cumulative number of males versus females (N = 5 plants at each distance, 2-tailed paired t-test, $P \leq 0.05$)

Table 6. Average number of male, female, and total weevils per potted plant (mean ± SEM) dispersing to potted plants at different distances from the source population			
Distance	Males	Females	Total
0.5 m	0.3 ± 0.10 A	0.3 ± 0.10	0.6 ± 0.30 A
1.5 m	0.2 ± 0.10 AB	0.2 ± 0.10	0.3 ± 0.10 AB
3.5 m	0.1 ± 0.10 AB	0.1 ± 0.030	0.2 ± 0.10 B
7.5 m	0.1 ± 0.02 B	0.1 ± 0.10	0.2 ± 0.04 B
15.5 m	0.0 ± 0.00 B	0.1 ± 0.10	0.1 ± 0.01 B
F value	3.80	1.75	2.89
P value	0.0234	0.1891	0.0565

N= 5 replicates per treatment. Mean followed by the same letter are not significantly different (2-way ANOVA, LSD *P*= 0.05)

<u>Distance Dispersal Experiment, 4-28 m</u>

When the experiment was repeated using 4, 12, and 28 m distances, the cumulative number of weevils collected was again higher on the potted plants closer to the mile-a-minute source (Figure 7, Table 7). More females than males were collected at all three distances, although the numbers were small and the difference was not significant. Only one male was collected off of a potted plant at 12 m, while three females were collected. As with the potted plants at 15.5 m in experiment two, no males were collected from the potted plants at 28 m; two females were collected. When looking at males, females, and the total number of weevils that dispersed, in all cases significantly more weevils dispersed to the closest distance, 4 m, than the farther distances, 12 m and 28 m (Table 7).

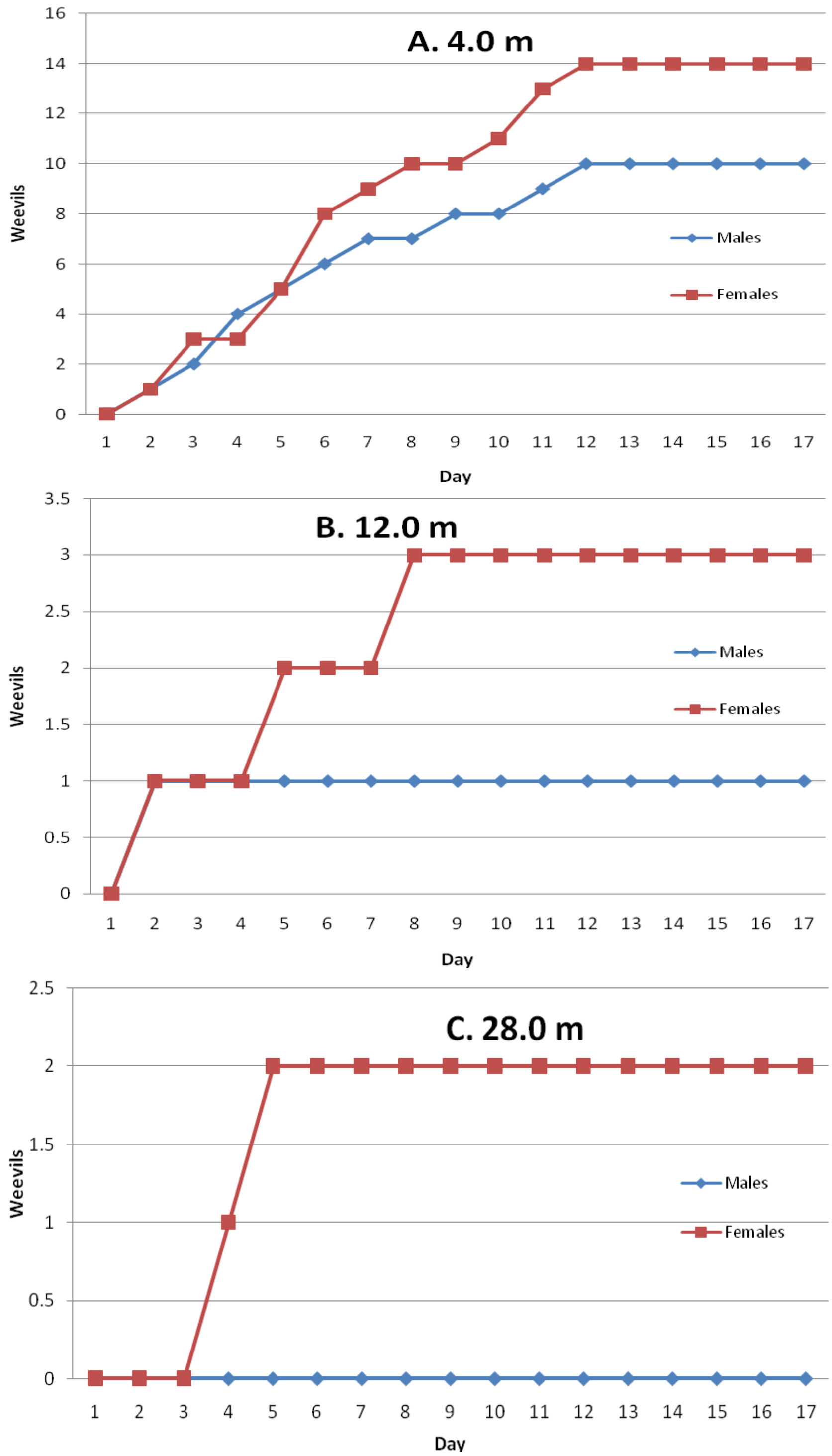


Figure 7. Cumulative number of male and female weevils dispersing, A. 4.0 m, B. 12.0 m, C. 28.0 m

Table 7. Average number of male, female, and total weevils (mean ± SEM) dispersing to potted plants.

Treatment	Males	Females	Total
4.0 m	0.10 ± 0.02 A	0.2 ± 0.1 A	0.3 ± 0.1 A
12.0 m	0.01 ± 0.01 B	0.02 ± 0.01 B	0.04 ± 0.01 B
28.0 m	0.00 ± 0.00 B	0.02 ± 0.01 B	0.02 ± 0.01 B
F value	15.67	5.90	11.45
P value	0.0017	0.0267	0.0045

N= 5 replicates per treatment. Mean followed by same letters are not significantly different (ANOVA, LSD *P*= 0.05)

Chapter 4

DISCUSSION

The first objective of this study was to determine whether *R. latipes* dispersal occurs in response to a high density of conspecifics. There was no direct connection revealed in the habitat island experiment between weevil density and dispersal, but the high density islands had significantly higher mile-a-minute weed defoliation than the low density treatment. Increased defoliation was linked to increased dispersal. There was a strong correlation between deteriorating mile-a-minute host quality and percent of weevils that dispersed from the habitat islands. The act of leaving a deteriorating habitat is not unique to *R. latipes*. For example, boll weevils, *Anthonomus grandis grandis* (Boheman), disperse from cotton fields after the cotton has been harvested (Showler 2003). Approximately 90% of trap-captured boll weevils were collected during and after cotton was harvested (Guerra and Garcia 1982).

The second objective was to see whether dispersing weevils are more likely to find host patches with or without conspecifics. In other Coleoptera, males have been shown to produce aggregation pheromones, which attract both male and female conspecifics. Males of many species of weevils including the pine weevil (*Hylobius abietus* (L.)), agave weevil (*Scyphophorus acupunctatus* (Gyllenhal)), cactus weevil (*Metemasius spinolae* (Gyllenhal)), sugar-beet weevil (*Bothynoderes punctiventris* (Germar)), and Cano weevil (*Anthonomus eugenii* (Cano)) produce an aggregation pheromone (Leather et al. 1999, Ruiz-Montiel et al. 2008, Tafoya et al. 2007, Cibrián-Tovar et al. 2005, Tóth et al. 2007, Patrock et al. 1992). A chrysomelid beetle, *Trirhabda virgata* (LeConte), was also found to disperse to its host, goldenrod (*Solidago altissima* (Messina)), when there were conspecifics already inhabiting the plants (Herzig 1995). However, in my experiment *R. latipes* were not more likely to be found on plants with resident weevils than on plants without resident weevils. There was no indication that either male or female weevils were responding positively or negatively to the presence of conspecifics.

The third objective of this study was to find out how far weevils were likely to disperse when faced with a declining food source. In both of my distance dispersal experiments, *R. latipes* adults were able to find isolated, potted mile-a-minute weed plants at all distances tested from 0.5- 28 m from the source population beginning one day after the experiments began. However, significantly more weevils reached the closer plants in both distance dispersal experiments (0.5 m in the first experiment vs. 3.5, 7.5, and 15.5m; 4 m in the second experiment vs. 12 and 28 m). Similar results were found with boll weevils following cotton harvest: most of the boll weevils collected did not move beyond 30 m from the edge of the cotton field (Showler 2003).

Dispersal may have been by walking in the habitat island experiment and to the closest potted plants in the distance dispersal experiments, but must have been by flying to the further distances. *R. latipes* adults are 2.0-2.5 mm in length so it is unlikely that a weevil found on a plant 28 m from the source population after four days or one at 12 m after only two days had walked that distance. Wolf spiders and carabid beetles, both generalist predators, were frequently seen on the ground, making walking to farther away plants too dangerous. The distance dispersal experiments were conducted in an uncut hay field; the dense vegetation would also have made walking to distant plants difficult. In another study, most dispersing boll weevils were seen to fly rather than walk away from cotton modules or bales (Sappington et al. 2006).

The final objective of this study was to establish whether there were any differences in male vs. female dispersal behavior. In the habitat island experiment, more than four times as many males as females were collected on the potted plants, which were located within about one meter of the source population. Similarly, in the distance dispersal experiments, more males than females were collected at the closest distances. However, beyond approximately 3-4 m, more females than males were collected, with only females at 15.5 and 28 m.

Male and female weevils behaved differently in their dispersal behavior, presumably so as to maximize their own survival and reproductive success. Male weevils had a tendency to disperse primarily to distances ≤ 3.5 m. This preference for remaining closer to the deteriorating source could be to intercept newly emerging females, which emerge ~2 days after males (Colpetzer et al. 2004b). Previous studies have shown that eggs are laid continuously and generations appear to overlap, meaning that adult weevils could be emerging continuously late in the season (Lake 2007).

Female weevils did not begin to disperse immediately after the mile-a-minute source was cut. Research has shown that boll weevils do not leave harvested cotton fields simultaneously, but rather continuously for several days (Jones and Coppedge 1999). Flying long distances is energetically taxing; they might continue to feed on the host in its early stages of deterioration to prepare for their dispersal. Some female weevils were collected on potted plants close to the mile-a-minute weed source, perhaps to find a mate or to obtain more nutrition before flying to more distant plants. Once the females had mated or if they had mated prior to leaving the source, they would have been able to bypass the plants close to the deteriorating source in favor of potted plants farther away. The healthy potted plants close to the source could be viewed as part of the same source and in danger of deteriorating as well. By flying up to 28 m, the females were more likely to find mile-a-minute weed patches far enough away from the deteriorating source to ensure it would not also be affected. *T. virgata* females were able to distinguish between lush and deteriorating habitat (Herzig and Root 1996). Most of the females of that species emigrated to host patches that contained healthy, undamaged goldenrod. Ninety-five percent of the female migrants collected had already mated. They did not need to find a host patch that contained males; instead they needed a healthy host patch to lay their eggs. Females feeding on undamaged plants were able to lay more eggs than those laying eggs on unhealthy plants (Herzig 1995).

Anisogamy could explain the differences between male and female dispersal distances. Males do not need to feed as much as females because sperm are less expensive to produce, so they are able to risk staying close to a deteriorating host to mate with more females (Alcock 2001). Gravid females had a feeding preference for the capitula of the mile-a-minute weed plant; they consumed significantly more capitula than males (Figure 8. Colpetzer et al. 2004b). The capitulum has higher protein content necessary to produce many healthy eggs. By dispersing away from the deteriorating host and other weevils, a gravid female would be able to consume more mile-a-minute weed and lay her eggs on a plant that is more likely to remain healthy long enough for her larvae to complete development.

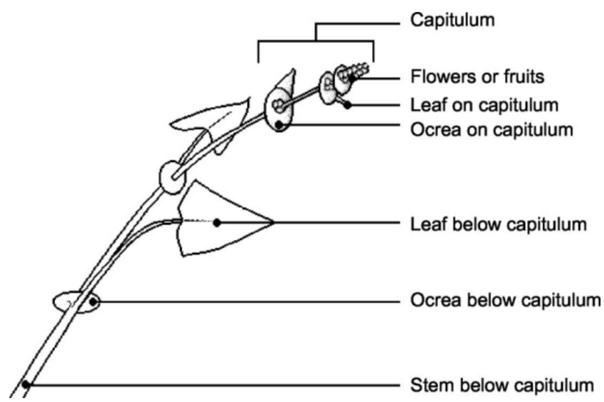


Figure 8. Diagram of mile-a-minute weed (Colpetzer et al. 2004b)

In conclusion, *R. latipes* dispersed from deteriorating mile-a-minute weed habitat. Although the deterioration was caused artificially by cutting in the distance dispersal experiments, one can assume that natural defoliation would also lead to the weevils dispersing. Unlike many other curculionid species, *R. latipes* were not drawn significantly more to new plants with conspecifics. Males were more likely to disperse shorter distances than females. Males and females responded to the deteriorating habitats in different ways to maximize their own reproductive success.

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