DISTRIBUTION AND MOVEMENT OF ADULT *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE) IN A FLORIDA CITRUS GROVE

H. N. NIGG,[1] S. E. SIMPSON,[2] L. E. RAMOS,[1] T. TOMERLIN, J. M. HARRISON,[3] AND N. CUYLER[1]
[1]University of Florida, IFAS, 700 Experiment Station Road, Lake Alfred, FL 33850

[2]Florida Department of Agriculture, Consumer Services, Division of Plant Industry, 3027 Lake Alfred Road, Winter Haven, FL 33881

[3]University of Florida, IFAS, Dept. Statistics, 526 McCarty Hall, PO Box 110339, Gainesville, FL 32611

ABSTRACT

Over 10 weeks, 765 adult, feral *Díaprepes abbreviatus* were captured from 750 young citrus trees by dislodging them into inverted umbrellas. Newly captured weevils were distributed evenly among plots throughout the experimental site. Five hundred eighty of these weevils were marked and released; 146 were recovered. Recaptured (marked) weevils tended to stay close to the release point. Because recaptured weevils were not homogenously distributed, a mark-release method for a population estimation was untenable. Weevils were recaptured at distances up to 120 m from the release point, the farthest distance checked. There were no differences between males and females in the numbers and distances moved. Marked females were recovered at the experimental site over a longer time period than marked males. Weevils were recaptured within 6 weeks of marking, but none after 6 weeks from first capture. Over the 10 week experimental period, Malaise and Tedders traps captured 0 and 2 weevils, respectively, compared to the 765 weevils captured with the beat method. Average adults per tree ranged from 0.016 to 0.376 per week with an overall average of 0.172 ± 0.140, enough adult weevils to thoroughly infest all trees with larvae.

Key Words: Population distribution, mark and release, Tedders trap, Malaise trap

RESUMEN

Durante un período de 10 semanas, se recolectaron 765 ejemplares adultos del tipo silvestre de gorgojo *Diaprepes abbreviatus,* a partir de 750 árboles cítricos, para lo cual se agitaron los mismos, recogiéndose los individuos desprendidos en una sombrilla invertida. Los individuos recolectados se distribuyeron al azar en toda el area experimental. Quinientos cincuenta de los mismos fueron debidamente marcados para su posterior identificación y liberados a continuación; de éstos, 146 fueron recuperados, en la mayoria de los casos en las proximidades de los puntos en que fueron dejados en libertad. Teniendo en cuenta que los individuos recuperados no fueron distribuidos de forma homogénea, no es aplicable un metodo para el cálculo de la población a partir de los datos de marcado y liberación de los individuos. Los gorgojos fueron recapturados a distancias de mayores de 120 m de los puntos en que fueron liberados. No se encontraron diferencias entre individuos femeninos y masculinos en cuanto a las distancias que se desplazaron y el número de los mismos. Las hembras marcadas fueron recuperadas en los puntos experimentales al cabo de períodos mas prolongados que en el caso de los machos. Los gorgojos fueron recapturados en un plazo no mayor de seis semanas a partir del momento de su marcaje. Al cabo del período experimental de 10 semanas, las trampas de tipo “Malaise” y “Tedders” solo permitieron capturar 0 y 2 individuos, respectivamente, en contraste con los 765 ejemplares capturados mediante el método aplicado en el experimento. El número promedio de individuos adultos por árbol osciló entre 0.172 y 0.376 por semana, para un promedio total de 0.172 ± 0.140, lo que significa una cantidad de gorgojos adultos suficiente para infestar todos los árboles con las larvas correspondientes.

Citrus is the most valuable agronomic crop in Florida, covering an estimated 850,000 acres and having an estimated annual value of approximately $8.6 billion in 1998 (R. Barber, Florida Citrus Mutual, Lakeland, FL, pers. comm.). *Diaprepes abbreviatus L.* (Coleoptera: Curculionidae) (ESA approved common name, Diaprepes) is a polyphagous herbivore whose most economically important host in Florida is *Citrus* spp. (Beavers et al. 1979b; Simpson et al. 1996). Since its discovery in Florida in 1964, *D. abbreviatus* has spread to 20 Florida counties, where it currently infests approximately 164,000 acres (66,420 ha) (Anonymous 1997). This area contains approximately 30,000 acres (12,150 ha) of infested commercial citrus. For some citrus growers, the first indication of infestation may be the sighting of adults and feeding damage on the leaves; however, lack of tree vigor may be the first sign that larvae of *D. abbreviatus* have been feeding on roots (Griffith 1975).

The female oviposits an average of 5,000 eggs over her lifetime, with 50-150 eggs per mass (Wolcott 1933, 1936, Simpson et al. 1996). An egg mass is laid between two leaves (generally mature leaves); the neonate larvae hatch and drop to the ground to feed on roots. Adult weevils feed on young citrus leaves. This cycle from egg to adult may take from 3 months to 2 yr for eggs from the same egg mass.

The adult weevil is secretive. That is, a citrus grower probably would not notice an initial infestation of a few beetles. Females reproduce themselves about 30 times, with a 1:1 sex ratio (Beavers & Selheime 1975). With this geometric progression, weevils should be numerous enough to be noticed in the third or fourth year of an infestation.

The larva is the damaging stage. Larval root feeding damage will cause a grove to become unprofitable within an estimated 5-7 yr after the initial infestation. To prevent large larval infestations from developing, it is essential that adult weevils in citrus groves be detected early, especially when the adult population is low. Various methods have been evaluated as surveillance tools for *D. abbreviatus* populations, although none appear to have been effective (Beavers et al. 1979a, 1984; Schroeder & Jones 1983, 1984; Jones & Schroeder 1984; Schroeder & Beavers 1985). Currently, modified pecan weevil traps (Tedders traps) (Tedders & Wood 1994) are used for monitoring the presence and seasonal abundance of *D. abbreviatus* adults by some researchers and citrus growers (J. L. Knapp, Univ. of Florida, pers. comm.). *D. abbreviatus* may also be collected by dislodging them from foliage onto ground cloths or into inverted umbrellas using a beating stick (Jones 1915; Nigg et al. 1999), a common collection method for some insects (Borror et al. 1981).

The movement and dispersal of D. *abbreviatus* are not understood. There appear to have been at least three introductions of Diaprepes into Florida since 1964 (Bas et al. 2000), but this weevil does not infest every acre of citrus. We have many grower reports of finding Diaprepes on mower decks, spray machines, and other equipment. This weevil has been reported in loads of fruit, and loads of fruit may move many miles between a citrus grove and a packing plant. In a genetic study, our data indicated man as the primary mover of this pest (Bas et al. 2000). Although we are beginning to understand the artificial movement of Diaprepes by man, we do not understand its natural movement and dispersal in a commercial citrus planting.

Also, there have been many reports of a single tree in a commercial citrus planting where many weevils congregate (Beavers et al. 1982; Jones & Schroeder 1984), a phenomenon we have personally observed. In addition to the population level, how this weevil distributes itself then may be important for treatment. That is, absence of adults in a portion of a planting could lead to treatment only where adults are present.

The objectives of this experiment were 1) to determine the distribution of D. *abbreviatus* over time in a commercial citrus grove, 2) to determine if a mark-release method could be used to estimate the population level, and 3) to relate the beat method weevil capture numbers with the numbers captured using the Malaise trap and the Tedders trap.

MATERIALS AND METHODS

Experimental

An experiment was conducted in a red navel orange *(Citrus sinensis* (L) Osbeck) grove (2.27 ha) planted in 1994 in Astatula sand with a 5-12% slope (Furman et al. 1975) in Mt. Dora, Florida (Lake County). Trees (0.9-1.2 m tall) were irrigated by a microsprinkler system and were in excellent horticultural condition. No pesticides had been applied to this grove for 8 months before starting this experiment, nor were any pesticides applied during the experiment. The experimental grove was surrounded on the north, east and west by mature citrus groves of trees approximately 3.5 m in height and on the south by an access road.

A 750 tree planting was divided into 25 plots; each 25 m × 41.5 m plot consisted of 30 trees planted in five rows of six trees (Fig. 1). A rain gauge and a platform (20.3 cm × 20.3 cm) for release of marked adult *D. abbreviatus* were placed in the center plot of the 25 experimental plots (Fig. 1). Fourteen Tedders traps (2.8 traps/acre, 6.2 traps/ha) with enlarged cone holes and 4 Malaise traps (0.6 traps/acre, 1.3 traps/ha) (Golden Owl Publishers, Lexington Park, MD) were arranged in each designated plot as shown in Fig. 1. Linear distances from the trap in each plot to the central release platform were measured. Tedders traps were also placed inside the dripline of every fourth tree in the second row of each citrus grove surrounding at a density of 28 traps/acre (62 traps/ha). These traps were placed to understand weevil emergence from the soil in the older groves surrounding the experimental site. Data of this type might have given an indication of the immigration into our site from older Diaprepes-infested groves. All traps were monitored weekly.

In addition to traps, weevils were also collected throughout the 25 plots with the beat method (Nigg et al. 1999). For beat samples, 1.3 m diameter, straight handled golf umbrellas were placed

Fig. 1. Experimental design and trap locations in each of 25 plots containing 30 trees (750 trees total). Weevils were collected in even or odd weeks as indicated. ★ 1 m high release platform; ● Malaise trap; ▲ Tedders trap (linear distance to release platform).

under the tree to cover the distance from trunk to dripline and the foliage was beaten with a 0.5 in. × 4 ft. oak dowel rod. The foliage directly over the umbrella was beaten from top to bottom. The umbrella then was moved to a new and contiguous area under the tree, the foliage was beaten, and this process was repeated until all of the foliage had been beaten. Weevils were removed from the umbrella by hand, were sexed based on a pointed (female) or a rounded (male) abdomen, and were placed in a vial with a polyurethane plug for a closure. Five people took these data: four to beat and one to immediately record data. In the first week, (week 0) all 750 trees at our test site were sampled for weevils by the beat method. All trees within the central plot were sampled weekly with the beat method. All the trees in the remaining plots were sampled by the beat method on a biweekly basis with half of the plots being sampled each week in an alternating pattern (Fig. 1). In week 9, all 750 trees (all 25 plots) were sampled by the beat method, so each tree was sampled a total of six times.

All collected weevils were moved to the release platform, removed from their cage individually, and marked on the elytra with colored enamel paint (Testors, No. 9146, The Testor Corp., Rockford, IL). Different colors were used for each week. This method was adapted from Cross & Mitchell (1964) and was a durable, non-toxic marking method for D. *abbreviatus* adults (HNN et al., unpublished data). Recaptured, previously marked weevils were re-marked at a different location on the elytra with the current week's color. Weevils were placed on the release platform after being marked and were not further disturbed.

Data were collected from May 30, 1996 to Aug. 1, 1996. The last sampling was at the grower's request due to the number of weevils being detected in the experimental site.

Data Analysis

The Kruskal-Wallis test was used to examine the radial symmetry of the population distribution among plots (Hollander & Wolfe 1973; SAS Institute 1989). Weevil capture status was categorized as either newly captured (unmarked) or recaptured (previously captured and marked) (Figs. 2 and 3). Poisson regression models were used to examine variables and their interactions (McCullagh & Nelder 1989). Estimates for these models were obtained using PROC GENMOD (SAS Institute 1996). Inferences for Poisson models were made with Wald Chi-Square tests (Agresti 1990). Statistical analysis of the population distribution was performed as follows Kruskal-Wallis tests were used to examine whether weevils tended to appear more often in one section of the experimental region. Plots in the northern half of the region were compared to southern plots, eastern plots were compared to western plots, and the four corners were compared. Newly captured and recaptured weevils were examined separately. The center plot was not used in these analyses. P-values were calculated from the Kruskal-Wallis test (Hollander & Wolfe 1973). No significant differences among the directions were found (P = 0.05). Because tests did not show any general asymmetry of counts in the grid, plots in the grid which were equidistant from the center were regarded as replicates.

The weevil counts in each plot were regarded as functions of the following variables:

1. Week (1, 2, . . . , 9)—Week 0 was not considered since recaptures were not present in that week.
2. Plot position from center - one center plot, four inner center plots, four inner corner plots, four outer center plots, eight knight plots (a chess knight's move from the center), and four outer corner plots. Their distances from the center are 0, 1, 1.41, 2, 2.24, and 2.83 units, respectively, where a unit is the length of one plot. For example, the Kruskal-Wallis tests showed that no adjustments for northern and southern plots were necessary, so the two southern outer corner plots could be regarded as replicates of the two northern outer corner plots.
3. Sex—male, female.
4. Capture Status—newly captured, recaptured.

An initial Poisson regression model was constructed with the four main effects and their two and three-way interactions, except for the interactions involving weeks and positions (McCullagh & Nelder 1989). For example, outer corner plots were counted only every other week, so the week*outer corner interaction was not estimable. This is the complex model in Table 2.

The simplified Poisson regression model was obtained by deleting nonsignificant terms and simplifying plot position effects by considering only their distances from the center. In the first model, a knight plot and an outer corner plot were regarded to be at two different positions in the grid, but their relative positions with respect to each other were not used. In the simplified model, the difference between a knight plot and an outer corner plot is not regarded as a difference in classifications; instead, the knight plot is regarded to be (2.83-2.24) = 0.59 units closer to the center. The fit of the simplified model was not significantly worse than the fit of the initial model (Chi-square = 24.59, df = 26, p = 0.54), but its terms were much easier to interpret. A summary for the simplified model appears in Table 2. Note that all terms in the simplified model were significant at the 0.05 level.

Distances from the release platform that weevils were recaptured were calculated by triangulation and were divided into three distance categories: 0-24 m, 24-72 m, and 73-120 m. These correspond generally to the central plot and the inner eight plots around the central plot and the outer 16 plots. Differences in recapture distance were compared by the GLM procedure and Tukey's HSD test (SAS 1996).

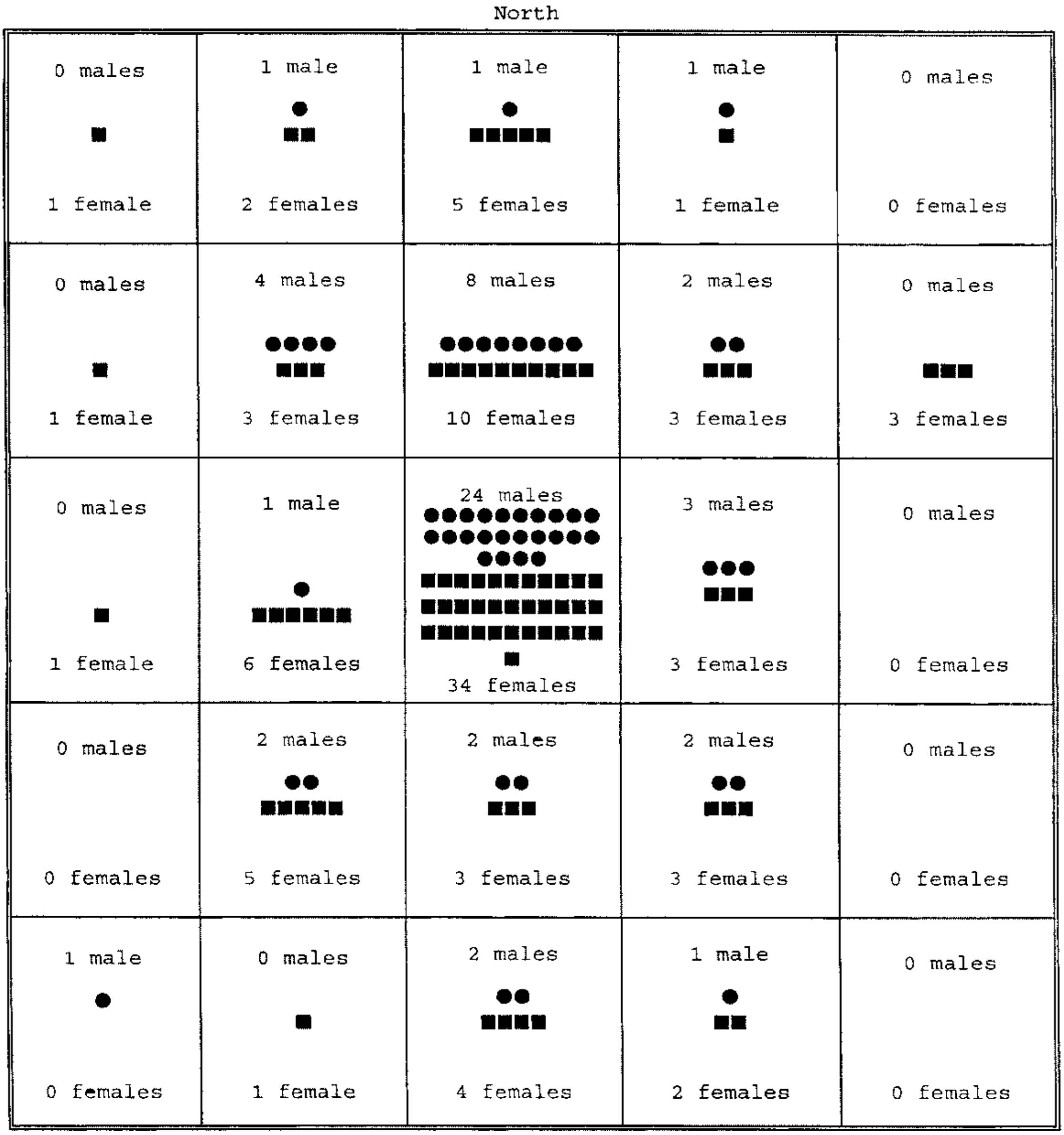

Fig. 2. Distribution of recaptured males (●) and recaptured females (■) from May 30, 1996 to August 1, 1996 in a red navel orange grove, Mount Dora, Florida (146 total weevils).

Results and Discussion

Statistical Analyses and Models

The fit of the Poisson regression models were evaluated by examining their standardized deviance residuals. These were calculated by comparing observed counts from those predicted by the model. Even though the general model does not assume a normal distribution of the counts, the standardized deviance residuals should appear to have a normal distribution with mean 0 and variance 1. There were no obvious departures from that distribution, indicating that the assumptions of the model were met closely enough for the estimates to be valid.

Simplified Model Interpretation

Since the interactions were significant, numerical interpretations were made from the interaction terms rather than the main effects (Table 2). Our estimates are based on this model constructed from all of the data.

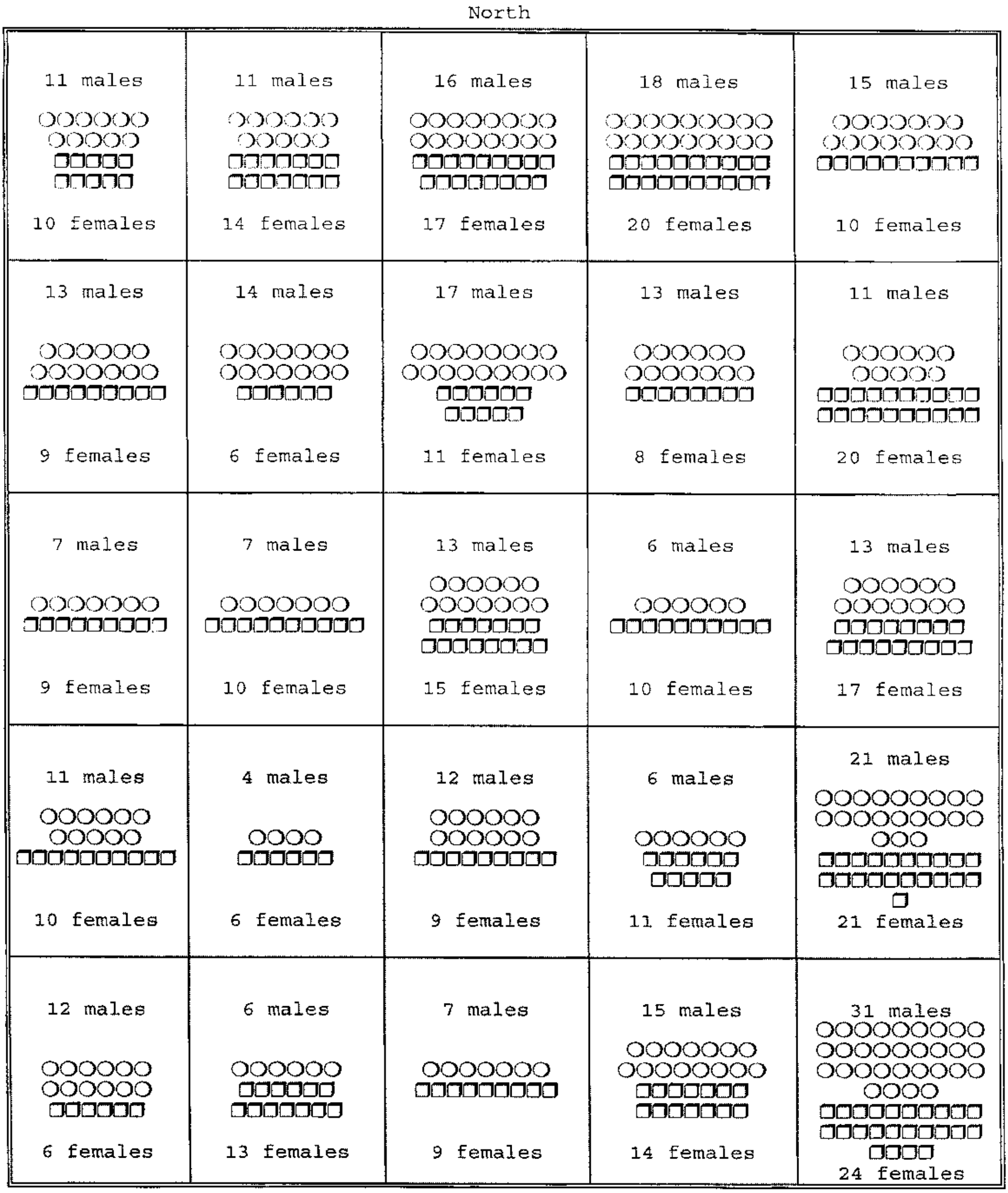

Fig. 3. Distribution of newly captured males (❍) and newly captured females (❒) from May 30, 1996 to August 1, 1996 in a red navel orange grove, Mount Dora, Florida (619 total weevils).

The capture status*plot position interaction can be explained as follows. Within the same week and gender, the number of newly captured weevils tended to increase by a factor of 1.30 for every additional unit from the center, so there was a slight tendency to capture more new insects on the periphery than in the center. For example, starting with the reference value of 0.21 newly captured males in the center plot in week 1, we would have expected to see 0.21 (1.30) = 0.27 newly captured males in an inner center plot in week 1 and 0.21 (1.302) = 0.35 newly captured males in an outer center plot in week 1. However, the average number of recaptured weevils tended to decrease by a factor of 0.26 for every additional unit from the center. For example, the center plot had, on average, $(1/0.26)^1 = 3.85$ times more recaptured weevils than an inner center plot and $(1/0.26)^2 = 14.8$ times more recaptured weevils than an outer plot. These numbers show that the newly captured weevils tended to be captured away from the center, while marked weevils which were recaptured had not migrated far from the center.

The capture status*sex interaction was also significant. Within any particular plot in one week, the average number of recaptured males was 2.21 times higher than the average number of newly captured males. For example, in the center plot in week 1, we would have expected to see 0.21 (2.21) = 0.46 recaptured males. For females, the average number of recaptured females was 3.73 times higher than the average number of newly captured females. In simpler terms, there were more recaptures than newly captured captures for both genders, but the tendency to recapture females was stronger than the tendency to recapture males. The difference between 2.21 and 3.73 provides the significant interaction. The same results showed that, among recaptured weevils, the average ratio of females to males was 1.60:1; among newly captured weevils, the average ratio of females to males was only 0.95:1. The model predicted 0.21 newly captured males in the center in week 1, so the estimated number of newly captured females in the center in week 1 was 0.21 (0.95) = 0.20.

The capture status*week interaction can be explained as follows. At week 1, the average number of recaptured weevils in a plot was 4.65 times higher than the average number of newly captured weevils, which was a significant difference (Chi-square = 9.83, df = 1, $p = 0.0017$). At week 2, the newly captured weevils outnumbered the recaptured weevils by a ratio of 2.44:1, but that difference was not significant. In fact, from weeks 2 to 9, the effects of time did not differ significantly between newly captured weevils and recaptured weevils; this difference occurred only in week 1. For both newly captured weevils and recaptured weevils, from weeks 2 through 9, the counts tended to increase by a factor of 1.28 each week. That rate of increase was significant (Chi-square = 173.67, df = 1, $p < 0.0001$). This estimate is supported by the beat method numbers. The beat method has a numbers efficiency of about 65% and a detection efficiency of 75% (Nigg et al., 1999). The weevil numbers for June 6, 13, and 20 might be attributable to a 35% inefficiency of the beat technique; thereafter, weevil absolute numbers increased each week.

We attempted to estimate the population by the mark and release method (Southwood 1966; Carothers 1973; Seber 1982). However, the fact that marked insects did not mix freely and homogeneously with the unmarked population (Fig. 2), would not allow a population estimate using a mark and release method (Southwood 1966; Carothers 1973).

General Observations

Over the 10 weeks of this experiment (May 30-Aug. 1), we captured 765 weevils (Table 1). We released 580 marked weevils and recovered 146 of these for a recovery rate of about 25% (Table 1, Fig. 2). The difference between 765 and 580 is the sum of weevils captured in week 9 (170) (not marked and released) plus 15 weevils that escaped before being marked in other weeks. The percent recapture varied from week to week (Table 1). In any week, we recaptured an average of 21% of weevils marked in the previous week. For weevils marked 3 weeks previously, only about 5% were recaptured at the experimental site. Over the course of the experiment, 17 weevils with two marks were recaptured; three weevils with three marks were recaptured, but none with four marks. Marked weevils were detected in the experimental site for no more than 6 weeks after being marked and released.

In week 1, recaptured weevils were 4.6-fold greater than newly captured weevils in all plots. However, in weeks 2-9, there were no significant differences between newly captured weevils and recaptured weevils in each plot. During the last 8 weeks, both recaptured weevils and newly captured weevils increased by the same factor of 1.28 each week.

Newly captured males outnumbered recaptured males by about a 5:1 ratio; the same ratio was about 3:1 for newly captured and recaptured females (Table 1). The ratio of recaptured males to recaptured females overall was 0.5:1. For newly captured weevils, the sex ratio was 1.2:1, males to females. These ratios are different because marked females were recaptured in the experimental site in greater numbers compared to marked males. Beavers & Selheime (1976) observed field captured *D. abbreviatus* sex ratios of 0.79: 1 ♂:♀ in 1972 and 0.69: 1 ♂:♀ in 1973.

Adult weevils per tree ranged from a low of 0.016 in week 3 to a high of 0.339 in week 7 (Table 1). Stated on a tree basis, in week 3 a weevil was captured about every 58 trees; in week 7 one weevil was captured about every 2.5 trees. Based on these population levels, the distribution of newly captured weevils (Fig. 3), and their reproductive potential, there were enough weevils present to infest all 750 trees of this experiment. Based on the distribution of newly captured weevils throughout the experimental site, spot pesticide treatment for this weevil appears unlikely.

Movement

The central release plot had the highest number of recaptured weevils (Fig. 2). The second

TABLE 1. *DIAPREPES ABBREVIATUS* ADULT UMBRELLA CAPTURE, MAY 30-AUG 1, 1996.

		Newly captured adults			Recaptured adults					
Week	(date)	New captures	Males/females	Ratio	Recaptures	Males/females	Ratio	Overall total captures	Released	Weevils/tree[a]
0	(5/30)	74	29/45	0.64	N/A	N/A N/A[b]	N/A	74	65	0.098
1	(6/06)	10	6/4	1.50	11	3/8	0.38	21	20	0.059
2	(6/13)	7	2/5	0.40	1	1/0	N/A	8	8	0.021
3	(6/20)	4	3/1	3.00	2	0/2	0.00	6	6	0.016
4	(6/27)	20	9/11	0.82	4	1/3	0.33	24	24	0.064
5	(7/C3)	61	35/26	1.35	9	3/6	0.50	70	69	0.187
6	(7/11)	96	44/52	0.85	22	6/16	0.38	118	118	0.315
7	(7/18)	106	48/58	0.83	34	13/21	0.62	140	137	0.376
8	(7/25)	104	57/47	1.21	30	10/20	0.50	134	133	0.357
9	(8/01)	137	77/60	1.28	33	18/15	1.20	170	0	0.227
Overall		619	310/309	1.19 + 0.72	146	55/91	0.49 + 0.34	765	580	0172 + 0.140

[a]Actual weevils collected with the umbrella divided by the number of trees sampled.
[b]N/A = Not applicable.

TABLE 2. STATISTICAL SUMMARY OF POISSON REGRESSION MODELS OF *DIAPREPES ABBREVIATUS* BEAT METHOD CAPTURES AND INTERACTION WITH PLOT POSITION FROM CENTER, SEX, WEEK AND CAPTURE STATUS.

		Wald Type III	
Effect	df	Chi-square	P
		Complex model	
Week	8	162.8	<0.0001
Capture status[a]	1	54.4	<0.0001
Plot position from center	5	66.3	<0.0001
Sex	1	2.3	0.13
Capture status*plot position[a]	5	121.6	<0.0001
Capture status*sex[a]	1	3.1	0.079
Capture status[a]*week	8	21.2	0.0066
Plot position*sex	5	3.8	0.57
Sex*week	8	8.1	0.42
Plot position*sex*capture status[a]	5	1.2	0.94
		Simplified model	
Week	8	164.2	<0.0001
Capture status[a]	1	18.4	<0.0001
Plot position from center	1	85.9	<0.0001
Sex	1	4.8	0.029
Capture status*plot position	1	188.3	<0.0001
Capture status*sex	1	7.4	0.0066
Capture status*week	8	22.5	0.0040

[a]Capture status = newly captured or recaptured after marking.

highest plot for recaptures was the plot immediately north of the central release plot with 18 recaptures or 12.3% of the recaptured weevils (Fig. 2). There were no statistical differences in the movement categories between sexes (Table 3). However, males appeared to be less represented in the 73-120 m category (Table 3). Beavers & Selheime (1978) found 10 of 100 marked weevils 3-26 m from their release point 4 days after release. After 50 days, one female and three males were found 18-228 m from the release point. In a second experiment, 11 of 122 released weevils were found 11-148 m from the release point after 7 days; after 52 days, 12 weevils were found 18-208 m from the release point (Beavers & Selheime 1978). What is not clear from our data and from Beavers & Selheime (1978) was the fate of the unrecovered weevils.

One explanation for marked weevils not being recaptured at our site is simply that they were not in the sampling zone when we sampled. Upon release, many marked weevils flew off-site to a mature grove, sometimes within seconds, an observation also made by Beavers & Selheime (1978). We agree with Beavers & Selheime (1978) that *D. abbreviatus is* capable of strong flight of short duration and distance. Another explanation for the low recovery of marked weevils is that the marking paint may have worn off. We believe this is unlikely as we recaptured weevils marked three weeks previously. Death is also a possible explanation for the rapid decline in marked wee-

TABLE 3. MARKED DIAPREPES ABBREVIATUS RECAPTURE DISTANCE FROM THE CENTRAL RELEASE POINT BY SEX.

Sex	Category	Recapture total	Average recaptured weevils/week	
Females	0-24 m	34	3.9	±3.3 a
	25-72 m	36	4.0	±4.5 a
	73-120 m	21	2.3	±3.8 a
Male	0-24 m	24	2.7	±2.8 a
	25-72 m	24	2.7	±3.7 a
	73-120 m	7	0.8	±1.1 a

Means ± SD Means followed by the same letter are not different at $\alpha = 0.5$ by Tukey's HSD test.

vils; however, we recovered only one dead marked weevil during the course of this experiment.

Distribution

Although the raw numerical data indicated that the population increased with time in the east and southeast plots, this trend was not statistically significant. According to the Poisson models, insect counts followed steady gradients from the center to the exterior plots. The simplified model was not statistically inferior to the complex full model (Wald chi-square = 24 6, df = 26, P = 0.54) (Table 2). In the simplified model, the interactions of capture status and plot position, capture status and sex, and capture status and week were significant (P = <0.01, Wald chi-square tests) (Table 2). Counts of newly captured weevils increased by a factor of 1.09 for every 10 m removed from the center plot. The peripheral plots averaged about 28 newly captured weevils per plot; interior plots averaged 20 newly captured weevils per plot. More newly captured weevils on the periphery of our site might be due to emergence of adults from a peripheral infestation in the first year after planting, i.e., in 1994-95.

Weevils may have immigrated into our site. The grove was 2-yr-old, and based on a 1 yr field life cycle (Simpson et al. 1996), perhaps only a few weevils had reached the adult stage in our experimental plots. However, the Tedders traps placed under the tree dripline in the surrounding groves caught only one weevil, indication that movement of a large population of weevils into our test site from surrounding groves was unlikely.

Trap Capture

The Malaise traps, which were designed to trap flying insects, caught only one unmarked weevil. One unmarked weevil was captured in a Tedders trap in the west adjoining mature grove in week 1. Two (one marked, one unmarked) weevils were captured in a Tedders trap in the experimental area in weeks 7 and 8 after releases of 118 and 137 weevils in the previous weeks, respectively. In our experiment, the Tedders traps were placed between trees in the experimental site. Our catches with this trap might have been greater with another trap placement, e.g., under the tree canopy. When used as described, the Tedders trap and Malaise traps were much less effective than the beat method for detecting *D. abbreviatus,* capturing two weevils and one weevil, respectively, compared to 765 total weevils with the beat method (Table 1).

In conclusion, over 10 weeks newly captured weevils were distributed evenly throughout the experimental site. Recaptured weevils were unevenly distributed thus preventing a population estimate with a mark-release method. The Malaise and Tedders traps captured one and two weevils, respectively, compared to 765 weevils with the beat method. Based on these results, we conclude that the beat method is much more accurate in determining population levels. Adult weevils per tree ranged from 0.016 to 0.376 per week, enough adult weevils to infest all trees at the experimental site.

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