Pyramidal Traps for Monitoring the Presence of Pecan Weevil (Coleoptera: Curculionidae)[1]

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ABSTRACT Pyramidal traps constructed of masonite and painted to reflect light levels ranging from 1 to 84% reflectance (black, shades of gray and white) were evaluated for attractiveness to adult pecan weevils, *Curculio caryae* (Horn). Black (1% reflectance) and dark gray (5% reflectance) were found to be more attractive to weevils than traps having greater reflectance (lighter grays and white). Dark gray traps captured almost 9 fold more weevils than did standard cone emergence traps. Dark gray traps also captured weevils in orchards after the emergence period as indicated by screen cone traps. Trap distances of 1.9 and 4.6 m from tree trunks did not influence trap effectiveness. Trap density of 4/tree did not provide an economic level of weevil control as measured by number of infested nuts per tree. Traps positioned on the eastern side of trees caught more weevils ($\alpha \leq 0.05$) than traps on the northern side, but captures were not significantly different from those positioned at the southern and western sides of trees.

KEY WORDS *Curculio caryae,* weevil traps, weevil attraction, pecan weevil

Several trapping systems have been used for monitoring emergence of pecan weevil adults, *Curculio caryae* (Horn) (Neal and Shepard 1976). The most sensitive traps for determining time of emergence and population density were cone emergence traps, which monitor only that portion of the orchard floor that they cover. Cone emergence traps estimated to within 20% the true mean of a weevil population (Boethel et al. 1976) but 12 such traps under each of 10 trees were required to accurately assess populations under Georgia conditions (Ellis and Hudson 1993-1994). Cone traps were rarely used by pecan growers because of the time and expense required for their fabrication and installation and because the required large number of traps disrupted orchard operations.

A new trap was recently developed that utilized reduced reflected light as a visual stimulus for weevils (Tedders and Wood 1994). The base was constructed of two triangular pieces of masonite board, painted dark brown and assembled to form a 1.2-m tall pyramid. Weevils attracted to the pyramid were collected in modified boll weevil, *Anthonomus grandis* Boheman, collecting trap tops mounted on top of the pyramid.

Although pyramidal traps captured large numbers of weevils, additional information was needed concerning the nature of weevil attraction to these traps. Such information included: the optimum level of reflected light for maximum

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weevil capture; the efficiency of trap capture relative to weevil density as measured by cone emergence traps; the effectiveness of traps at variable distances from tree trunks; whether traps provided detectable control of weevils by preventing their entrance into trees; and whether weevil capture was influenced by cardinal direction placement of traps. A series of tests were conducted at the Southeastern Fruit and Tree Nut Research Laboratory at Byron, GA, during 1992 and 1993 to obtain this information.

Materials and Methods

Effect of Percent Reflected Light. During 1992, a study evaluated the response of weevils to pyramidal traps (55 cm base by 122 cm height) painted black (1.0% reflectance), seven shades of gray (5.0, 11.0, 18.0, 25.0, 37.0, 44.0, and 66.0% reflectance) and white (84% reflectance). Light reflected from samples of masonite coated with each paint was measured in the laboratory by methods described by Tedders and Wood (1994). One trap of each reflective value (9 traps) was placed at random in a circle surrounding each tree. Traps formed a circle at 3.9 m distance from the center of the tree trunk; thus, traps were 2.6 m (center to center) apart. The test orchard of 77-year-old 'Stuart' cv. trees, spaced 23.2 by 23.2 m, had not been treated with insecticide for more than ten years. Trunks of all trees were sprayed with whitewash to a height of about 2.1 m (Tedders and Wood 1994). Traps were examined for weevils every 2 to 3 days beginning July 17 until October 9 when they were no longer found. Weeds and grasses in the test area were minimal owing to heavy shading by trees and periodic mowing. The experimental design was a randomized complete block with ten single tree replicates. Counts of observations of the mean numbers of males, females, and males plus females/trap were statistically analyzed by SAS-ANOVA (1992).

Pyramidal Trap vs. Cone Traps. During 1993, we compared the sampling efficiency of pyramidal traps with that of cone emergence traps. Cone traps were 80 cm height by 92 cm diam as recommended by the Georgia Cooperative Extension Service (Ellis and Hudson, 1993-1994). The experiment compared the use of 12 cone traps/tree with four pyramidal traps/tree. The trunks of trees with pyramidal traps were whitewashed and the trunks with cone traps were left natural. Experimental design was randomized complete block with 10 replicates. For the cone traps treatment, three of 12 traps were placed in line on each cardinal direction and located at 1.2, 2.4, and 3.7 m from the trunk. For the pyramidal traps treatment, one trap was placed on each cardinal direction, each 1.8 m from the trunk and the pyramid was painted dark gray (5% reflectance). The orchard was comprised of 60-year-old 'Stuart' cv. trees having canopy radii averaging 8.3 m. Trees were spaced 15.5 by 15.5 m. Traps were examined every 2 to 3 days from 19 July until 15 November when weevils were no longer found. Weevils in this orchard had been controlled with insecticides in accordance with the Georgia Cooperative Extension Service recommendations (Ellis et al. 1992) for several years prior to the experiment. The weevil population was known to be small and typical of most commercial orchards. Insecticide was not used in the orchard during 1993. The grass and weed sod within the test area was first mowed and then herbicided with one application of glyphosphate (9.03 kg ai/ha) 14 d prior to the initiation of the test. One-hundred nuts were randomly taken from each tree at harvest and examined for larval infestation. Both trap types were evaluated for mean capture of weevil/trap and for the effect of direction on weevil capture. Cone traps were evaluated for the effect of distance from the tree. Counts of mean numbers of captured males, females, and males plus female weevils/treatment and infested nuts/treatment were statistically analyzed by SAS-ANOVA.

Effect of Pyramidal Trap Distance From Trees. Treatments were one trap located 1.8 m from the tree trunk compared with one trap located 4.6 m from the trunk of an adjacent tree. Canopy radii of trees averaged 9.2 m and trees were spaced 23.2 by 23.2 m. All traps were placed on the southeastern side of trees on the herbicided tree row strips. Tree trunks of both treatments were whitewashed to about 2.1 m height. The test was a randomized complete block design with 10 replications with single tree experimental units. Trees were 78 years old with six blocks of 'Schley' cv. and 4 blocks of 'Stuart' cv. The trees had not been treated with insecticide for more than 11 years and weevil infestations were known to be high. Traps were examined for weevil capture every 2 to 3 days from 19 July until 2 December when no more weevils were found. Counts of mean numbers of captured males, females, and males plus female weevils/treatment were statistically analyzed by SAS-ANOVA.

Weevil Control by Traps. This test was to determine if four gray pyramidal traps (5% reflectance) surrounding a tree could provide measurable weevil control. For the first treatment, four traps were stationed under each tree and each trap was at 2.4 m distance from the whitewashed trunk on the northern, southern, eastern, and western sides. For the second treatment, traps were not used but tree trunks were whitewashed. For treatment three, no traps or whitewash was used. The experimental design was a randomized complete block of 10 replications with single tree plots. Trees were 78-year-old 'Stuart' cv. with a light nutlet set. Grass and weed sod beneath trees was minimal due to heavy shade from the broad tree canopies ($\bar{x}$ radii = 9.2 m). Insecticide was not used during 1993 and the trees had not been treated with insecticide or miticide for more than 11 years. Weevil numbers in the orchard were known to be large. Traps were examined for weevil captures every 2 to 3 days from 17 July until 2 December, when no more were found. One hundred nuts/tree were randomly collected and examined for larval infestation. The mean number of infested nuts/treatment and the numbers of captured weevils from each cardinal direction were statistically analyzed by SAS-ANOVA.

Results and Discussion

Effect of Percent Reflected Light. The first weevil was captured on 17 July. In general, trap captures increased gradually on each sample date until 14 August. Most weevils were captured from 17 August to 14 September. The largest capture for a single sample period occurred 17 August, three days after 5.4 cm rainfall. Capture declined thereafter until October 7.

When either males, females, or combined captures of males and females were observed, there were obvious periodic increases in captures as light reflectance by traps decreased (Fig. 1A, 1B, 1C). A total of 803 weevils (442 males – 361 females) were captured by all 90 traps during the test period.

Most male weevils were captured by black traps (1% reflectance; mean capture/trap = 10.8). There was no significant difference ($\alpha \leq 0.05$) in the number of males captured by traps of 1% and 5% reflectance (Fig. 1A).

Most female weevils were captured by dark gray traps (5% reflectance, mean capture/trap = 11.5). A dramatic increase ($\alpha < 0.05$) in capture was observed for traps reflecting 1% and 5% light, as compared with traps reflecting 11% or more light (Fig. 1B).

Mean numbers of males and females combined, captured by 1% and 5% reflectance traps, were 20 and 22 weevils, respectively, and these treatments were not significantly different ($\alpha \leq 0.05$). Means and standard errors for males, females, and males and females combined are given in Table 1.

The stepwise nature of capture of weevils by traps having incremental change in reflected light (Fig. 1) indicates that the rates of change of trap reflectance used in this test did not always elicit difference in weevil response. Perhaps weevils were unable to detect differences in the levels of reflected light used in the test or perhaps the weevil population level was too small (although considered to be large) to allow for resolution by change in reflectance levels. However, we concluded that reflectance levels of 1% and 5% were statistically equal for maximum weevil capture, but we elected to utilize 5% gray traps for subsequent tests simply because 5% gray traps captured the most weevils.

Table 1. Mean (± SEM) capture of male, female, and male plus female pecan weevils by traps of indicated light reflectance. Byron, GA, 1993.

Percent Reflected Light	Males	Females	Males + Females
1	10.8 ± 1.96	9.2 ± 2.11	20.0 ± 3.81
5	10.5 ± 2.67	11.5 ± 2.69	22.0 ± 4.97
11	6.1 ± 1.74	3.5 ± 1.41	9.6 ± 3.07
18	6.4 ± 2.64	3.7 ± 1.48	10.1 ± 4.02
25	2.5 ± 0.45	2.9 ± 0.59	5.4 ± 0.75
37	3.5 ± 1.39	2.1 ± 0.81	5.6 ± 2.11
44	1.6 ± 0.37	1.1 ± 0.31	2.7 ± 0.52
66	1.7 ± 0.54	1.1 ± 0.31	2.8 ± 0.73
84	1.1 ± 0.31	1.0 ± 0.30	2.1 ± 0.41

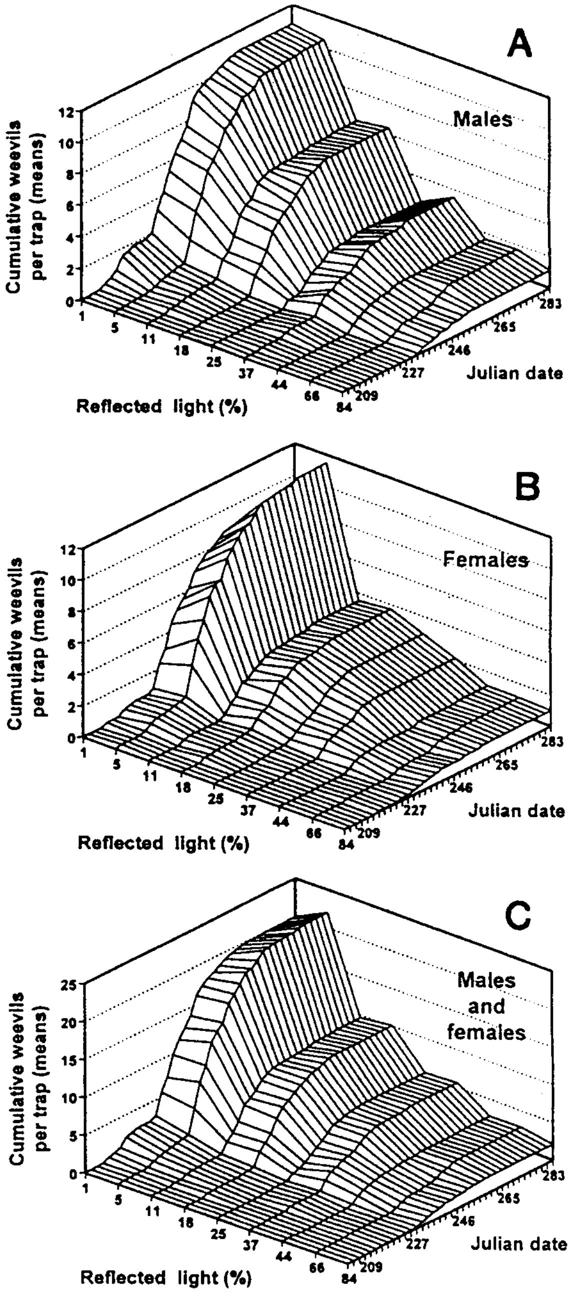

Fig. 1. Cumulative pecan weevil capture (mean/trap), percent light reflected by pyramidal trap, and date of weevil capture; A-Males; B-Females; C-Males plus females. July-October 1992, Byron, GA.

Pyramidal Traps vs. Cone Traps. The first weevil in cone emergence traps was found on 9 August and the last on 20 September, indicating an emergence period spanning approximately 43 days (Fig. 2A). More than 50% of emergence occurred between 2 and 14 September, with major peaks in emergence on 7 and 13 September. The 7 September peak was largely females (Fig. 2C) whereas the 13 September peak was mostly males (Fig. 2B). Peak emergence may not have been well defined due to the small numbers of captured weevils. Pooled counts of weevils captured by all cone emergence traps was 46 ($\bar{x}$ = 0.38 ± 3.03 / trap). Ninety out of 120 traps (75%) failed to capture weevils. Sixty-one percent of weevils captured in cone traps were males.

The first weevil captured by pyramidal traps was also on 9 August, and the last on 28 October, indicating weevil activity for approximately 63 days, 2 wks longer than that indicated by cone traps. Three peaks of weevil emergence were indicated on 16 August, 1 September, and 20 September. The largest peak (20 September, Fig. 2A, 2B) was predominantly males and occurred about the same time as the last capture of weevils by cone traps. The largest peak of females occurred on 16 August and significant numbers of females also were captured after the last capture of females by cone traps (Fig. 2C). Pooled count of weevils captured by all pyramidal traps was 136 ($\bar{x}$ = 3.40 ± 4.25 / trap). Only 4 out of 40 pyramidal traps failed to capture weevils. Fifty-seven percent of weevils captured by pyramidal traps were males.

When comparing treatments (12 cone traps vs. 4 pyramidal traps), pyramidal traps captured 3.0-fold more weevils/tree than cone traps. When traps were compared on a 1 cone trap vs. 1 pyramidal trap basis, pyramidal traps captured 8.9-fold more weevils. Pyramidal traps captured significantly more weevils during and following the emergence period than cone traps ($\alpha \leq 0.05$).

There was no directional effect ($\alpha \leq 0.05$) for either type trap, nor was there a significant difference ($\alpha \leq 0.05$) in number of weevils in cone traps based upon distance from the tree trunk. However, low numbers of weevils in this test may have masked such differences.

Nuts from trees of the cone traps treatment averaged 14.8% infested and those of pyramidal traps averaged 12.5% with no significant differences ($\alpha \leq 0.05$).

Effect of Trap Distance from Trees. The first weevil was captured in this test on 6 August and the last on 22 November. Average seasonal weevil capture/pyramidal trap was 66.2 at 1.8 m and 67.4 at 4.6 m. This was not significantly different ($\alpha \leq 0.05$). Indeed, there was an almost perfect overlap of the curves plotted for traps of both distances as expected (Fig. 3A). Peaks of weevil capture were similar for all dates and mean numbers captured were also similar. The first peak occurred during 6 to 18 August and the second on 13 September. Minor numbers of weevils were captured at both distances during October and November. More than 50% of all weevil captures occurred between 30 August and 22 September. Mostly males were captured at both distances, 58.7% at 1.8 m and 58.2% at 4.6 m. There also was a significant difference ($\alpha \leq 0.05$) in weevil capture among replicates attributed to cultivar differences ('Stuart' vs 'Schley'). As was observed in the two previous tests, a large number of males were captured during the last week of September (Fig. 3B).

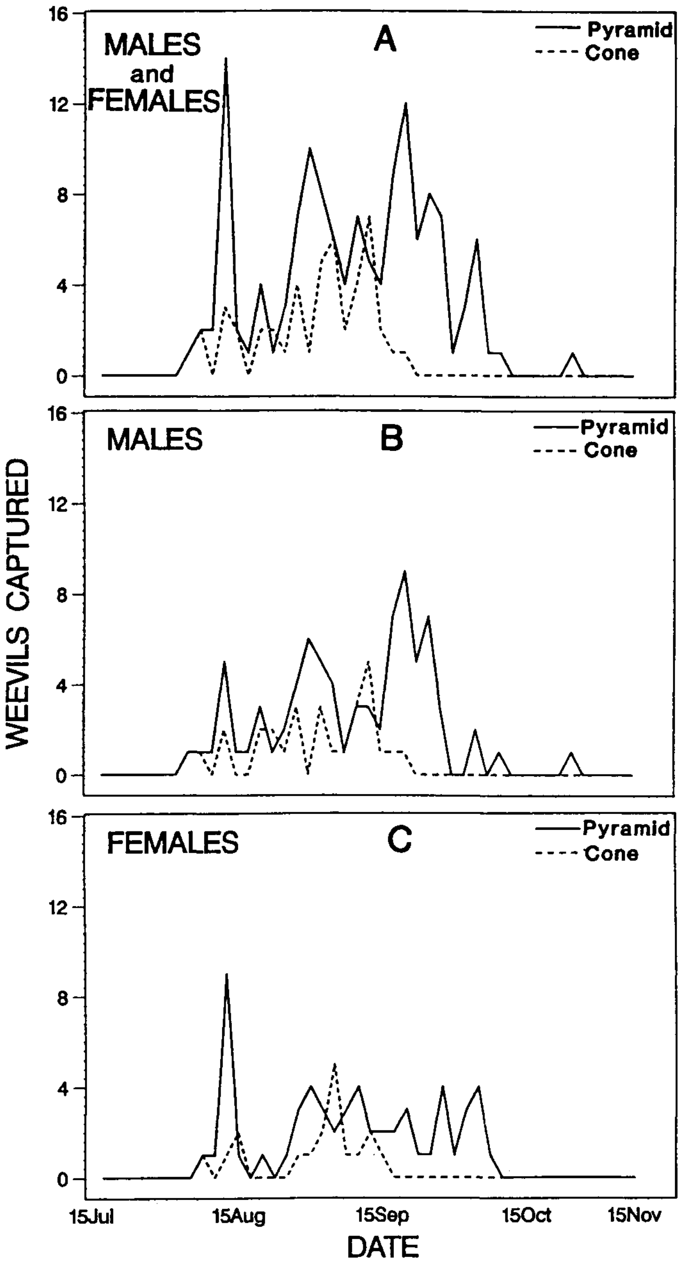

Fig. 2. A-Total number of pecan weevils captured by 40-dark gray pyramidal traps compared with total weevils captured by 120-cone emergence traps; B-Male weevils captured by pyramidal and cone traps; C-Female weevils captured by pyramidal and cone traps. July-November 1993, Byron, GA.

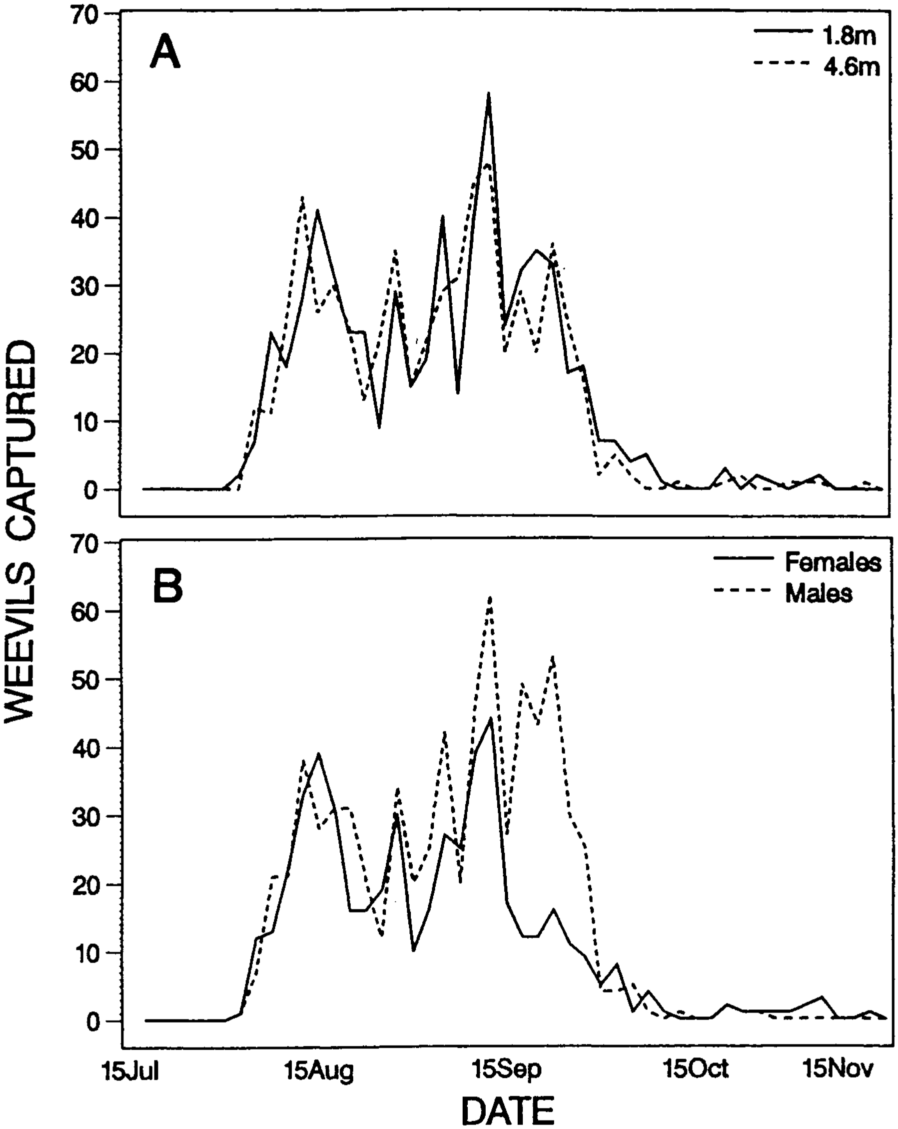

Fig. 3. A-Mean number of both sexes of weevils captured by pyramidal traps located 1.8 and 4.6 m distance from tree trunks; B-Mean number of each weevil sex captured by pyramidal traps located at 1.8 and 4.6 m; curves represented captured males and females (pooled data). July-November 1993, Byron, GA.

Weevil Control by Traps. The first weevil was captured in this test on 19 July and the last on 26 November (Fig. 4). However, substantial capture did not begin until 9 August. Total weevil capture per 40 traps (10 replicates) was 2,107 ($\bar{x}$ = 52.7/trap). Distinct peaks of capture occurred on 13 August, 7 September and 22 September. More than 50% of all weevils were captured during the period 3 to 24 September. Weevils captured were 59.7% males. Again, we observed a large capture of males during the latter part of September.

The majority of nutlets on the test trees aborted during early August as a result of drought; thus we were unable to accurately assess the effect of traps for weevil control. The 100 nut samples from trees were randomly taken from nuts remaining on the tree and from aborted nuts on the ground. Most trees had few nuts remaining at harvest, thus feeding pressure on the nuts was high. Assessment of weevil injury resulting from feeding and oviposition revealed means of 76, 91, and 81% damage to nuts of natural trees, whitewashed trees, and whitewashed trees plus 4 traps, respectively; however, mean infestations were not significantly different ($\alpha \leq 0.05$).

A direction effect of weevil capture was observed as traps on the eastern side of trees captured a mean of 70 weevils/trap; those on the southern side - 56; western side - 48; and northern side - 36. Captures by traps on eastern and northern sides were significantly different ($\alpha \leq 0.05$; df = 27; ms =-960) but

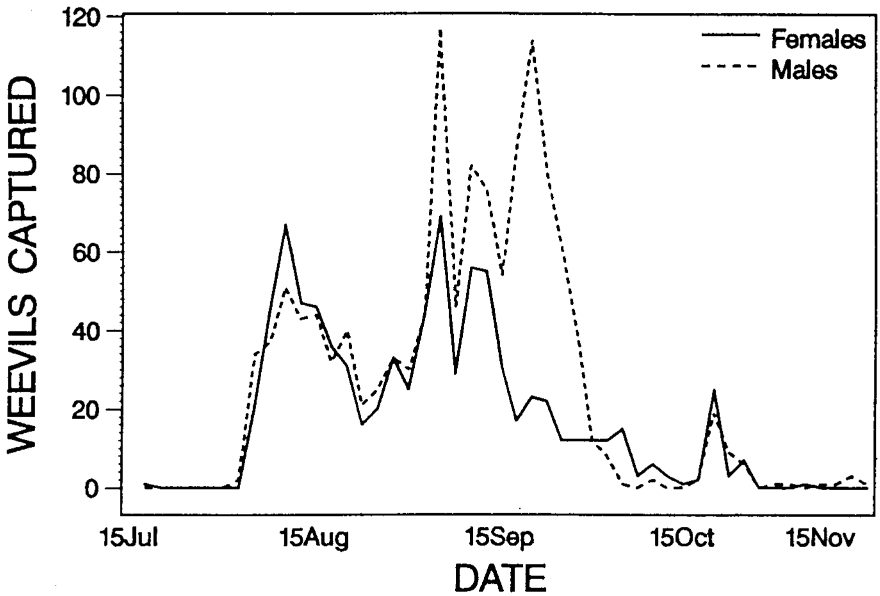

Fig. 4. Total numbers of male and female weevils captured/four pyramidal traps. July-November 1993, Byron, GA.

eastern captures were not significantly different ($\alpha \leq 0.05$) than southern and western captures and northern captures were not significantly different ($\alpha \leq 0.05$) than southern and western captures. Rainey et al. (1970) found more weevils on the northern quadrant with second most on the eastern quadrant. Differences in both studies may be due to clumped distribution of adults emerging from the soil, resulting from various biotic and abiotic factors.

Conclusions

These data do not necessarily indicate that pyramidal traps offer a better method than cone traps for determining the emergence period of pecan weevils. However, pyramidal traps offer a more practical and efficient method for detecting the presence of weevils within pecan orchards. Pyramidal traps capture more weevils/trap and should provide users information about weevils over a longer period of time than do cone traps. The primary concern of growers is the relative seasonal abundance of adult weevils in the pecan orchard and the loss of nuts to a given weevil population. The emergence pattern is of secondary importance.

One important result of these experiments was the capture of large numbers of male weevils late in the season (Fig. 2B-20 September; Fig. 3B - 22 September; and Fig. 4 - 20 September). The presence of large numbers of males was also detected by use of the cone traps (Fig. 2C - 13 September), but in cone traps, this occurred at least one week earlier than that indicated by pyramidal traps. This phenomenon was possibly the result of male migration within or between orchards. Male migration may be a means by which pecan weevils diversify their gene pool. However, such a method of diversification does not seem efficient since there would be few virgin females available in late September. Conversely, the lack of females may be all the more reason for male dispersion. Weevils do not usually migrate in large numbers and persistent populations remain in specific areas of orchards, or even under certain trees, year after year (Osburn et al. 1963). While this hypothesis remains to be disproven, we suspect that females are less prone to fly than males and that a male migration occurs largely after the major emergence period based on the results of these experiments. Harris et al. (1981) found that in groves containing no pecan nuts, both sexes migrated and the female tended to migrate from infested groves even when nuts were present. Also, it is conceivable that shorter-lived males may have already mated and may be more prone to being captured as a function of the aging process.

These data indicate that use of 1% black or 5% gray pyramidal traps placed under trees with whitewashed trunks is an improved method for monitoring adult weevils during and after the emergence period. However, the use of four pyramid traps/tree did not exhibit evidence of weevil control by trapping the emerging individuals, but these results were discounted because of drought. For maximum effectiveness traps should be positioned on the eastern side of whitewashed trees at distances of from 1.8 m to one-half the canopy radius.

This research was based upon the premise that weevils are attracted (or respond) to certain objects reflecting low levels of visible light. Their responsiveness to such objects may also be dependent on background illumination. We also believe that weevils perceive pyramidal traps as tree trunks and that they do not recognize whitewashed tree trunks as such. If these assumptions are correct, and the easterly directional effect can be verified, then it is possible that weevils may tend to emerge from the soil during the cover of darkness and subsequently move eastward as the sky lightens in early morning and as tree trunks (or traps) are perceived as dark silhouettes.

Further study with the pyramidal trap strategy is needed to define optimum reflectance for maximum attraction of weevils, the role (if any) of color in reflected light by the trap, the influence of background illumination, the role (if any) of infrared radiation, and the diurnal timing of weevil emergence from the soil.

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