United States
Department of
Agriculture

Agricultural
Research
Service

1995-3

July 1995

Sustaining Pecan Productivity Into the 21st Century

Second National Pecan Workshop Proceedings

Wagoner, Oklahoma
July 23–26, 1994

UPDATE ON PECAN WEEVIL

W.L. Tedders[1] and B.W. Wood[1]

Additional index words. *Curculio caryae*, pyramidal, trap, monitoring system, visual attraction

ABSTRACT

An inexpensive pyramidal-shaped trap constructed of masonite and a boll weevil eradication trap top effectively monitored the emergence of pecan weevil adults, *Curculio caryae* Horn. Weevils were preferentially attracted to brown pyramidal traps when traps were painted brown vs. white. Brown traps positioned adjacent to trees having whitewashed trunks captured more weevils than the same traps adjacent to non- whitewashed trees. Tall pyramidal traps captured more weevils than short pyramidal traps having the same surface area. Two pyramidal traps/tree captured twice as many weevils as one trap/tree. Black pyramidal traps (1% reflectance) and dark gray ones (5% reflectance) captured more weevils than traps painted 6 lighter shades of gray (11, 18, 25, 37, 44, and 66% reflectance) and white (84% reflectance). There was no significant difference between capture by 1% and 5% reflectance traps. Five percent reflectance pyramidal traps (dark gray) captured almost 9 fold more weevils than did standard cone emergence cages. Dark gray traps captured weevils after the emergence period as determined by cone emergence traps. Weevil capture by dark gray traps located 1.9 and 4.6 m distance from tree trunks were not significantly different. Four dark gray pyramidal traps/tree did not provide control of weevils. Dark gray traps positioned on the eastern side of trees caught significantly more weevils than traps on the northern side of trees.

The pecan weevil, *Curculio caryae* (Horn), is a major pest of pecan trees in the U.S. and its control requires extensive use of chemical pesticides if the population is greater than a few individuals per tree. Pecan weevils are effectively controlled with insecticide, but control disrupts the orchard ecosystem and leads to major outbreaks of aphids and mites (Dutcher and Payne 1983). The need to effectively control weevil populations without excessive disruption of the ecosystem requires that there be an effective and practical means of monitoring weevil emergence. A number of monitoring methods have been used but each has met with varied acceptance. These methods include limb jarring, various tree-trunk trap bands, pyrethrum knock-down sprays, pheromone traps, and ground cover traps (Neel and Shepard 1976). The most recently developed method was a malaise trap for installation on the crotch of a tree (Dutcher et al. 1986). None of these methods seem to be accepted by the majority of growers having a serious problem with detection of weevils.

Important requirements for a practical and efficient trap for monitoring the appearance of pecan weevil adults are: a) sensitivity in detecting weevil presence; b) acceptable costs for construction and operation; c) convenience of installation, use, and storage; and d) acceptance by the grower. This paper describes a new trap that may satisfy these requirements. Also included is a chronological account of experiments from 1990 to 1993 with the trap and the results.

METHODS AND MATERIALS

We hypothesized that pecan weevil adults, upon emergence from the soil, were attracted to dark tree trunks which they visually observed. This seemed to be logical because weevils are secretive insects, they are frequently found beneath flakes of bark on tree trunks, they accumulate beneath burlap bands used by some growers for monitoring weevil presence (Tedders 1974), and it has been shown that 84% of weevils either fly or crawl to the tree trunk (Raney and Eikenbary 1968). With this information in mind we devised a trap base that conceivably could mimic the trunks of a tree (Tedders and Wood 1994, 1995).

The trap base was constructed of two triangular pieces of 0.64 cm thick tempered masonite board, each measuring 53.3 cm base x 121.8 cm height. One triangular piece was partially bisected with a 0.48 cm wide vertical saw-cut from the apex to one-half way to the base. The second piece of masonite was partially bisected with a 0.48 cm wide vertical saw-cut from the center of the base to one-half way to the apex. The two triangular pieces were then interlocked, utilizing the vertical bisects, to form a free-standing pyramidal shaped base. The pyramidal base was then painted with white or dark colored paint as required by each experiment. Boll weevil collecting trap tops (Anonymous 1990) were used on top of the pyramid for capturing weevils that were attracted to the base and that crawled upward on the base. The collecting trap tops were modified by enlarging the entrance hole to 0.95 cm diam.

We used whitewash (Anderson and Roth 1923) to paint or increase the reflective surface, of the tree trunks. Whitewash was sprayed on with a Hypro p.t.o. pump (New Brighton, MN) powered by a 5- Hp Briggs & Stratton gasoline engine. The pump was adapted with a hand-held John Bean Spraymiser gun having a No. 4 orifice disc. From 4 to 6 liters of whitewash was required to cover the trunk and lower part of scaffold limbs of 75- year-old trees to a height of 2.1-2.4 m.

---

[1] Research Entomologist and Research Horticulturist, respectively. USDA-ARS,Southeastern Fruit & Tree Nut Research Laboratory, 111 Dunbar Road, Byron, GA 31008

The degree of light reflected by pyramidal trap bases and tree trunks was estimated from a reflectance curve developed from known standards (Eastman Kodak Co., Inc., Rochester, NY) and measured in the laboratory with a Gossen Lunasix electronic exposure meter (P. Gossen and Co. GMBH, Erlangen, Germany) under constant lighting conditions. Lighting for measurements was by one BCA No. 1 GE incandescent photoflood lamp (General Electric Co., Cleveland, OH) backed by a 28-cm aluminum reflector. The bulb and reflector were positioned at 30_ from perpendicular center and at 25.5 cm distance from the subject. Minor illumination was provided by an overhead fluorescent lighting system. Total incident light measurement at the subject was 2200 Lux. Exposure meter measurements of light reflected by 4.5 cm^2 painted swatches of masonite were then easily converted to percent reflected light. Bark was removed from the trunks of whitewashed and natural trees, returned to the laboratory, and cut into several 4.5-cm^3 pieces. These were similarly measured and the values calculated for percent reflected light. Natural bark averaged 12 to 17%. Whitewashed pecan bark reflected about 84% of the light.

Trees used in the experiments were either 'Schley' or 'Stuart' cv. and were about 75-years-old. Unless otherwise stated the test orchards had received no insecticide for at least 10 years. The experiments were conducted from the last week of July until the last week of October of 1990-1993. Traps were examined for capture of weevils every 2 or 3 days.

Test 1. This study was initiated to evaluate the relative effectiveness of dark brown (5%) and white (84%) trap bases for attracting weevils. A brown trap and a white trap were randomly placed on opposite sides of a 75-year-old tree at ca. 3 m from the trunk. The location of the two traps relative to compass direction was random. The experimental design consisted of two trap color treatments (brown vs. white) structured as a randomized complete block with five single tree blocks. The total weevil count was then statistically analyzed by ANOVA.

Test 2. A second test was conducted to better understand the reaction of weevils to brown- and white-painted surfaces. We compared the number of weevils captured in a brown trap placed adjacent to a white-painted tree trunk with the number captured in a brown trap placed adjacent to the trunk of an unpainted tree.

We also decided to test an additional variable where the bases of traps were of different shapes but having the same surface area (tall vs. short). Bases of short traps were pentagons measuring 61 cm base x 91.4 cm height. The same brown and white paints of Test 1 were used.

Experimental design was a 2 x 2 factorial having 10 trees per treatment structured in a randomized complete block design. The four treatments were tall trap - natural tree (unpainted); tall trap - whitewashed tree; short trap - natural tree; short trap - whitewashed tree. One trap per tree was placed approximately 2.4 m from the tree trunk. Traps were placed at random on either the eastern or western side of the tree trunk (tree row) where grass had been removed by herbicide. Data analysis was for total counts per study period.

Test 3. A test was conducted to determine if one brown trap per tree would catch more or less weevils than two traps per tree, on a catch per trap basis. Experimental design consisted of two treatments in a randomized complete block design with six blocks. Treatments were one brown trap (A) per whitewashed tree and two brown traps (B) per whitewashed tree. Trap location and whitewash were the same as that described for Test 2. The location of trap A under a tree was randomly selected for either the eastern or western side. Where two traps (B) were used, one was placed on each side of the tree and at the same distances as for A. Data were analyzed by use of a *t*-test of the means.

Test 4. A study was designed to evaluate the attraction response of weevils to trap bases painted black (1% reflectance), seven shades of gray (5, 11, 18, 25, 37, 44, and 66% reflectance) and white (84% reflectance). One trap of each color (9 traps) was placed at random in a circle surrounding each tree. Traps forming the circle were at 40° and 3.9 m distances from the center of the tree trunk; thus, traps were 2.6 m (center to center) apart. Trunks of all trees were whitewashed to a height of about 2.1 m. The experimental design was a randomized complete block with ten single tree blocks. Counts of observations of the mean numbers of males, females, and males plus females/trap were statistically analyzed by SAS-ANOVA.

Test 5. A study was designed to compare the sampling efficiency of dark gray pyramidal traps (5%) with that of cone emergence traps. Cone traps were of the design recommended by the Georgia Cooperative Extension Service (Ellis and Hudson 1993-1994). The experiment compared the capture of weevils by twelve cone traps/tree with capture by 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 a randomized complete block with 10 blocks. For the cone traps treatment, three of the 12 traps were placed in line on each cardinal direction and located at 1.2, 2.4, and 3.7 m distances from the trunk. For the pyramidal traps treatment, one trap was placed on each cardinal direction, each 1.8 m distance from the trunk. The orchard was comprised of trees having canopy radii averaging 8.3 m. Weevils in this orchard has 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 1991. 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 days prior to the initiation of the test. One-hundred nuts were randomly taken from each tree at harvest and examined for larval infestation. Because cone and pyramidal traps were positioned in the four cardinal directions, trap catches of weevils also were evaluated for the effect of direction. In addition, catches by cone traps were evaluated for the effect of distances 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.

Test 6. This test was designed to compare the effect of distance of dark gray pyramidal traps (5%) from the tree trunk on weevil capture. 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. All traps were placed on the southeastern side of trees on the herbicided tree row strips. Tree trunks of both treatments were whitewashed. The test was a randomized complete block design, of 10 blocks with single tree experimental units. Weevil numbers were known to be large. Counts of mean numbers of captured males, females, and males plus female weevils/treatment were statistically analyzed by SAS-ANOVA.

Test 7. This test was designed to determine if four gray pyramidal traps (5%) surrounding a tree could provide measurable weevil control. For the first treatment, four traps were stationed under each tree; each at 2.4 m distance from the trunk on the northern, southern, eastern, and western sides. The tree trunks were whitewashed. For the second treatment, traps were not used but tree trunks were whitewashed. For treatment three, no traps or whitewash were used. Trees had a small set of nutlets. Grass and weed sod beneath trees was minimal due to heavy shade from the broad canopies of the trees ($\bar{x}$ radii=9.2 m). Weevil numbers in the orchard were large. The experimental design was a randomized complete block of 10 blocks and single trees were the basic experimental unit. 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

Test 1. A total of 61 weevils (38 males, 23 females) were caught in the five brown traps and only 7 weevils (2 males, 5 females) were caught in the five white traps. When catches of both sexes are considered collectively, brown traps captured more weevils that did white traps ($\alpha \leq .05$). When the sexes were considered separately, the brown traps again caught more weevils than white ones ($\alpha \leq 0.10$). These data indicate that weevils are attracted to this type trap and that brown traps are more attractive than white traps in an orchard environment at the time of weevil emergence.

Test 2. Tall and short traps adjacent to whitewashed trees captured a total of 360 and 282 weevils, respectively, while tall and short traps adjacent to natural trees captured 144 each (Fig. 1). Fitting of quadratic regression equations to cumulative catches of male and female weevils and both sexes combined for each treatment throughout the trapping period indicated that treatment differences occurred (Fig. 2). Analysis of variance of the coefficient of linear regression on date of cumulative number of weevils captured per trap indicate that traps adjacent to whitewashed trees captured significantly more weevils than did traps adjacent to natural trees, and tall traps adjacent to whitewashed trees captured significantly more weevils than short traps adjacent to whitewashed trees. The reason that the tall traps captured more weevils than did short traps is not understood but may be related to the fact that a tall trap likely would be easier for a weevil in flight to see, due to its height. If males are more prone than females to fly, and if flight is above the short traps, then tall traps would likely be more effective at catching male weevils. We believe that this may have occurred. Also, the 44% females collected by the short traps is comparable to the 45% females reported from the closed cone trap collections by Dutcher et al. (1986) and which is believed to be near the true sex ratio for these weevils. There were no differences between tall and short traps adjacent to natural trees, but this would be expected because trees in these treatments were likely to be at least as attractive to the adults as were the traps.

Test 3. Means of data collected during this test were analyzed for males, for females, and for both sexes combined. Because Treatment A provided one sample per tree and Treatment B provided two samples per tree, the means of Treatment A were compared with one-half the means of Treatment B. Significant differences between the means of A and one-half of B were not detected for males, females, or both combined. Therefore, under these conditions two traps per tree would appear to capture twice as many weevils as one trap per tree, indicating that traps placed on opposite sides of a tree at these distances do not compete with each other.

Test 4. Total weevils captured in ten traps of each color were: 84% reflectance - 21 weevils, 66% - 28, 44% - 27, 37% - 56, 25% - 54, 18% - 101, 11% - 96, 5% - 220, and 1% - 200, for a total of 803 weevils (442 males - 361 females).

More male weevils were captured by black traps (1% reflectance; mean capture/trap 10.8) and by 5% reflectance traps. Captures of males decreased as trap reflectance increased. There was no significant difference ($\alpha \leq 0.05$) in the number of males captured by a 1% reflectance trap as compared with 5% reflectance traps.

Most female were captured by dark gray traps (5% reflectance, mean capture/trap 11.5). Capture decreased as traps reflectance increased, but with a more gradual change than that observed for males. A dramatic increase ($\alpha \leq 0.05$) in capture was observed for traps reflecting 1% and 5% light, as compared with traps reflecting 11% or more light.

When captures of males and females combined were observed, there were obvious periodic decreases in captures as light reflectance of traps increased (Fig. 3). Mean capture/trap of 1% and 5% reflectance traps were 20 and 22 weevils, respectively, and these treatments were not significantly different ($\alpha \leq 0.05$). The stepwise nature of capture by traps with periodic change in reflectance indicates that the rates of change of trap reflectances 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 to small to allow for resolution of change at the reflectance levels. From this test we conclude that reflectance levels of 1-5% were best for best capturing weevils. We elected to utilize 5% gray traps for additional tests because traps of that reflectance captured more weevils.

Test 5. The first weevil found in cone emergence was on August 9 and the last was on September 20, indicating an emergence period spanning about 43 days (Fig. 4). More than 50% of emergence occurred between September 2 and 14 with major peaks in emergence on September 7 and 13. The September 7 peak was mostly females whereas the September 13 peak was mostly males. Peak emergence may not have been well defined due to the small numbers of captured weevils (α=0.38/trap). Ninety out of 120 cone traps (75%) failed to capture weevils. Sixty-one percent of weevils captured in cone traps were males.

The first weevil captured by dark gray pyramidal traps was also on August 9, and the last was on October 28, indicating an emergence period of about 63 days; about two weeks longer than that indicated by cone traps. Three peaks of weevil presence were indicated on August 16, September 1, and September 20. The largest peak 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 August 16 but significant numbers of females also were captured after the last capture of females by cone traps. Pooled counts of weevils captured by all pyramidal traps was 136 (α=3.40/trap). Fifty-seven percent of weevils captured by pyramidal traps were males.

When comparing treatments (12 cone traps/tree vs. 4 pyramidal traps/tree), pyramidal traps captured 3.0 fold more weevils/trees 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 indicated by cone traps ($\alpha \leq 0.05$).

In this test, there was no directional effect ($\alpha \leq 0.05$) 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 these differences, if they exist.

Weevil infestation of nuts were not significantly different ($\alpha \leq 0.05$). Nuts from trees of the cone traps treatment averaged 14.8% infested and those of pyramidal traps averaged 12.5%.

Test 6. Average weevil capture/trap season was 66.2 at 1.8 m and 67.4 at 4.5 m and these were not significantly different ($\alpha \leq 0.05$). Indeed, there was an almost perfect overlap of the curves plotted for the traps of both distances (Fig. 5). Peaks of weevil capture were similar for all dates and mean numbers captured were also similar. The first peak occurred during August 6-28 and the second on September 13. Minor numbers of weevils were captured at both distances during October and November. More than 50% of all weevil captures occurred between August 30 and September 22. Weevils captured at 1.8 m and 4.6 m, were mostly males (58.7 and 58.2%, respectively).

Test 7. Substantial capture did not begin until August 9. Total weevil capture per 40 traps (10 replicates) was 2,107 (α=52.7/trap). Distinct peaks of capture occurred on August 13, September 7 and September 22. More than 50% of all weevils were captured during the period September 3-24. Of all weevils captured during the test, 59.7% were males.

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 only a few nuts remaining at harvest; thus feeding pressure on these few remaining 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, these means were not significantly different ($\alpha \leq 0.10$).

A direction effect of weevil capture by traps was evidenced in this experiment. 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. Capture by traps on eastern and northern sides were significantly different ($\alpha \leq 0.05$; df=27; ms=960) but eastern and northern captures were not significantly different ($\alpha \leq .05$) than southern and western captures.

CONCLUSIONS

These experiments indicate that pyramidal traps offer a practical and efficient method for detecting the presence of weevils within pecan orchards. The primary concern by growers is the relative abundance of adult weevils in the pecan orchard at any given time and the potential for loss of nuts by a given weevil population. Pyramidal traps capture more weevils/trap and should provide users information about weevils over a longer period of time than do cone traps. Pyramidal traps are more sensitive for detecting small weevil populations.

These data indicate that the 1 or 5% gray pyramidal traps placed under trees with whitewashed trunks is superior to the standard cone emergence trapping system for capturing and monitoring adult weevils during and after the emergence period. The use of four pyramidal traps/tree did not exhibit evidence of weevil control by trapping the emerging individuals. For maximum effectiveness, the data indicate that traps should be preferentially positioned on the eastern side of whitewashed trees at distances from 1.8 m to one-half the canopy radius.

This research was based upon the premise that weevils are attracted to tree trunks reflecting low levels of visible light. Weevil responsiveness to low levels of light may also be dependent on background illumination. We believe that weevils perceive pyramidal traps as tree trunks and that they do not recognize whitewashed tree trunks as such. If these assumptions prove correct, then significant knowledge of the behavior of pecan weevils has been gained.

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

LITERATURE CITED

Anderson, O.G. and F.C. Roth. 1923. Insecticides and fungicides and appliances. John Wiley and Sons, Inc., New York.

Anonymous. 1990. The boll weevil trap: an eradication tool. Fact Sheet. USDA, APHIS.

Dutcher, J.D. and J.A. Payne. 1983. Impact assessment of carbaryl, dimethoate, and dialifor on foliar and nut pests of pecan orchards. J. Georgia Entomol. Soc. 18(4):495-507.

Dutcher, J.D., J.A. Payne and J.K. Sharpe. 1986. Monitoring adult pecan weevil (Coleoptera: Curculionidae) emergence with a malaise trap. J. Econ. Entomol. 79(5):1397-1400.

Ellis, HC and R. Hudson. 1993-1994. Pecan pest management handbook. Univ. Ga. Coop. Ext. Serv. 71 pp.

Ellis, HC, P. Bertrand, T.F. Crocker and S. Brown. 1992. Georgia Pecan Spray Guide. Univ. Ga. Coop. Ext. Serv. 12 pp.

Neel, W.W. and M. Shepard. 1976. Sampling and adult pecan weevils. Southern Cooperative Extension Bulletin 208. Misc. Agric. and Forestry Exp. Sta., Miss. State. 17 pp.

Raney, H.G. and R.D. Eikenbary. 1968. Investigations on flight habitats of the pecan weevil *Curculio caryae* (Coleoptera: Curculionidae). Can. Entomol. 100:1091-1095.

Tedders, W.L. 1974. Bands detect weevils. Pecan Quarterly 8(3):24-25.

Tedders, W.L. and B.W. Wood. 1994. A new technique for monitoring pecan weevil emergence (Coleoptera: Curculionidae). J. Entomol. Sci. 29(1):18-30.

Tedders, W.L. and B.W. Wood. 1995. Experiments with pyramidal traps for monitoring pecan weevil emergence (Coleoptera: Curculionidae). J. Entomol. Sci. (In press)

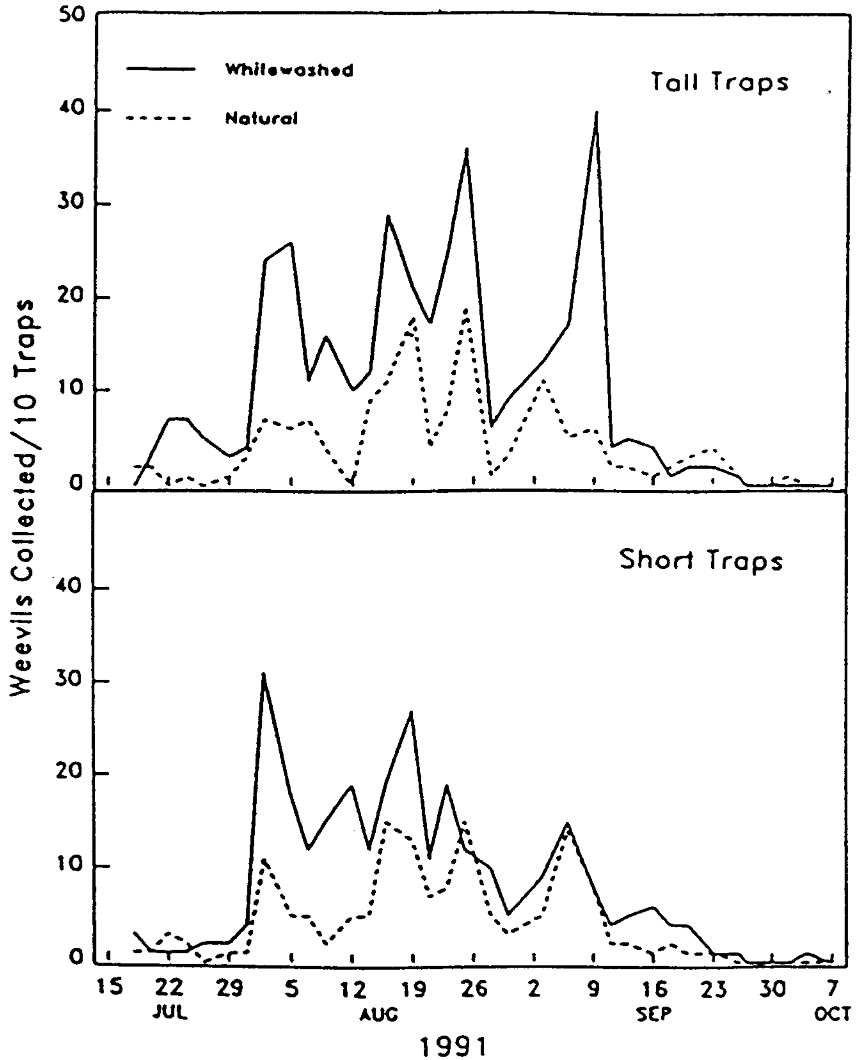

Figure 1. Total number of weevils collected by10 tall traps adjacent of whitewashed trees and 10 traps adjacent to natural trees, and number of weevils collected by 10 short traps placed adjacent to whitewashed trees and 10 traps adjacent to natural trees, 18 Jul-7 Oct 1991.

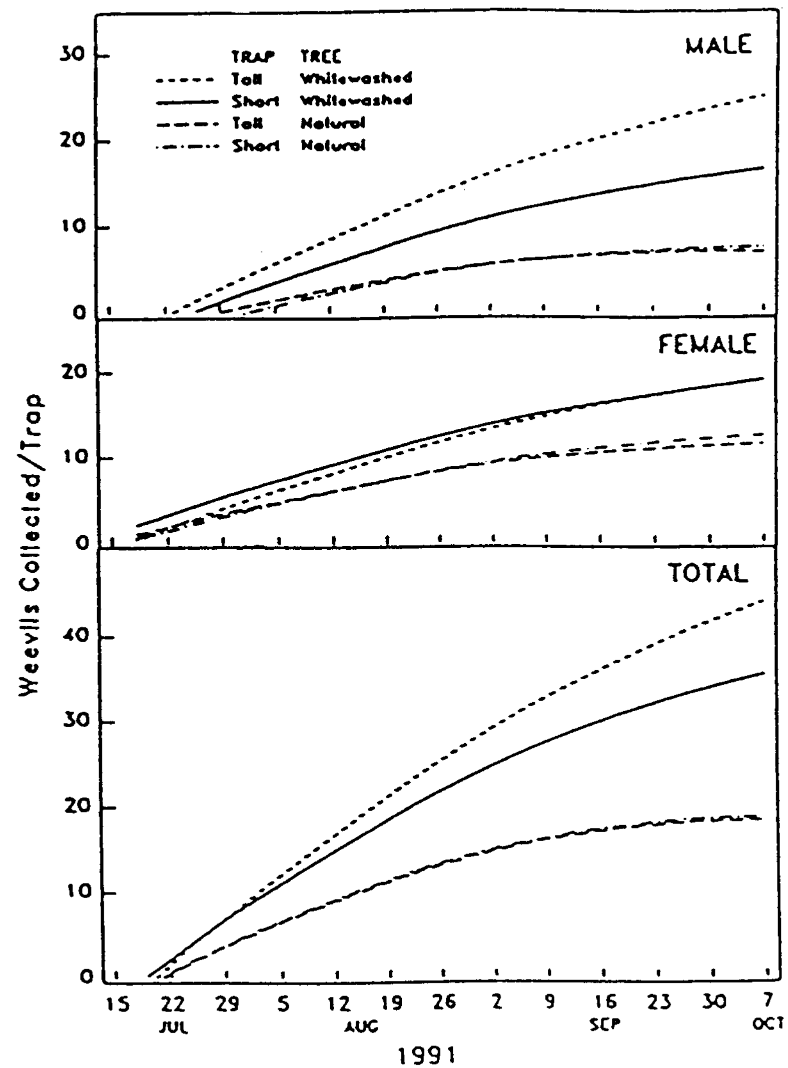

Figure 2. Linear regression of cumulative numbers of male weevils, of female weevils,and of male plus female weevils, collected by tall and short traps adjacent to whitewashed and natural trees, July-Oct 1991.

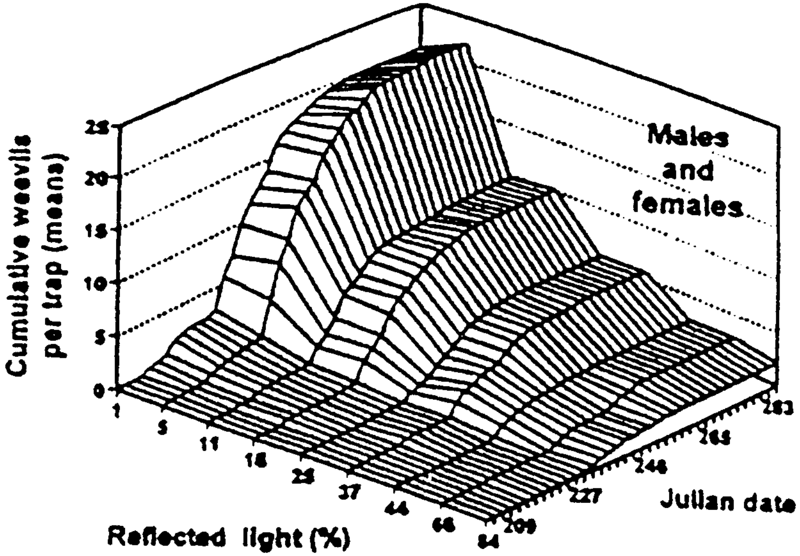

Figure 3. Graphs of cumulative pecan weevil capture (mean/trap), percent light reflected by pyramidal trap and date of weevil capture; July-October 1992, Byron, GA.

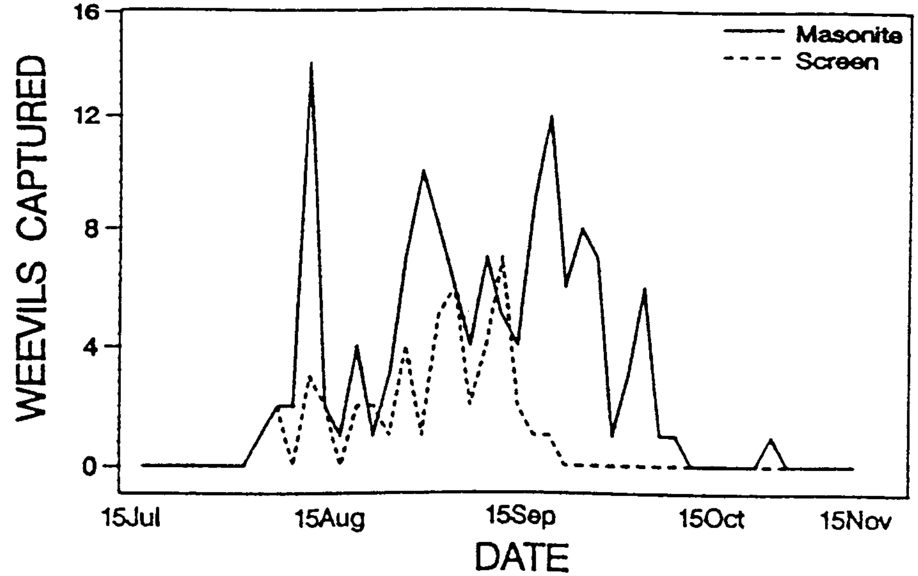

Figure 4. Total number of pecan weevils captured by 40 dark gray pyramidal traps compared with total weevils captured by 120 cone emergence traps, July-November 1992, Byron, GA.

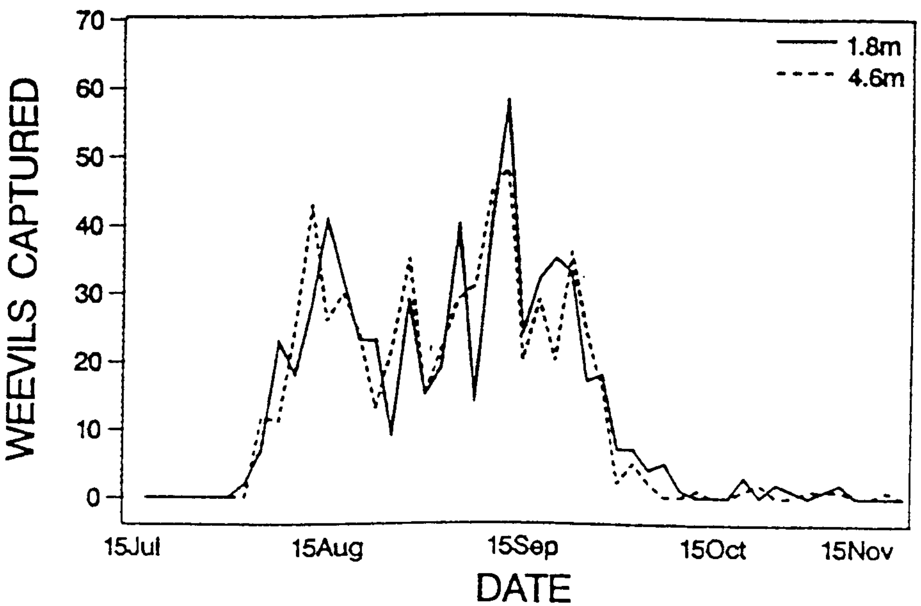

Figure 5. Mean number of weevils captured by pyramidal traps located 1.8 and 4.6 m distance from tree trunks, July-November 1992, Byron, GA.