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ABSTRACT: Broadcast treatments of a number of anticoagulant baits were found to be effective for the control of pine voles in orchards. Rates necessary for good control were: Volak - 15 lbs/A; Bromodiolone - 15 lbs/A; Rozol - 20 lbs/A; two applications of Ramik-Brown - 20 lbs/A each. At least 3 days of good weather appeared to be required for good vole control.

Cellophane packeted baits of Volak placed at each tree in vole runways under cinder blocks gave excellent control. Bait remained in excellent condition for long periods of time or until opened by voles.

An electromagnetic device was evaluated for vole control in a 30 acre orchard. The instrument was found to be ineffective over the 8 week test period.

A ground cover spray application of Kerb at 4 lbs of 50 WP/A was not effective as a repellent when applied at the rate of 600 gal. of water/sprayed acre (400 gal/A of orchard).

INTRODUCTION: Broadcast applications of baits for pine vole control have not been previously researched or successfully used by the fruit industry. Currently, Zinc Phosphide ($Zn_3P_2$) broadcast applications are in use for meadow vole control, but not for the pine vole. Since hand placement of $Zn_3P_2$ grain baits has given very poor pine vole control (2), broadcast applications of these formulations would not be expected to be effective. Since hand placed anticoagulant bait formulations have been much more effective against pine voles than $Zn_3P_2$ (2), various rates of four anticoagulants were tested for their potential use as a broadcast treatment in orchards.

In the orchard environment, anticoagulant bait formulations have been found to be acceptable to voles for only a short period of time due to moisture absorption and molding of the bait after rain or heavy dew. Since one of the main disadvantages of chemical control methods has been the rapid rebound of the population after treatment, a cellophane packaged Volak bait was evaluated for its control potential because the packet could protect the bait from the environment.

Since one of the electromagnetic devices, "Nature Shield", made by Solara Environmental Products, 15191 Sunland Lane, Costa Mesa, California was displayed at one of our Virginia fruit schools, the necessity for determining the effectiveness of the device was quite obvious (3). The device is advertized to give control of many rodents including voles and designed to give control over a 30-acre plus area and was priced slightly less than $1000.

The herbicide, Kerb, was found by the Rohm & Haas Company to have rodent repellent properties. For this reason, a single plot of a 4 lb/A of a 50 WP formulation was ground sprayed at the rate of 600 gal.

of water/treated acre on 2/3 of the orchard floor directed as an under-tree-row strip.

Rapid field evaluation of treatments for pine vole control in orchards many years ago led to apple indexing techniques (5). Within the last 10 years animal biologists who have had the responsibility within the EPA to evaluate field efficacy data have been on occasion quite critical of the apple indexing technique. For this reason, a comparison of the apple indexing and live trapping techniques was made since we were interested to know if live traps were as efficient as apples in detection of the presence of voles at a tree.

METHODS AND MATERIALS: Evaluation of pine vole control plots was determined using methods previously described (1,3). Randomized complete block designs were used in experiments by blocking plots according to the pre-treatment activity readings by first ranking plots from high to low and assigning treatments randomly to activity categories: high, medium, low. All experiments were conducted in mature orchards in the age range of 15-40 years. Data summarized in Table 1, Table 2, Table 3, Table 4, and Table 5 were collected from experiments conducted in orchards having 50, 80, 80, 50, and 50 trees/A, respectively. Twenty to 30 monitor sites were established per plot with either 1 (Tables 2,3) or 2 sites/tree (Tables 1,4,5). Since plots were quite variable in population level some plots contained more total area and more sites in an attempt to better equalize the population per plot.

Cellophane packets were placed under cinder blocks at the rate of 1 per tree. Since this orchard had rubber mats placed the previous year cinder blocks were placed on top of the rubber mat to prevent non-target species from getting to the bait.

The electromagnetic device was placed in an orchard with a rather heavy infestation of pine voles. The orchard was a well mowed and maintained block of 42-year-old York trees set 35' X 35'. Activity sites (1 per tree) were established across the block (13 rows wide) and within the row length (67 tree spaces) in a perpendicular fashion across the center of the "Nature Shield" device. Sites were not established where trees were previously removed. Activity readings were taken 8 times during the 62 day test period. The first device was placed March 21, 1978 and the second on April 21 at the request of the company since no significant control of the animal had been achieved after the first month. All sites were dead trapped with snap traps, baited with apple, during the period May 29-June 1.

Kerb, a herbicide, found to have rodent repellent activity was ground sprayed at the rate of 4 lbs/A of a 50 WP. The application was made using a high pressure gun application at 600 gal. of water per sprayed acre. The 2/3 of the orchard floor under the trees was sprayed at a rate of 400 gallons/geographic acre of orchard.

To determine whether live trap or apples were more sensitive to detection of animal presence, two rows with 50 sites each (2 sites/tree) were established so that apples placed in one row could be exchanged daily with traps in an adjacent row the next day. On October 16, 1978 live traps were placed in row 1 and whole apples (with a 2.5 cm slice

removed) were placed in row 2 for a period of 6 hours. The following day apples were placed in row 1 and traps in row 2 for 6 hours. Traps and apples were exchanged daily for 4 more days (Table 6) for a total of 6 days.

RESULTS AND DISCUSSION: Broadcast applications of anticoagulant formulations of Volak, Rozol, and Bromodialone gave excellent control of voles in a single application at 19, 23, and 15 lbs/A respectively (Table 1). Ramik-Brown at 20 lbs/A gave some control, but one application would not be considered adequate (Table 1). A single broadcast treatment of Ramik-Brown was approximately equivalent to a single 10 lb/A hand placed application (Table 2). However, activity on December 7 indicated that two broadcast applications of 20 lbs. each would be required to give consistent adequate control (Table 2). Previous experiments have shown that two - 10 lbs/A hand placed applications are necessary for adequate control under heavy populations (2).

The broadcast application of Volak at 11 lbs/A gave excellent control in this orchard but with considerable variability between plots. Activity on December 1 was 0, 0, and 32% for each plot, respectively, which is not acceptable even though the average (11%) looks pretty good (Table 3). In the past we have observed that when the lower limit of a control measure is tried, great variability between plots may result. In 1977 and 1978 rates of 15-20 lbs/A of Volak has resulted in consistent control between plots and years. I believe that 15 lbs/A should be the lowest recommended rate for broadcast applications of Volak.

Cellophane packets of Volak placed under cinder blocks gave excellent control of voles (Table 3). The continuous availability of baits from a single hand placed packet application provides a number of advantages over that of ground sprays, broadcast, and hand placed bulk baits. Toxicant methods presently available are effective for only a short period of time due to moisture absorption, molding of baits, and weathering of ground sprayed materials such as Endrin and Chlorophacinone. Changes in adjoining field culture may also cause unpredicted vole invasions after a previously applied toxicant is no longer effective. Animal movement under snow cover has always been a serious problem, particularly in areas where snow packs make baiting impossible in the winter.

Probably the greatest advantage of place packs is that of reducing and maintaining a very low population over a long period of time. In addition, insufficient vole numbers may exist within the orchard environment so that the reproductive potential is eliminated. If this can be achieved no rebound in population should occur and the costs for replacement packets should go down drastically in subsequent years. Durability of the compound and bait formulation over long periods of time (i.e. 1-3 years) in the field should be checked. If the bait remains good for several years, only those packets opened during one year would have to be replaced the following year.

Substantial bait stations such as cinder blocks (2" X 8" X 16") weighing approximately 12 lbs. each) or automobile tires cut longitudinally (weighing 8-10 lbs. each) would be required to prevent non-target animals from removing place packs. Our plots containing Volak place

packs and Volak broadcast (Table 3) were near a farmhouse where 3 large dogs were let run in the orchard. Other dogs were seen while working in the plot area. No mats were moved or dogs killed over the 3 month period the packets were left in the orchard. For this reason, we believe they can be used safely.

The electromagnetic device did not affect the distribution of active trees down the row during the course of the experiment nor were the numbers of animals per tree affected, the closer the trees were from the device. Activity remained high while the device was in place and large numbers of animals were trapped after the 62-day trial period (Table 4).

Kerb, a herbicide, did not adequately affect the % of trees infested over a 20 day period. If the material was to act as a repellent and dislodge the animals from the plot, a rapid decline of activity would have been expected, but no decline occurred (Table 5).

Since monitoring of populations using live trap and release techniques requires trapping and tagging of animals over a rather long period of time (several days), the method has many disadvantages when used for evaluation of treatments. First, weather conditions from October through December may be cold, rainy, and much difficulty can be encountered and great differences may exist between beginning and ending weather conditions within the same experiment. In addition, traps usually cannot be left open during the night period as animals in traps may die from exposure. Thirdly, an experimenter may want to compare the relative effectiveness of 4-8 treatments in the same experiment. To statistically analyze data, at least three replicates of treatment would be required, and the amount of labor and traps required to make these type of comparisons may be prohibitive, and in my opinion, very unnecessary. Since vole populations are always changing and can materially change during the course of an experiment, the important fact to know is whether the treatment has eliminated the voles at most of the trees in the plot and that the apple index measurement is correlated well with population level. In this comparison experiment (Table 6), the apple indexing technique was found 104% more efficient for detecting the presence of animals than the live trapping for day time 6 hour periods. Since the presence of animals at a tree can be equated with the potential for damage at that tree, it seems to me that the apple indexing technique has much to offer since it requires much less labor, equipment and time to conduct than live trap and release techniques. Apple indexing also does not disturb the population prior to treatment. Experiments such as the Kearneysville cultural experiment (4) could not have been done without a rapid technique.

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Table 1. Effect of broadcast treatments of anticoagulants on pine vole activity and populations (1978).

| Treatment | No. of plots | Rate kg/ha | Rate lbs/A | Date treated | % Activity[z] Nov 3 | % Activity[z] Dec 1 | Voles/plot (Dec 4-8) | Voles/ site | % Control |
|---|---|---|---|---|---|---|---|---|---|
| Control | 3 | -- | -- | -- | 79 a[y] | 56 a | 9.7 a | 0.37 a | 0 |
| Volak | 3 | 21 | 19 | Nov 9 | 83 a | 1 b | 0.3 b | 0.01 b | 97 |
| Ramik-Brown | 3 | 22 | 20 | Nov 9 | 79 a | 21 ab | 4.7 a | 0.16 a | 57 |
| Rozol | 3 | 26 | 23 | Nov 9 | 81 a | 5 b | 0.6 b | 0.02 b | 95 |
| Bromadiolone | 3 | 17 | 15 | Nov 9 | 80 a | 10 b | 0.0 b | 0.00 b | 100 |

[z] Apples placed in 2 holes or runs 5-15 cm below the soil surface on opposite sides of the tree were examined 24 hrs after placement. Percent activity refers to all sites with vole tooth marks on the apple.

[y] Mean separation, within columns by Duncan's multiple range test, 5%.

Table 2. Effect of broadcast and hand placed treatments of Ramik-Brown (DPN) on pine vole activity and populations (1978).

| Treatment | No. of plots | Rate kg/ha | Rate lbs/A | Date treated | % Activity[z] Oct 31 | % Activity[z] Nov 21 | % Activity[z] Dec 7 | Voles/plot (Dec 11-15) | Voles/ site | % Control |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 3 | -- | -- | -- | 85 a[y] | 84 a | 83 a | 42.7 a | 1.74 a | 0 |
| Ramik - Broadcast | 3 | 22 | 20 | Oct 31 | | | | | | |
| | | 22 | 20 | Nov 21 | 84 a | 23 b | 11 c | 0.7 c | .03 c | 98 |
| Ramik - Broadcast | 3 | 22 | 20 | Nov 21 | 81 a | 74 a | 25 bc | 3.0 bc | .13 bc | 93 |
| Ramik - Hand placed | 3 | 11 | 10 | Nov 21 | 82 a | 79 a | 36 b | 6.0 b | .23 b | 87 |

[z] Apples placed in a hole or run 5-15 cm below the soil surface near the tree trunk were examined 24 hours after placement. Percent activity refers to the % of sites with vole tooth marks on the apple.

[y] Mean separation, within columns by Duncan's multiple range test, 5%.

Table 3. Effect of broadcast and hand placed packeted Volak baits on pine vole populations (1978).

| Treatment | No. of plots | Rate kg/ha | Rate lbs/A | Date treated | % Activity[z] Nov 3 | % Activity[z] Dec 1 | Voles/plot (Dec 4-8) | Voles/ site | % Control |
|---|---|---|---|---|---|---|---|---|---|
| Control | 3 | -- | -- | -- | 83 a[y] | 70 a | 21 a | 0.92 a | 0 |
| Volak - Broadcast | 3 | 12 | 11 | Nov 10 | 78 b | 11 b | 1.3 b | 0.06 b | 93 |
| Volak - packets (1 packet/tree) | 3 | 8 | 7 | Nov 10 | 76 b | 0 b | 0.3 b | 0.01 b | 99 |

[z] Apples placed in a hole or run 5-15 cm below the soil surface near the tree trunk were examined 24 hours after placement. Percent activity refers to the % of sites with vole tooth marks on the apple.

[y] Mean separation, within columns by Duncan's multiple range test, 5%.

Table 4. Effect of the "Nature Shield" magnetic field device on pine vole activity and population level (1978).

| Location[y] | No. of trees monitored | % Activity[z] Days from first placement of device 0 | 9 | 17 | 31 | 38 | 43 | 50 | 57 | 62 | Voles trapped May 29-June 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Row (North-South) | 59 | 71 | 95 | 95 | 92 | 86 | 86 | 97 | 97 | 97 | 207 |
| Across Rows (East-West) | 12 | 92 | 100 | 100 | 100 | 92 | 92 | 100 | 100 | 100 | 53 |
| Total | 71 | 75 | 96 | 96 | 93 | 87 | 87 | 97 | 99 | 97 | 260 |
| | | | | | | | | | | Average | 3.7 voles/ tree |

[y] Device was located in row 7 at tree 34 in the approximate center of the orchard.

[z] Refers to the % of trees with a detectable pine vole population as indexed by the apple activity method (2).

Table 5. Effect of Kerb, a herbicide, applied as a ground cover spray, rodent repellent for vole control (1978).

| Treatment | No. of plots | Rate kg/ha | Rate lbs/A | % Activity[z] Nov 3 | % Activity[z] Dec 1 | Voles/site (Dec 4-8) | % Control |
|---|---|---|---|---|---|---|---|
| Control | 3 | -- | -- | 79 | 56 | 0.37 | -- |
| Kerb 50% WP | 1 | 4.4 | 4.0 | 75 | 67 | 0.50 | 0 |

[z] Apples placed in a hole or run 5-15 cm below the soil surface near the tree trunk were examined 24 hours after placement. Percent activity refers to the % of sites with vole tooth marks on the apple.

Table 6. Efficiency of apple indexing or live trapping for detection of pine vole presence at established sites in an orchard (1978).

| Treatment | % Active traps or apples October 16 | 17 | 18 | 19 | 23 | 24 | % Active (average) |
|---|---|---|---|---|---|---|---|
| | | | Row 1 | | | | |
| Live trap | 42[z] | | 38 | | 20 | | 33.3 |
| Apple | | 76 | | 66 | | 60 | 67 |
| | | | Row 2 | | | | |
| Live trap | | 26 | | 30 | | 24 | 26.6 |
| Apple | 42 | | 62 | | 62 | | 55.3 |
| | | | | | Average live trap | | 30.0 |
| | | | | | Average apple index | | 61.2 |

[z] On alternating dates either apples or live traps were placed under plastic trash can lids for a period of 6 hours (9:30 am - 3:30 pm) in each of 2 rows. Data reflect the % of 50 traps or 50 apples active during each 6 hour period.