COMPARISON OF METHODS FOR DETECTING VOLES UNDER APPLE TREES

MARK E. TOBIN,[1] U. S. Department of Interior, New York Cooperative Fish and Wildlife Research Unit, Cornell University, Ithaca, NY 14853-3001

MILO E. RICHMOND, U. S. Department of Interior, New York Cooperative Fish and Wildlife Research Unit, Cornell University, Ithaca, NY 14853-3001

RICHARD M. ENGEMAN, U. S. Department of Agriculture, Denver Wildlife Research Center, P.O. Box 25266, Building 16, Denver, CO 80225

Abstract: We conducted a study in 2 heavily infested orchards in the mid-Hudson Valley of New York to evaluate methods for detecting the presence of meadow voles (MV, *Microtus pennsylvanicus*) and pine voles (PV, *M. pinetorum*) under apple trees. We quantified several possible signs indicating the presence of voles in each of the 4 quadrants under the canopy of each tree, and then set and monitored traps until capture success in the orchard declined to zero. There was no evidence that the 4 quadrants differed with respect to any of the variables examined. The apple slice index (ASI) was the best indicator for both species. Detection improved significantly ($P < 0.05$) when the ASI was used in conjunction with the number of runways (MV) or tunnels (PV) under the tree, although neither of the latter 2 signs was by itself a reliable indicator. The ASI and search for runways and tunnels should be conducted in at least 2 quadrants under each tree. The significance of these findings for managing voles in apple orchards is discussed.

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Growers in the United States lose millions of dollars annually because of vole damage to apple trees (Pearson 1976, Pearson and Forshey 1978, Phillips et al. 1987, Richmond et al. 1987, Askham 1988). Vole girdling on trunks and roots kills trees, reduces yields, and increases the time required for new plantings to come into production. Growers use a variety of techniques to reduce vole populations in apple orchards, including maintaining a vegetation-free zone under the canopy, mowing the groundcover regularly, installing wire-mesh guards around the bases of trees, removing apple drops, prunings, leaf litter, and other debris from orchards, and applying rodenticides (Byers and Young 1978). Growers with acute problems should use as many of these methods as practical or possible (Eadie 1954).

Because even well-managed orchards are susceptible to invasion and damage by voles, growers need reliable methods of detecting these pests before populations build up and appreciable damage occurs. Most growers use indirect methods to assess vole populations in their orchards, including monitoring the occurrence of damage, estimating the abundance of vole runways and tunnels, and conducting the apple slice index (ASI) (Byers 1975). The latter technique entails placing a slice of apple in a vole runway or tunnel and checking it 24 hours later to see whether it has been partially eaten, is missing, or has otherwise been disturbed by voles.

Detecting voles usually is easy where populations are high, but it is more difficult where animals are scarce or distributions are disjunct. To monitor vole populations efficiently, a grower needs to know which index most reliably indicates the presence of voles and which sampling strategy (e.g., the location and intensity of searches) best characterizes an orchard's vole population. In this study we evaluated: (1) differences among the 4 sides of each tree inspected for evidence of voles; (2) differences between the 2 alley sides of a tree versus the 2 within row sides of a tree; and (3) the combination of variables that best indicates the presence of voles, as measured by captures.

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STUDY AREA

We conducted this study in portions of 2 apple orchards in the mid-Hudson Valley of New York: one heavily infested with meadow voles (MV) (primarily an above-ground species), and the other heavily infested with pine voles (PV) (a burrowing species). The block having MV encompassed about 1.4 ha in the town of Esopus and contained 266 apple trees of various cultivars and ages. The block having PV was south of New Paltz and encompassed about 1.5 ha of 268 mature McIntosh apple trees (Gourley 1983).

METHODS

Depending on the species present in the orchard, we recorded the following variables for each of the north (N), south (S), east (E), and west (W) quadrants under the canopy of each tree: number of active runways (MV) or tunnels (PV), number of inactive runways (MV) or tunnels (PV), total length of all tunnels (PV), and the results of the ASI (MV and PV). We subsequently set and monitored standard snap-traps and, in the PV orchard, metal Sherman live-traps, until trapping success in the orchard declined to zero.

We conducted a series of 1-way ANOVA's to compare the 4 quadrants with respect to the number of: (1) active runways

[1] Present address: U.S. Department of Agriculture, Denver Wildlife Research Center, P.O. Box 10880, Hilo, HI 96721

or tunnels; (2) inactive runways or tunnels; and (3) combined number of runways or tunnels. Because voles may concentrate their activity on the sides of trees that are farthest from the orchard alleys, we specified an *a priori* contrast to test for differences between the NS (which faced the adjacent trees within the same row) versus the EW (which faced the alleys between the rows of trees) quadrants with respect to the above variables. The results of the ASI were compared among quadrants using a 2-x-4 chi-square contingency table.

We conducted a series of discriminant analyses to explore which of the previously discussed variables best indicates the presence of voles at a tree (as measured by whether there was at least 1 capture). We considered the variables for the 4 quadrants individually, as well as their sums over the 4 quadrants, and their sums over the NS quadrants and the EW quadrants. We assumed that inspecting opposite sides of a tree is more informative than inspecting adjacent sides. To insure that we would not overlook an important variable, we used the SAS procedure "PROC STEPDISC" (SAS Institute 1988) to perform forward selection, backward elimination, and stepwise selection discriminate analyses to identify those variables that contributed most to predicting the presence of voles at a tree. After obtaining a clearer picture of which variables had potential for indicating vole presence, we used the SAS nonparametric procedure "PROC DISCRIM" (SAS Institute 1988) to evaluate which sets of candidate variables most accurately classified the capture results. Our criterion was the estimated percent of classification errors—the lower the percent of errors, the better the classification model for predicting the presence of voles. The discriminate functions used for classification are not of great general use because they are specific for the data from these 2 orchards, but they provide a means for assessing the type of classification (determination of vole presence) that is possible from these variables and evaluation methods. We conducted follow-up analyses to determine whether recording the presence or absence of runways instead of their number would suffice for predicting the presence of voles.

RESULTS

We captured 247 MV ($\bar{x}$ = 0.93/tree) and no PV in the Esopus orchard. There were no differences among quadrants in the number of active runways (F = 0.71; 3, 1060 df; P = 0.54), inactive runways (F = 0.40; 3, 1060 df; P = 0.75), or active and inactive runways combined (F = 0.94; 3, 1060 df; P = 0.42) (Table 1).

We captured 472 PV ($\bar{x}$ = 1.76/tree) and no MV in the New Paltz orchard. The 4 quadrants differed slightly but significantly with respect to the numbers of active tunnels (F = 3.00; 3, 1068; P = 0.03), inactive tunnels (F = 2.82; 3, 1068; P = 0.04), and active and inactive tunnels combined (F = 2.68; 3, 1068; P = 0.05). However, the small magnitude of the differences among quadrants and the lack of any particular pattern relating to the orchard situation (Table 1) indicate that these differences are not of biological importance with regard to selecting which side of a tree to sample. There were no differences between the alley quadrants and the within-row quadrants (F = 0.09; 1, 1068 df; P = 0.76 for active tunnels; F = 1.21; 1,1068 df; P = 0.27 for inactive tunnels; and F = 0.22; 1, 1068 df; P = 0.64 for active and inactive tunnels combined).

Table 1. Mean number (SE) of active and inactive runways or tunnels in each quadrant under the canopy of apple trees in 2 orchards in the mid-Hudson Valley of New York. The New Paltz orchard contained pine voles exclusively, and the Esopus orchard contained meadow voles exclusively.

		Number of runways or tunnels		
Species	Quadrant	Active	Inactive	All
Meadow voles	N	0.37 (0.05)	0.06 (0.02)	0.43 (0.05)
	S	0.38 (0.05)	0.07 (0.02)	0.45 (0.05)
	E	0.47 (0.05)	0.08 (0.02)	0.55 (0.05)
	W	0.40 (0.05)	0.08 (0.02)	0.48 (0.06)
Pine voles	N	1.74 (0.10)	1.05 (0.08)	2.79 (0.11)
	S	2.20 (0.12)	0.90 (0.07)	3.10 (0.10)
	E	2.02 (0.11)	1.01 (0.08)	3.04 (0.11)
	W	1.99 (0.11)	0.76 (0.07)	2.75 (0.11)

The contingency table data for the ASI indicated no differences among quadrants for either species of voles (X^2 = 0.98; 3 df; P = 0.81 for PV, and X^2 = 1.69; 3 df; P = 0.64 for MV).

The preliminary stepwise discriminate analyses indicated that the ASI is important, both in all quadrants and in subsets of quadrants, for indicating the presence of MV. Measures of the number of runs also showed potential for indicating the presence of this species. Because the ANOVA revealed no differences among quadrants, we looked at NS and N as being representative of using 2 and 1 quadrants, respectively. The nonparametric discriminate function indicated that the ASI used in conjunction with the total number of runs around a tree offered the best indication of MV presence (Table 2). The ASI from only 1 quadrant in conjunction with total runways did not perform as well as when 2 quadrants were used. However, the use of 2 quadrants for the ASI in conjunction with total runs worked as well as when 4 quadrants were used.

Table 2. Percent of classification errors in discriminate functions to predict the number of voles captured under individual apple trees. The variables for the 2 species were measured in separate orchards in the mid-Hudson Valley of New York before trapping out all the voles at each site.

Variables included	% classification errors: Meadow voles	% classification errors: Pine voles
ASI-total	35.1	33.6
Tunnels/runways-total	40.5	35.0
ASI-total & tunnels/runways-total	28.4	27.1
ASI-NS	33.5	36.8
ASI-NS & runways/tunnels-total	28.3	28.8
ASI-N	34.3	41.6
ASI-N & runways/tunnels-total	32.9	33.7

When the presence or absence of runways in the 4 quadrants combined was used to predict the presence of MV, the rate of classification errors was 45.7%. This declined to 31.6% when the presence or absence of runways was used in conjunction with the ASI-NS.

The preliminary discriminate function analyses for PV indicated that ASI, either in all quadrants or in subsets of quadrants, best predicted the presence of this species under apple trees (Table 1). The length of tunnels also was important, but we excluded it from further consideration because it is labor intensive and impractical to measure. Additional exploratory runs indicated that the number of tunnels around a tree may contribute to predicting the presence of PV. Thus, in the nonparametric analyses for PV, we considered similar variables as for MV except that number of tunnels replaced number of runways. Conducting the ASI in 4 quadrants was only slightly better than conducting it in only 2 quadrants for predicting capture success for PV, but both of these were significantly better than conducting it in 1 quadrant (Table 2).

We could not evaluate the use of the binary variable, presence or absence of tunnels, for predicting the presence of PV because all trees in the New Paltz block had tunnels.

DISCUSSION

Several investigators have evaluated the relationship between various indices and the density of vole populations in orchards (Byers 1975, 1979, 1981, Hayes and Cullinan 1984, Cullinan 1984). However, Byers (1978) suggested that for control purposes it may be more useful to determine the percent of trees infested rather than the density of voles in an orchard. Even a single vole can kill an apple tree. The economic threshold for controlling voles therefore is very low, and growers should apply controls wherever they see evidence of these pests.

The ASI was the single most reliable indicator in our study of the presence of voles under an apple tree. This index was first described by Horsfall (1956). It has been used widely to estimate vole populations (e.g., Byers 1975, Hayes and Cullinan 1984, Cullinan 1984) and to evaluate control techniques (e.g., Byers 1979, 1981, Hunter et al. 1987).

Runways or tunnels by themselves were not reliable indicators, although when used in conjunction with the ASI these signs significantly enhanced the detection of voles. The presence of runways or tunnels alone can be misleading in that voles could have died or emigrated from the area even though signs of their activity persist. Thus, the presence of runways and tunnels is not sensitive to short-term population changes. However, fresh grass clippings and vole droppings in runways indicate the recent presence of MV.

Our results indicate that one should conduct an ASI and search for runways and tunnels in at least 2 quadrants under a tree before concluding that no voles reside there. For MV, the presence or absence of runways is almost as good a predictor as the number of runways, especially when used in conjunction with the ASI-NS. The increased ease of collecting the binary data for runways probably offsets the slight reduction in accuracy.

The reliability of vole indices may vary among years, seasons, and areas (Hayes and Cullinan 1978, Hayne and Sullivan 1983). This study was conducted in 2 older orchards that contained extremely high populations of voles, and the results may not apply to younger orchards or where there are fewer animals. More studies are needed to determine the reliability of the monitoring techniques described in this study.

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