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Ross E. Byers
Virginia Polytechnic Institute and State University, Winchester, Virginia

Mark H. Merson
Virginia Polytechnic Institute and State University, Winchester, Virginia

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Ross E. Byers and Mark H. Merson
Winchester Fruit Research Laboratory
Virginia Polytechnic Institute and State University
Winchester, Virginia 22601

Abstract. Broadcast treatments of Volak (Brodifacoum), Rozol (Chlorophacinone), ZP Rodent Bait AG, and Ramik-Brown (Diphacinone) gave excellent to good control of voles in decreasing order of effectiveness. A saccharin formulation of Ramik-Brown or doubling the concentration of diphacinone to 0.01% did not result in any additional control over the current formulation. Hand placement of ZP Rodent Bait AG at 1 to 3 lbs/A gave excellent control of voles. Place packs of ZP Rodent Bait AG were not opened at all sites, however, residual activity from apple activity data indicated that this product gave excellent control. Additional field and laboratory evaluations are suggested.

Low broadcast rates of Rozol at 9 lbs/A did not give adequate control of pine and meadow voles. The FMC Zinc Phosphide corn and oat formulation did not perform well even when compared to even lower rates of ZP Rodent Bait AG in broadcast trials.

The caching response of pine and meadow voles were found to differ markedly in one field experiment. Over 60% of the sites visited by pine voles had over 25 grams of blank pellets removed in a 24 hour period. Less than 2% of the meadow vole sites had 25 g removed in the same period of time.

Methods and Materials:

1) Field trials --- Evaluation of pine and meadow vole control plots was determined using methods previously described (1,2). In these experiments, plots were blocked according to pre-treatment activity readings by first ranking plots from high to low and assigning treatments randomly into activity categories high, medium, and low. Data summarized in Tables 1 and 2 were taken from orchards having approximately 35 trees per acre (35' X 35').

2) Since plastic packaged bait has the advantage of continuous availability to voles as well as non targets, site covers (split tires or cinder blocks, 2 X 8 X 16 inches) were evaluated as a station for placing plastic packaged Volak or ZP packets. Volak or ZP packets were placed in 47 sites in each of 3 replicate plots of tires or cinder blocks in an attempt to give immediate control. This treatment was then followed within 45 days with another treatment so that packets would then be available for the next 6 month period.

A control plot was not maintained in close proximity to this orchard since continued invasion might have taken place.

3) To determine if pine and meadow voles had a different caching behavior in the field, two orchards were selected with similar tree ages and spacings. Sixty sites were determined to be active using the

apple indexing technique. Animals were live trapped, toe clipped and released. Data indicated 50 meadow voles and 60 pine voles visited the 60 active sites in the two blocks. Some trees were eliminated from the experiment in both blocks if voles were not trapped at these trees. One pine vole was trapped in the meadow vole block but no meadow voles were found in the pine vole block. Three different pellet sizes were placed in the sites by blocking the 60 sites into 3 blocks according to the degree of feeding on an apple and the number of voles visiting the sites. This assured a more equal distribution of pellet sizes among animals visiting various sites in the field. Fifty grams of pelleted bait were allowed to remain in the sites for a 24 hour period. Pellets were of 3 sizes: 0.22, 0.32, 0.48 mm in diameter and having 1,315 pellets/50 g, 714 pellets/50 g and 294 pellets/50 g respectively. The bait was oven dried in paper bags for 24 hours at 100°C.

Results and Discussion: Broadcast data (Table 1) show that Rozol (CPN) applied at 9 lbs/A is inadequate and that rates should be nearer 20 lbs/A. The ZP Rodent Bait AG gave respectable control at 11 lbs/A but the 14 lbs/A rate appeared to give better control even though not statistically different. The FMC ZP grain treatment at 16 lbs was totally inadequate for control of pine and meadow voles. Hand placement of the ZP Rodent Bait AG at 1-3 lbs gave good control. The results between ZP Rodent Bait AG and the FMC grain bait indicate that inadequate control with grain baits has been the formulation rather than the method of application (hand or broadcast baiting).

The CPN-grain pellet from Lipha (Table 2) appeared to be equal or superior to the CPN-wax pellet used in the USA (Tables 1 and 2). The whole grain-CPN wheat has performed the poorest over the last 2 years field work. The Velsicol DPN formulations gave about the same control level with little if any additional benefit from the .01% DPN level of toxicant or the addition of saccharin. The BFC and the ZP Rodent Bait AG broadcast baiting gave excellent control at rates near 20 lbs/A. Good control of voles was achieved with two applications of packaged Volak bait applied either in the spring of 1979 or the fall of 1980. Populations however did not go to zero as expected and apparently an adequate number of voles existed in the area so that by the fall of 1979 or fall of 1980, the number of packets opened over the period show that voles had existed under 70% or more of the trees in both years in both the tire and cinder block treatments. Cinder blocks or tires as site covers gave similar results. Although the population as indexed on apples remained low from one season to the next, two applications of packets per year were required to maintain an unopened packet at the site. The ZP packet placed in December 1980 gave a good reduction in the population. However, activity on apples placed at the sites remained at 8-10% activity. These results are similar to the results of hand placed and broadcast ZP Rodent Bait in Tables 1 and 2.

Even though Lanier, Estep and Dewsbury (3) found that the meadow and prairie voles were strong hoarding animals under laboratory conditions, under field conditions during the period when orchard baiting is being conducted (December) the meadow vole was not a strong caching vole. The pine vole however has a much stronger hoarding response (Table 1). No differences were found between the amounts of 3 pellet sizes cached by pine voles. Theoretically, broadcast baits made in the

smaller pellet sizes would be more likely to intercept normal vole ranging. With acute toxicants like ZP Rodent Bait the interception of only one pellet would be a lethal dose. We believe more studies should be conducted on the optimum pellet size.

LITERATURE CITED

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2. Byers, R. E. 1981. Pine vole control with anticoagulant baits in orchards. J. Amer. Soc. Hort. Sci. 106:101-105.

3. Chapman, D. G. and W. S. Overton. 1966. Estimating and testing differences between population levels by the Schnabel estimation method. J. Wildlife Management 30:173-180.

Table 1. Effect of broadcast and hand placed rodenticide baits on pine and meadow vole activity and populations treated November 5, 1980.

Treatment	Rate kg/ha	Rate lb/acre	% Highly active sites[z] Nov 4	% Highly active sites[z] Nov 21	% Active sites[z] Nov 4	% Active sites[z] Nov 21	Voles/plot Nov 25-Dec 1	Voles/site[y] Nov 25-Dec 1	% Control
Control			59 a[x]	51 a	80 a	67 a	29 a	.95 a	0
0.005% CPN - broadcast	10	9	58 a	33 ab	81 a	50 ab	10 bc	.32 bc	66
0.005% CPN - broadcast	19	17	39 b	9 cd	79 a	19 bcd	3 c	.12 bc	87
0.010% DPN - broadcast	21	19	56 a	5 cd	81 a	15 cd	4 bc	.14 bc	85
2% ZP - Pellet - broadcast	12	11	58 a	4 d	83 a	15 cd	4 bc	.14 bc	85
2% ZP - Pellet - broadcast	16	14	54 ab	3 d	82 a	6 d	2 c	.07 c	93
2% ZP - Grain - broadcast	18	16	52 ab	20 bc	84 a	40 abc	13 b	.42 bc	56
2% ZP - Pellet - hand placed	1	1	61 a	9 cd	84 a	19 bcd	3 c	.10 bc	89
2% ZP - Pellet - hand placed	3	3	51 ab	3 d	83 a	3 d	3 c	.11 bc	88

[z] Apples placed in 2 holes or runs 5-15 cm below the soil surface on opposite sides of the tree trunk were examined 24 hours after placement. Percent highly active sites refer to sites having a portion of apple of 2.5 cm removed by vole feeding. Percent activity refers to all sites having vole tooth marks on the apple.

[y] The population consisted of a mixture of 47% pine voles and 53% meadow voles.

[x] Mean separation, within columns by Duncan's Multiple Range Test, 5% (3 replicates per treatment).

Table 2. Effect of broadcast rodenticide baits on pine and meadow vole activity and populations treated October 30, 1980.

Treatment	Rate kg/ha	Rate lbs/A	% Highly active sites[z] Oct 22	% Highly active sites[z] Nov 14	% Active sites[z] Oct 22	% Active sites[z] Nov 14	Voles/plot Nov 17-21	Voles/site[y] Nov 17-21	% Control
Control			62 a[x]	71 a	87 a	88 a	30.7 a	1.28 a	0
0.005% CPN-Wheat	27	22	59 a	10 de	87 a	20 cd	3.0 bc	0.13 bc	90
0.005% CPN (USA)	22	18	50 a	4 ef	83 a	21 cd	.7 c	0.13 c	98
0.005% CPN (French)	22	18	47 a	0 f	85 a	0 e	0 c	0.00 c	100
0.005% DPN-pellet	24	19	48 a	24 bc	81 a	38 bc	3.7 bc	0.15 bc	89
0.005% DPN + Saccharin pellet	27	22	64 a	30 b	87 a	58 b	7.7 b	0.32 b	75
0.010% DPN + Saccharin pellet	24	19	55 a	15 cd	87 a	24 cd	4.3 bc	0.18 bc	86
0.005% BFC-pellet	21	17	44 a	0 f	81 a	3 e	0.0 c	0.00 c	100
2% ZP-pellet	26	21	55 a	0 f	87 a	10 de	1.0 c	0.04 c	97

[z] Apples placed in 2 holes or runs 5-15 cm below the soil surface on opposite sides of the tree trunk were examined 24 hours after placement. Percent highly active sites refer to the sites having a portion of apple of 2.5 cm removed by vole feeding. Percent activity refers to all sites having vole tooth marks on the apple.

[y] The population consisted of a mixture of 52% pine voles and 48% meadow voles.

[x] Mean separation, within columns by Duncan's Multiple Range Test, 5% (3 replicates per treatment).

Table 3. Caching response of pine and meadow voles given 50 grams of bait/active site under field conditions (December 18, 1980).

Treatment	Pellet diameter (cm)	Pellet number per 50 g	Wt/pellet (g)	% of sites with more than 25 grams removed after 24 hours	
				Meadow	Pine
Small pellets	0.24	1,316	0.04	0.8 a	70 a
Medium pellets	0.32	714	0.07	0.0 a	57 a
Large pellets	0.48	294	0.17	1.7 a	60 a

Three pellet sizes were placed in 20 active sites each in two orchards previously determined by 5 days of live trapping to contain either pine voles or meadow voles. Fifty meadow voles and 60 pine voles were live trapped - toe clipped - released at 60 sites in each of two separate orchard blocks over a 5 day period. Using the Schnabel estimator (3) the meadow vole population was estimated at $47 \pm \frac{15}{11}$ voles/60 sites and the pine vole population at $91 \pm \frac{45}{31}$ voles/60 sites.