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FIELD EFFICACY EVALUATION OF PELLETED STRYCHNINE BAITS FOR CONTROL OF MOUNTAIN BEAVERS (*Aplodontia rufa*)

D. L. CAMPBELL, and J. P. FARLEY, USDA, Animal and Plant Health Inspection Service, Forest Animal Damage Control Research Station, Denver Wildlife Research Center, 3625 93rd Ave. SW, Olympia, Washington 98502

R. M. ENGEMAN, USDA, Animal and Plant Health Inspection Service, Denver Wildlife Research Center, Building 16, Denver Federal Center, P. O. Box 25266, Denver, Colorado 80255-0266

ABSTRACT: Radio–telemetry evaluation of several concentrations of pelleted strychnine bait in earlier tests indicated moderate to good bait efficacy for control of mountain beavers. Evaluation of operational baiting with 0.0%, 0.15%, 0.50%, and 0.90% strychnine bait pellets was made in 1990 and 1991 on 24 reforestation units in Washington and Oregon. Results of baiting monitored with burrow activity indicators showed there was little differencce in reduction of activity among treatments. Chemical assays and pen bioassays showed baits were lethal, but ingestion was often delayed or baits were discarded. Re–examination of test plots 1 year after baiting showed no detectable change in activity among treatments.

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INTRODUCTION

Mountain beaver (*Aplodontia rufa*) cause economic losses through severe damage to reforestation on over 121,500 ha in Oregon and Washington (Northwest Forest Animal Damage Committee 1979). Most forest managers in western Oregon consider damage by mountain beaver the most serious limiting factor to successful regeneration of conifers (Campbell and Evans 1984). Damage to unprotected tree seedlings by mountain beavers over a 3 year period in coastal Oregon showed that about 75% of the study trees were damaged and about one-half were killed by mountain beavers (Campbell et al. 1988). Plantations that are 10 to 15 years old and older also are being damaged by mountain beavers (Evans 1987). Stems and roots of large trees are girdled as the tree canopies close, resulting in understocked stands. Stands that have been pre-commercially thinned are also girdled.

Mountain beaver control methods have been reviewed (Campbell and Evans 1988) but are primarily limited to trapping and use of plastic mesh seedling protectors developed in the 1960s and 1970s (Campbell and Evans 1975). In the early 1980s a water-resistant pelleted bait was developed at Olympia for evaluation of reserpine to control mountain beavers (D. L. Campbell, G. D. Lindsey, and J. Evans, unpublished report, Denver Wildlife Research Center, 26 pp, 1983). Registration of reserpine as a pesticide appeared complex and studies required for registration were not economically feasible; however, the water-resistant bait pellets developed for this use were subsequently formulated with strychnine for mountain beaver control by Oregon Rodent Control Outfitters (ORCO). A Special Local Needs (SLN) registration of ORCO Boomer-Rid 0.31% strychnine alkaloid bait (EPA SLN OR-840029; EPA Est. No.5042-OR-1) for mountain beaver control in Oregon made this product available for use by forest managers. Field tests with Boomer-Rid indicated a 67% reduction in mountain beaver damage to conifers (W. Schaap unpublished report, Oregon State University, 10 pp., 1986). On October 10, 1986 the Environmental Protection Agency (EPA) issued a "Call in of Applications and Data for Federally Registered and Intrastate Products Containing Strychnine" in which efficacy requirements for registration of various strychnine baits were established (EPA 1986). Additional field efficacy studies were required for retaining the Oregon Boomer-Rid Registration.

Radio-telemetry studies of mountain beavers exposed to Boomer-Rid baits containing various strychnine concentrations continued to show promising results (D. L. Campbell and J. Evans, unpublished report, Denver Wildlife Research Center, 22 pp., 1989). After reviewing these data, EPA requested that field efficacy tests be made at strychnine bait concentrations of 0.0%, 0.15%, 0.50% and 0.90% using operational procedures in typical field conditions.

This report summarizes the operational field efficacy evaluation of 4 strychnine alkaloid concentrations of green-dyed ORCO Boomer-Rid bait pellets on a variety of damaged or recently planted reforestation units in western Washington and Oregon. Use of trade names in this report is for purposes of identification and does not indicate endorsement of commercial products by the U. S. Department of Agriculture.

METHODS

Study Areas

The study was conducted in geographical areas representing typical mountain beaver problem sites in western Washington and Oregon. Forest units selected were Douglas fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) clearcuts, either recently planted or less than 5 years old, which had a history of potential for mountain beaver damage. A total of 24 units were baited, with 16 located in southwestern Washington and 8 located in coastal Oregon. Units averaged about 24 ha and ranged in size from 10 to 76 ha.

Census Methods and Data Analysis

Activity by mountain beavers in each unit was determined before and after bait application using 10 sample plots in each unit prior to bait application. Each sample plot was 0.027 ha with a 9.3 m radius and spaced at least 60 m apart and from the edges of clearcuts.

Two methods were used in each sample plot to determine mountain beaver activity. Five burrows at least 1 m apart in each sample plot were marked with wire flags prior to baiting. Sword fern (*Polystichum munitum*) packets and paper knockdowns were used as burrow activity indicators (Engeman et al. 1991). Sword fern packets consisted of 3 sword fern fronds tied with plastic flagging for identification. Waterproof paper knockdowns were secured by wooden

Table 1. Mountain beaver strychnine bait test units and size, bait applied, number and percentage of checked burrows with bait removed, percentage of pellets removed by mountain beavers within 24 hours of placement, and percent reduction of burrow activity 21 days after baiting.

Conc. (%)	Unit Name	Size (ha)	Bait per ha (kg)	Burrows with bait removed (#)	Burrows with bait removed (%)	Pellets removed (%)	Reduction in activity[a] (%)
0.00	Simpson SC 24 & 25	76.4	—[b]	116	84	75	0
	WDNR Sort yard B	36.0	0.09	78	86	77	0
	WDNR II Windy Ridge	20.0	0.26	84	89	85	0
	WeyCo WA R2600	31.2	0.13	111	94	88	0
	WeyCo OR #402	16.0	0.23	92	89	64	0
	WeyCo II OR #026	15.2	0.10	101	79	71	0
0.15	Simpson SC 33	61.2	0.47	143	85	76	10
	WDNR Bgn. Alder	26.0	0.16	62	100	98	30
	WDNR Gasline	12.0	0.12	52	83	73	50
	WeyCo WA L295	16.0	0.31	104	89	83	40
	WeyCo OR #025-C	11.6	0.06	78	77	55	20
	WeyCo II OR #030	11.2	0.34	98	88	80	20
0.50	Simpson SC 30	38.8	0.31	86	93	89	20
	WDNR RT. Corner	26.8	0.09	90	86	76	0
	WDNR II L. Line	12.0	0.81	91	77	60	10
	WeyCo WA Picco E2560	20.0	0.15	115	83	78	60
	WeyCo OR #025-B	14.4	0.16	93	75	49	20
	WeyCo II OR #009	8.0	0.26	88	77	56	20
0.90	Simpson SC 39	33.6	0.50	147	80	62	10
	WDNR Gaddis Cr	35.2	0.64	92	83	60	0
	WDNR II Sort yard A	16.0	0.05	85	58	53	20
	WeyCo WA Vesta H1020	42.0	0.18	88	74	59	0
	WeyCo OR #025-A	16.0	0.23	78	69	47	70
	WeyCo OR #027	14.0	0.26	98	94	72	80

[a]There were 10 sample plots for each unit.
[b]Bait was applied only to burrows in and around sample plots

sticks pushed into burrow floors. Seven days after installation, and before baiting, the burrows were checked for missing sword fern packets and for bent or missing knockdowns to assure that the burrow systems were active. Any remaining activity indicators were removed. Fourteen days after baiting, new activity indicators were installed in the same burrows and these were checked 7 days later to determine activity. If all 5 burrows in each plot were found inactive 21 days after baiting the mountain beaver was considered dead. Sword fern packets and knockdowns were the 2 variables used to determine baiting efficacy.

Bait Application

In April and May 1990, a total of 6 units were baited with each strychnine bait concentration (0.00%, 0.15, 0.50% and 0.90%) assigned at random to 4 units in each geographical area. Bait was applied by contractors familiar with baiting or trapping mountain beavers. The bait was placed inside 10 burrows in each burrow system except in a few instances where 10 active burrows were not found. Five bait pellets (totaling approximately 9.5 g) were placed inside each burrow with a long-handled spoon. Burrows baited were at least 1 m apart and were marked with a small piece of colored flagging as they were baited. When bait was applied, the sample activity plots and burrows that were marked prior to baiting were included. The quantity of bait used depended upon the number of burrow systems in a test unit; amounts ranged from 0.05 kg/ha in units with few active burrow systems to 0.81 kg/ha on the WDNR II L line where active burrow systems were more abundant.

Following the first baiting and measurement of reduction in mountain beaver activity, bait was re-applied to Weyerhaeuser Co. (WeyCo) units in Washington to determine if a second baiting would have greater effects.

Bait Acceptance

Each of the 5 flagged burrows in each sample plot and other baited burrows were checked 24 hours after baiting to determine if bait was missing. This procedure also aided in searching for non-target species that may have been killed by feeding on the bait.

Carcass Surveys

Each sample plot baited was systematically searched for carcasses of any animal species from 24 to 48 hours after baiting, and again at 14 and 21 days after baiting. Baited burrows were also examined for carcasses after 24 hours when bait acceptance was checked. Re-baited units in Washington were searched a second time on the same schedule.

Pen Bioassays

Mountain beavers were live trapped from Simpson Timber Co. units baited with 0.90% and 0.00% bait, and an unbaited unit, to determine if adults or juveniles remained active after baiting and to determine bait acceptance. Captured animals were maintained on native vegetation and bioassayed in pens at Olympia. Ten 0.90% strychnine bait pellets were offered each animal for 14 days to determine daily acceptance of bait and mortality. Three groups of animals were tested; 1 group which had been treated with 0.90% bait, 1 group that had been treated with 0.00% bait, and 1 group that had not been baited.

Re-examination of Plot Activity

At approximately 1 year after baiting, all burrows in sample plots in each unit were re-examined visually to determine if mountain beavers were active.

RESULTS

Chemical assays of the ORCO formulated strychnine alkaloid pelleted baits by Denver Wildlife Research Center (DWRC) chemists showed that all strychnine concentrations were at or near the nominal level of 0.00%, 0.15%, 0.50%, and 0.90%. In the field, a high percentage of bait of all concentrations tested was accepted or removed by mountain beavers or other species within 24 hours after baiting (Table 1). Overall, within 24 hours, 70.3% of bait pellets were taken and 83.0% of burrows had bait taken. Nearly all plots (98%) had bait taken. Percentages of pellets taken at 0.00% and 0.15% concentration were 76.7 $\pm$ 8.9% and 77.5 $\pm$ 14.0% respectively. Less bait (68.0 $\pm$ 15.3%) of the 0.50% concentration was taken and less of the 0.90% concentration (58.8 $\pm$ 8.5%) was taken during the first 24 hours. No bait was found in burrows examined 14 days after baiting.

Reduction of Mountain Beaver Activity

Based on removal of marked sword fern and the flattening or removal of paper knockdown activity indicators from burrows, only moderate reductions of mountain beaver activity were associated with application of the pelleted strychnine bait on most units (Table 1). All 6 units treated with 0.00% strychnine bait remained 100% active. The average reductions in unit plot activity were 28.3% for the 0.15% strychnine bait; 21.7% for the 0.50% strychnine bait; and 30.0% for the 0.90% strychnine bait. Units with activity reduction of 50% or more occurred only on the Washington Department of Natural Resources (WDNR) Gasline unit (0.15% strychnine bait; 50% reduction), the WeyCo WA Picco E2560 unit (0.50% strychnine bait; 60% reduction), the WeyCo OR #025-A unit (0.90% strychnine bait; 70% reduction); and the WeyCo II OR #027 unit (0.90% strychnine bait; 80% reduction).

Table 2. Comparison of mean percent activity for 60 mountain beaver plots for each pelleted strychnine bait concentration (10 plots in each of 6 reforestation units) 21 days after operational baiting.

Strychnine Concentration in Bait (%)	Plot Activity Indicators (n=300) Sword fern[a] (%)[c]	Knockdowns[b] (%)[c]
0.00	100 a	98 a
0.15	70 b	72 b
0.50	78 a b	83 a b
0.90	70 b	72 b

[a]The ANOVA p value = 0.10, therefore the experiment-wise error rate for Duncans Multiple Range Test was set at 0.1.
[b]The ANOVA p value = 0.06, therefore the experiment-wise error rate for Duncans Multiple Range Test was set at 0.05.
[c]Means with no letter in common are significantly different at the indicated probability level.

Statistical analysis using a randomized block design on the 2 activity indicator variables indicated few differences among treatments. Comparison of treatments for the 6 units and 60 plots for each concentration are shown in Table 2. The untreated (0.00%) control plots were significantly different from the 0.15% and 0.90% plots, but not different from the 0.50% plots. Also, the 0.50% treatment plots were not significantly different from the 0.15% or the 0.90% plots. No treatment showed greater than a 30% reduction in plot activity.

Effects of Amounts of Bait Applied

The amounts of bait applied did not appear to affect baiting efficacy for individual units (Table 1). The highest amount of 0.50% concentration bait (0.81 kg/ha) was applied to the WDNR L line which subsequently had only a 10% decline in plot activity. Similarly, application of 0.65 kg/ha of 0.90% concentration bait on the WDNR Gaddis Cr. unit resulted in no reduction in activity. The highest reduction in mountain beaver activity occurred on the WeyCo, OR #025-A and WeyCo II OR #027 units which had 0.90% strychnine bait applications of 0.23 kg/ha and 0.26 kg/ha respectively.

Effects of 2 Baitings

A second bait application on the WeyCo WA units within a month after initial treatment did not have much effect on mountain beaver activity (Table 3). Activity increased 60% to 70% after re-baiting with the 0.15% concentration. Similarly, activity increased from 40% to 60% on the unit re-baited with a 0.50% concentration and decreased from 100% to 80% on the unit re-baited with the 0.90% concentration.

Recovery of Carcasses

The only carcasses found during examinations of the units were 1 deer mouse (*Peromyscus maniculatus*) and 1

Table 3. Mountain beaver activity on 4 Washington units that were treated again with strychnine bait within a month after initial treatments.

Concentration (%)	Unit	Initial Baiting		Rebaited	
		Date Baited	% Reduction In Activity	Date Baited	% Reduction In Activity
0.00	R2600	4/26/90	0.0	5/18/91	0.0
0.15	L295	4/26/90	40.0	5/18/91	30.0
0.50	Picco E2560	4/25/90	60.0	5/18/91	40.0
0.90	Vesta H-1020	4/27/90	0.0	5/18/91	20.0

unidentified rabbit or hare. The mouse was recovered from the 0.50% strychnine bait treated unit WeyCo II OR #009. The partial skin of a rabbit or hare was recovered from the 0.90% strychnine bait treated unit WeyCo II OR. #027. The mouse carcass was recovered within 48 hours after baiting; the partial rabbit or hare skin was found 14 days after baiting. No chemical assays were made of these tissues.

Pen Bioassays

Six adult males and 1 adult female were captured on Simpson unit SC-39 (0.90% strychnine) in 7 individual sample plots, and 3 juveniles (2♀, 1♂) were live trapped in 1 sample plot, showing that baiting did not kill either adults or juveniles in those plots. These animals initially discarded most bait offered in the bioassay, but 75% (6 of 8) each consumed 1 lethal bait within 13 days. Five of 6 animals (83.3%) previously exposed to untreated bait died after consuming 1 pellet each within 1 day. Five of 6 previously unbaited animals (83.3%) accepted bait after 1 to 6 days and died after ingesting 1 pellet. Green dyed bait was recovered from the gastrointestinal tracts of all mountain beavers that died after baiting. Carcasses were frozen for tissue assay for strychnine.

Activity 1 Year After Treatment

Re-examination of sample plots on most test units showed that mountain beaver activity in 1991 was equal to or greater than activity 3 weeks after the units were baited in 1990. A decrease in activity on the Simpson SC-24 & 25 unit from 100% to 40% activity may have been related to live trapping. Similarly, activity on the live trapped Simpson SC-39 unit had decreased from 90% to 10%. Decreases in the number of active plots also occurred on 2 of the 0.15% units and 2 of the 0.50% units; possible reasons for those decreases in activity could not be determined.

DISCUSSION AND CONCLUSIONS

Delays in obtaining Federal Experimental Use Permits caused baiting of these study units to be delayed from the intended January - March period to an April - May period. However, baiting was only slightly later than when effective reduction of mountain beaver activity was achieved during the radio-telemetry tests during the previous year. Vegetation abundance varied considerably among treated units and may have affected bait ingestion, even though bait was quickly moved from the placement site in most burrows. Re-baiting 1 group of units also did not result in much reduction in mountain beaver activity. The differences found in the operational baiting compared with baiting results using radio-telemetry could be due to more precise bait placements for the animals with known locations. Also, differences in bait palatability due to different times of manufacture or variations within the formulation ingredients might have affected rates of bait acceptance and ingestion.

Live trapping confirmed that burrow indicators detected plots where mountain beavers remained active after the plots were treated. Pen bioassays with live trapped animals showed that consumption of 1 bait pellet was usually lethal, but bait was often not accepted for several days. Much of the bait given penned animals was discarded or ignored.

Further evaluation of these or similar bait pellets should include operational applications in winter. In addition, examination of baiting effects on mountain beaver activity should be conducted in older forest stands subject to girdling damage.

Hazards to non-target species associated with this study appeared minimal considering the size and number of baited units in the 2 states. Although some carcasses might have been missed because of logging slash and vegetation, the bait sites and sample plots were well searched within the time non-target exposure was expected. Some mountain beavers baited in pen bioassays were recovered from the ground surface, but most were recovered from nests or shelters. In previous radio-telemetry field tests of this bait all mountain beavers were recovered from nests or burrows. The baits and procedures we utilized did not appear to present hazards for non-target animals.

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