

Strychnine for the Control of Richardson's Ground Squirrels: Efficiency and Selectivity Issues

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ABSTRACT: Strychnine has recently been made available in Canada under an emergency registration program for the control of Richardson's ground squirrels. From 2007 to 2009, we tested the control efficacy of this poison using >1-year-old and newly produced strychnine on hulless oats, canary seed, and alfalfa pellets. Newly produced 2% liquid strychnine, mixed with hulless oats to formulate 0.4% strychnine freshly mixed baits, controlled $\geq 70\%$ of adult and juvenile ground squirrels in spring and summer. Other types of strychnine baits were not as reliable from one season to the other. At 0.2% concentration, strychnine-treated oats were relatively inefficient. When >1 year old, the control efficacy of strychnine baits dropped significantly. Independent of the age of the product, strychnine killed non-target animals. This paper recommends a series of measures to ensure quality control and greater selectivity.

KEY WORDS: non-target species, Richardson's ground squirrel, rodenticides, Saskatchewan, *Spermophilus richardsonii*, strychnine

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INTRODUCTION

Strychnine was first registered in Canada in 1928 (PMRA 2005) for the control of Richardson's ground squirrels (*Spermophilus richardsonii*), even though it was distributed in Saskatchewan as early as 1912 (Isern 1988). Because of its toxicity to a variety of species, its secondary persistence (Littrell 1990), and its misuse (Howell and Wishart 1969, Wobeser and Blakley 1987), strychnine became a source of concern for the public and professionals (Hegdal and Gatz 1977, Landals 1993, Owen-Carter 1993). Also, in 1993, the Canadian Federal Government banned the popular liquid strychnine solution, and replaced it with ready-to-use (RTU) strychnine-treated oats that were found ineffective for the control of Richardson's ground squirrels (Proulx 2010). It was not until 2007 that an Emergency Registration program of 2% liquid strychnine was granted by the Pest Management Regulatory Agency of Canada and became effective in 2008 (Wilk and Hartley 2008) for the control of a ground squirrel population outbreak (Proulx 2010). The Emergency Registration requires that 2% liquid strychnine be mixed with grain to formulate 0.4% freshly mixed (FM) baits.

Even though farmers and politicians consider that liquid strychnine is the only effective poison to control ground squirrel populations (Proulx 2010), the ability of FM 0.4% strychnine-treated baits to control Richardson's ground squirrel populations was never thoroughly tested in the Canadian Prairies (Proulx and Feldstein 1994, McKinnon and Mineau 2004). In the United States, following a recommendation by EPA (1983) to reduce non-target hazards, Matschke et al. (1987) tested the toxicity of 3 strychnine bait concentrations (0.20%, 0.35%, and 0.50%) in laboratory with 8 species of ground squirrels (*Spermophilus* spp.). Using animals that had been fasting for 24 h, Matschke et al. (1987) concluded that Richardson's ground squirrels may be effectively controlled at the 0.20% or lower strychnine concentration.

The objective of this study was to assess the effectiveness of FM strychnine-treated baits to control Richardson's ground squirrel populations. A corollary objective was to document the potential impact of this poison bait on non-target species.

METHODS

The study was carried out in southwest Saskatchewan (Figure 1) from 2007 to 2009. Study plots corresponded to native and seeded grasslands and alfalfa fields that were located within a same quarter section or in different ones. When located within a same quarter section, study plots were separated by a >150-m-wide buffer zone. In order to capture a similar number of Richardson's ground squirrels from one study plot to the other, the size of the plots varied from 0.2 to 1.8 ha in spring and summer.

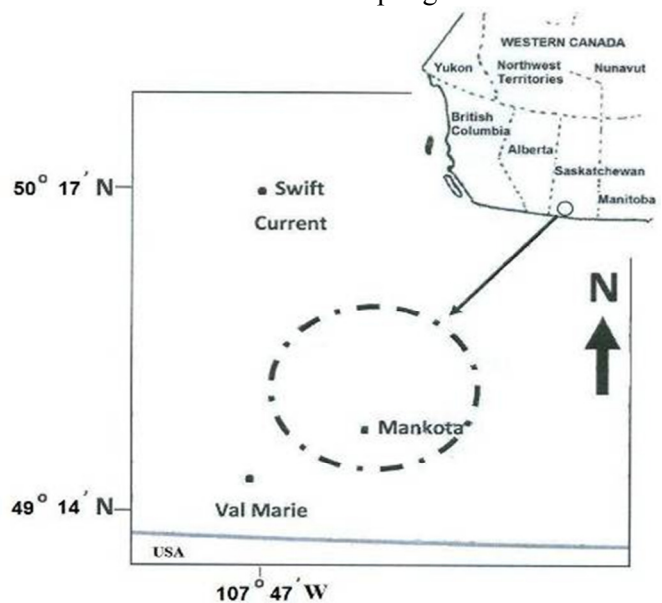


Figure 1. Location of study area.

Tests were conducted during 2 test periods: spring (13 April - 1 June, 2007-2009) and summer (14 June - 2 July, 2008-2009). Tomahawk live-traps (15 × 15 × 48 cm; Tomahawk Live Trap, Tomahawk, WI) baited with peanut butter on bread, were set early in the morning and checked by mid-afternoon. All ground squirrels were tagged (Monel #1 tag, Newport, KY) in both ears. Their sex, weight, and general body condition were recorded before releasing them at their capture site. In spring, captured populations consisted of adult Richardson's ground squirrels only. In summer, only juveniles were included in the populations. Live-trapping followed the highest standards of humaneness (Powell and Proulx 2003).

The year of production of strychnine solutions (Nu-Gro Corporation, Fort Saskatchewan, AB) differed from one year to the other. In 2007, newly produced strychnine solutions were unavailable on the market, and we used a 5-year-old product, i.e., that had been made in 2002 for experimental purpose. In 2008, strychnine was freshly produced in spring. In 2009, we used a 1-year-old solution. Each year, FM 0.4% strychnine baits were produced by mixing a 250 ml 2% solution to 1 kg of hullless oats (standard bait) and stirring it for at least 10 min. Strychnine baits were also made with canary seed in 2008, and alfalfa pellets in 2009, for comparison of control efficiencies with hullless oats, and to assess their impact on non-target species. Finally, in 2008, we also tested 0.2% strychnine-treated hullless oats.

Strychnine baits were tested in 2-4 study plots/test period. They were used within 30 min from being mixed. Baits were applied at burrow systems where captures and recaptures occurred, and in all the holes with signs of activity located within the delineated study plots. The identification of active holes was done by flagging and shovelling dirt in all openings the day before treatment, and marking re-opened holes on treatment day. Early in the morning, one tablespoon of bait (approximately 13-15 g) was placed with a long-handled spoon as far as possible into burrow openings. As per label instructions, treated holes were covered with dirt. In each study plot, live trapping was initiated the following day and lasted up to 15 days to capture all animals present. An attempt was made to recover carcasses of ground squirrels and non-target species that died on the surface. Dead animals were collected and autopsied to confirm the presence of bait in their cheeks and digestive system. All collected carcasses were buried in a 60-cm-deep dirt hole. When moribund animals were found, they were quickly and humanely euthanized with a blow to the head.

For each test period, 2-3 control ground populations were live-trapped and marked in representative sites to determine average natural mortality for study plots. Control efficacy was evaluated using Abbott's formula modified by Henderson and Tilton (1955) as follows:

$$M = 100 \times [1 - (t2 \times c1) / (t1 \times c2)]$$

where M (%) = Richardson's ground squirrel mortality, t = treated population, c = control population, 1 = population before treatment, and 2 = population after treatment.

Student- t tests were used to compare mean control levels of toxicants (Zar 1999). The proportions of ground

squirrels still alive after treatments were compared with Fisher Exact Probability and Chi-square tests (Siegel 1956). A 0.05 level of significance was used for all tests. Strychnine baits were found acceptable if they controlled at least 70% of ground squirrel populations (Matschke and Fagerstone 1984).

The search for non-target species was conducted during the post-treatment live-trapping sessions in 2008 and 2009 along transects that criss-crossed the study plots.

RESULTS

Control Efficiency

0.4% Strychnine-Treated Oats

Estimates of natural mortality and control efficiency of FM 0.4% strychnine-treated oat baits varied within and between years (Tables 1 and 2). In 2007, only 2 spring tests were carried out, and control efficiency was 38.1% (Table 1). The proportion of ground squirrels alive after treatment in spring 2007 was significantly ($P < 0.05$) higher than that observed in spring 2008 and in 2 tests of spring 2009. The FM 0.4% strychnine-treated baits failed the 70% acceptance threshold in 2007.

On average, FM 0.4% strychnine-treated oats controlled 79.8% (standard deviation: 10.4%) of ground squirrels in 2008, and 68.3% ($\pm 10.5\%$) in 2009. There was no significant difference ($t = 1.787$, $P > 0.05$) between means. However, control efficiency was consistently $>70\%$ in spring and summer 2008. In 2009, most (75%) spring tests had $>70\%$ control, but all summer tests had $<70\%$ control (Table 1). The FM 0.4% strychnine-treated oat baits passed the 70% acceptance threshold in 2008 and spring 2009.

0.2% Strychnine-Treated Oats

Control efficiency was $<70\%$ in spring and summer 2008 (Table 2). The proportion of ground squirrels alive after treatment with FM 0.2% strychnine baits was significantly ($P < 0.05$) higher than that observed with FM 0.4% strychnine baits in spring test no. 2. The FM 0.2% strychnine-treated baits failed the 70% acceptance threshold in 2008.

0.4% Strychnine-Treated Canary Seed

On average, there was no significant difference ($t = 2.137$, $P > 0.05$) between the control efficiencies of FM 0.4% strychnine oat and canary seed baits (Tables 1 and 2). However, the control efficiency of canary seed baits was $<70\%$ in one spring test (Table 2). More than 70% control was achieved in all summer tests.

0.4% Strychnine-Treated Alfalfa Pellets

Control efficiency in all spring and summer tests was $<70\%$.

Non-Target Species

Dead Richardson's ground squirrels were found on surface in study plots treated with different strychnine baits (Table 3). Deer mice (*Peromyscus maniculatus*) and songbirds were found in all plots with strychnine-treated oats. In 2009, one northern harrier (*Circus cyaneus*) was also collected. The autopsy revealed the

Table 1. Control efficacy of FM 0.4% strychnine-treated oat baits in spring and summer 2007-2009, southern Saskatchewan, Canada.

Variable	0.4% strychnine-treated oats													
	2007		2008				2009							
	Spring		Spring		Summer		Spring				Summer			
	#1	#2	#1	#2	#1	#2	#1	#2	#3	#4	#1	#2	#3	#4
Marked population – <i>n</i>	24	24	23	27	20	20	22	14	20	20	20	21	22	20
Ground squirrels alive after treatment	13	13	5	1	3	3	3	3	2	4	6	6	6	6
Natural mortality (%)	12.5	12.5	19.2	19.2	39.2	39.2	29.4	29.4	29.4	29.4	28.1	28.1	28.1	28.1
Strychnine mortality (%)	38.1	38.1	73.1	95.4	75.4	75.4	80.7	69.6	85.8	71.7	58.3	60.2	62.1	58.3
Average control efficacy (SD)	38.1% (–)		79.8 % (10.4)				68.3% (10.5)							

Table 2. Control efficacy of FM 0.2% strychnine-treated oat baits, and FM 0.4% strychnine-treated canary seed and alfalfa pellets in spring and summer 2008-2009, southern Saskatchewan, Canada.

Variable	0.2% strychnine-treated oats				0.4% strychnine-treated canary seeds				0.4% strychnine-treated alfalfa pellets			
	Spring		Summer		Spring		Summer		Spring		Summer	
	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
Marked population – <i>n</i>	26	24	20	24	24	24	20	20	21	21	21	22
Ground squirrels alive after treatment	10	10	5	5	3	7	2	1	5	9	9	7
Natural mortality (%)	19.2	19.2	39.2	39.2	19.2	19.2	39.2	39.2	29.4	29.4	28.1	28.1
Strychnine mortality (%)	52.3	48.4	59.0	65.8	84.5	63.9	83.4	92.2	66.3	40.4	40.4	55.7
Average control efficacy (SD)	56.4% (7.7)				81% (12.1)				50.7% (12.7)			

Table 3. Number of Richardson’s ground squirrels found dead on surface in study plots treated with strychnine baits, southern Saskatchewan, Canada, 2008 and 2009.

Poison bait	Richardson’s ground squirrels dead on surface			
	2008		2009	
	Spring	Summer	Spring	Summer
0.4% strychnine-oats	40	21	32	10
0.2% strychnine-oats	8	4	-	-
0.4% strychnine-canary seeds	8	9	-	-
0.4% strychnine-alfalfa pellets	-	-	3	0

presence of one strychnine-poisoned deer mouse in its stomach. Only deer mice were found in study plots with strychnine-treated canary seed. Non-target species were not found in study plots with strychnine-treated alfalfa pellets.

DISCUSSION

The efficacy of strychnine baits varied significantly from year to year. The low performance of baits in 2007 was possibly due to the staleness of strychnine that had been produced in 2002. In contrast, freshly produced strychnine effectively controlled ground squirrel populations in 2008. In 2009, however, the same strychnine that had effectively controlled ground squirrels in 2008 failed

in 25% of spring tests and in all summer tests. If freshly produced strychnine is as effective as the 2008 findings suggest, then the 2007 and 2009 results suggest that storing strychnine for ≥ 1 year impacts significantly on its performance. This may be due to the evaporation of the anise oil that is added to strychnine as an attractant. Freshly produced liquid strychnine has a very potent licorice smell, which was not noticeable in 2007 and less potent in 2009. The lack of consistency in the control efficacy of strychnine may also be due to peculiarities in the feeding behaviour of ground squirrels from different populations, and from year to year, even though vegetation was similar among study plots. Obviously, this study warrants further testing with freshly produced

liquid strychnine that has been analyzed in laboratory for quality control. The production, storage, and distribution of strychnine, and its use in fields, need to be better monitored by government regulating agencies.

Baits that were readily accepted by ground squirrels, i.e., oats and canary seed, were also ingested by non-target species. Using alfalfa pellets would likely reduce the number of non-target bird species, but it would decrease the efficacy of a control program for ground squirrels. Placing baits in burrow systems and covering them with dirt is ineffective because ground squirrels clean their burrow system soon after the application of the baits and spread kernels on surface. Many ground squirrels also die on surface and are taken by carnivores. Picking up carcasses of poisoned animals would help to reduce secondary poisoning. Controlling Richardson's ground squirrels without primary poisoning of non-target species and secondary poisoning of predators can only be achieved by containing baits in a secure area and not allowing access to poisoned ground squirrels. Proulx et al. (2010) developed a multi-capture pen trap that allows ground squirrels to enter and feed on strychnine baits but not to escape. Preliminary tests with prototypes resulted in ground squirrel control levels that were similar to those obtained by placing baits in burrow systems, and there was no loss of non-target species. More efficiency tests with freshly produced strychnine must be conducted over large areas to assess how pen traps with FM 0.4% strychnine-treated oats can be used effectively.

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