Field Evidence of Non-Target and Secondary Poisoning by Strychnine and Chlorophacinone Used to Control Richardson's Ground Squirrels in Southwest Saskatchewan

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Abstract – Richardson's Ground Squirrels (*Spermophilus richardsonii*) are considered to be major pests in southwest Saskatchewan where recent population outbreaks have caused damage to grasslands, pastures and crops. Although it is known that poisons pose potential threats to wildlife, since 2008, southwest Saskatchewan farmers have used large quantities of 0.4% strychnine (an acute poison available as freshly mixed and ready-to-use baits) and chlorophacinone (an anticoagulant that causes fatal hemorrhages) to control ground squirrels. In the last two years, I have gathered field evidence that both strychnine and chlorophacinone kill ground squirrels but also a diversity of songbirds, small mammals, and predators including raptors, American Badger (*Taxidea taxus*), and Long-tailed Weasel (*Mustela frenata*). The control of Richardson's Ground Squirrel populations and the future of all predators, including species at risk, lie in the implementation of an Integrated Pest Management Program.

Introduction

In 2000-2001, the Canadian prairies experienced a severe drought with a warm winter and low precipitation (Liu et al. 2004) that depressed plant growth (Heath et al. 1973) and created ideal habitat conditions for Richardson's ground squirrel (*Spermophilus richardsonii*) (Yensen and Sherman 2003). Ground squirrel populations irrupted with spring densities often exceeding 40 adults/ha (Proulx and Walsh 2007, Proulx et al. 2009). Poor grassland management, the use of inefficient rodenticides, the loss of predators, and socio-economic changes further exacerbated the situation created by the drought (Proulx 2010). In 2007, 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 ground squirrels. The program requires that 2% liquid strychnine be mixed with grain to formulate 0.4% freshly mixed (FM) baits. In 2008, distributors of anticoagulant (chlorophacinone) baits also offered ready-to-use (RTU) oat mixtures to farmers. As a result, massive poisoning campaigns were conducted across private land (Fig. 1). For example, in the rural municipality of Mankota (1,696 km² of farmland located about 150 km southeast of Swift Current, Saskatchewan) alone, 730 cases (12 x 250 ml bottles per case) of liquid strychnine, producing 8,760 kg of poison bait, were sold in May-June 2008, compared to a total of 30 cases in the previous 10 years (M. Sherven, Administrator, R.M. of Mankota, pers. commun., 2008)

Figure 1. Bait stations with anticoagulant-treated oats placed at the border of a cropland to control Richardson's Ground Squirrels, southwest Saskatchewan, summer 2008.

Over 2,000 kg of RTU chlorophacinone-treated oats were sold to farmers during the same time period (T. Schultz, Edmonton Exterminators, 2008, pers. commun.). Even though non-target and secondary poisoning has been frequently reported in the past (Howell and Wishart 1969, Hegdal and Gatz 1977, Wobeser and Blakley 1987, James et al. 1990), federal Members of Parliament and Senators argued that the 1993 strychnine ban was unjustified and requested that the poison be made available to all farmers (Government of Canada 2001, Standing Senate Committee on Agriculture and Forestry 2001). Even though secondary poisoning of predators feeding on rodents poisoned by anticoagulants was reported in the past (McDonald et al. 1988, Hosea 2000), RTU chlorophacinone baits were sold as posing no secondary poisoning problems (Schultz 2008).

The purpose of this paper is to

1. report primary poisoning of non-target species and secondary poisoning of predators in southwest Saskatchewan, and
2. raise concerns about the negative impact of such poisoning on the survival of species at risk and predators in general.

Study Area

The study was carried out in southwest Saskatchewan (Fig. 2) in grassland plots (0.4 to 1.4 ha) with similar ground squirrel populations.

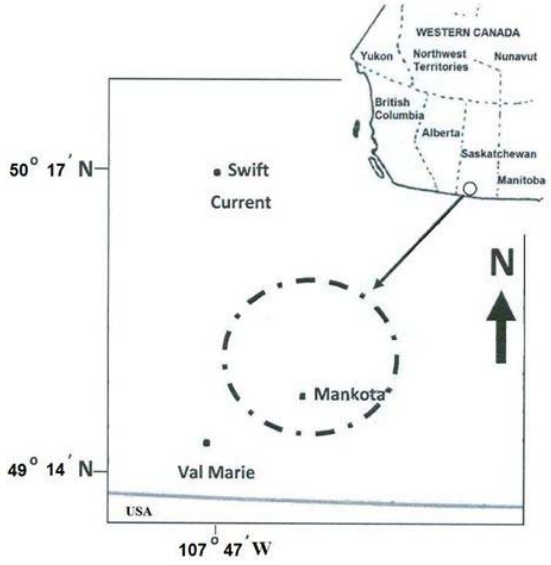

Figure 2. Location of study area in southwest Saskatchewan, Canada.

Methods

Ground squirrel trapping occurred in spring (5 May-1 June) and summer (14 June-2 July). Poison tests were carried out during two test periods: spring (13 April-1 June, 2007-2009) and summer (14 June-2 July, 2008-2009). Ground squirrels were captured in 15 x 15 x 48 cm Tomahawk live-traps (Tomahawk Live Trap, Tomahawk, WI) baited with peanut butter on bread. Poison baits (hulless oats or canary seeds) were applied as per label instructions. Strychnine baits (Nu-Gro Co., Brantford, ON, and Maxim Co., Regina, SK) were applied at burrow systems where ground squirrel captures and recaptures occurred, and in all holes with signs of activity located within the delineated study plots. Active holes were identified by flagging and shovelling dirt in all openings the day before treatment, and marking reopened holes on treatment day. One tablespoon of bait (13-15 g) was placed as far as possible into burrow openings using a long-handled spoon. Treated holes were covered with dirt. Anticoagulant baits (13-15 g of 0.7% chlorophacinone mixed with hulless oats or winter wheat; Nu-Gro Co., Brantford, ON) were placed in burrow openings, which were left open after treatment. A second treatment of burrow openings occurred 48 h later. Anticoagulant applications also involved bait stations with 1 kg of treated grains that were placed 40 m apart along the perimeter of a few study plots; they were refilled 48 h later. Some treatments involved the combined use of treatment at burrow openings and bait stations. Bait rejection was monitored in all 2008 study plots 24 h after treatment. Since bait rejection was almost nil with anticoagulants, only data related to strychnine were reported here. Live trapping was initiated the day following completion of treatments, and lasted up to 15 days to capture all animals present. Dead animals found on surface were collected and autopsied.

The assessment of the potential impact of poisoning on Burrowing Owls (*Athene cunicularia*) was assessed with regurgitation pellets collected at three different nests located near study plots. Pellets were dated, bagged and kept frozen until analysis by Alpha Wildlife Research & Management laboratory in Sherwood Park, AB. They were soaked overnight in a mild water-bleach solution, washed through a sieve, and oven-dried at 75°C. Pellet remains were identified according to Chandler (1916) and Moore et al. (1974). Frequencies were compared to each other with Fisher and Student-*t* tests; comparisons of means involved analysis of variance followed by Tukey test (Zar 1999).

Table 1. Frequency of strychnine bait rejection and non-target species found dead on surface, spring and summer 2008 and 2009.

Poison bait	Study plot size (ha)	# of ground squirrel burrow openings treated	# of burrow openings with rejected bait (%)	Non-target species
		Spring 2008		
RTU 0.4% oats	0.6	442	34 (7.7)	3 Horned Larks[1], 1 Deer Mouse[2]
	0.7	435	40 (9.2)	1 Horned Lark, 3 Chestnut-collared Longspurs[3]
FM 0.4% oats	1.4	440	31 (7.1)	2 Deer Mice
	0.6	455	46 (10.1)	4 Deer Mice
FM 0.4% canary seeds	0.7	406	14 (3.5)	–
	0.8	651	47 (7.2)	–
FM 0.2% oats	1.1	276	45 (16.3)	1 Horned Lark, 1 Common Grackle[4]
	1.0	433	49 (11.4)	1 Horned Lark
		Summer 2008		
RTU 0.4% oats	1.1	357	57 (19)	1 Olive-backed Pocket Mouse[5]
	0.9	265	38 (16.7)	–
FM 0.4% oats	0.7	393	67 (20.6)	2 Deer Mice
	0.9	307	34 (12.5)	1 Common Grackle
FM 0.4% canary seeds	0.7	258	15 96.2)	4 Deer Mice
	0.4	252	29 (13.0)	–
FM 0.2% oats	0.9	269	28 (11.6)	1 Horned Lark, 1 Deer Mouse
	0.7	533	56 (11.7)	–
		Spring 2009		
RTU 0.4% oats	0.7	363	–	1 Western Meadowlark[6]
	3.5	788	–	–
FM 0.4% oats	1.1	258	–	1 Vesper Sparrow[7] 1 Northern Harrier[8], 7 Deer Mice
	0.8	196	–	1 Deer Mouse
	2.2	1652	–	–
	0.9	567	–	1 Vesper Sparrow
	0.9	427	–	1 Western Meadowlark
	1.2	509	–	–
		Summer 2009		
RTU 0.4% oats	0.3	144	–	4 Deer Mice
	0.4	126	–	–
FM 0.4% oats	0.3	197	–	–
	0.7	208	–	–
	0.3	364	–	2 Deer Mice
	0.5	619	–	1 Horned Lark, 4 Deer Mice
	0.3	276	–	1 Deer Mouse
	0.2	81	–	–

[1]*Eremophila alpestris*, [2]*Peromyscus maniculatus*, [3]*Calcarius ornatus*, [4]*Quiscalus quiscula*, [5]*Perognathus fasciatus*, [6]*Sturnella neglecta*, [7]*Pooecetes gramineus*, [8] *Circus cyaneus*

Table 2. Average number of Richardson's Ground Squirrels found dead on surface in fields treated with 0.4% strychnine baits and anticoagulant baits, spring and summer 2008 and 2009.

Poison bait (n)	Average study plot size – ha (standard deviation)	Average # of Richardson's Ground Squirrels dead on surface (SD)
Spring 2008		
0.4% strychnine baits (6)	0.8 (0.3)	9.3 (8.6)
Anticoagulant baits (10)	0.7 (0.2)	11.7 (5.4)
Summer 2008		
0.4% strychnine baits (6)	0.8 (0.2)	5.8 (5.3)
Anticoagulant baits (10)	0.7 (0.3)	0.9 (1.2)
Spring 2009		
0.4% strychnine baits (8)	1.4 (1.0)	4.6 (5.4)
Anticoagulant baits (8)	0.7 (0.2)	21.1 (20.5)
Summer 2009		
0.4% strychnine baits (8)	0.4 (0.2)	2.0 (2.4)
Anticoagulant baits (8)	0.4 (0.1)	1.9 (2.3)

Results

Bait Rejection and Non-target Species

On average, strychnine bait rejection was greater in summer (13.9%) than in spring (9.1%) ($t = 2.275$, $P < 0.05$; Table 1). However, non-target species found dead on surface were frequent during both seasons, in 2008 and 2009 (Table 1).

In 2008, one White-tailed Jackrabbit (*Lepus townsendii*) was found dead beside a bait station filled with anticoagulant-treated oats. An autopsy confirmed the presence of hemorrhages in the body cavity. In 2009, two Deer Mice were found in fields treated with anticoagulants.

Number of Ground Squirrels Dead on Surface

On average, seven (SD: 6.8) ground squirrels were found dead on surface in study plots that averaged 0.7 ha (±0.3 ha) in size (Fig. 3). The number of Richardson's Ground Squirrels found dying or dead on surface was significantly different ($F_{7,56} = 4.950$, $P < 0.05$) between seasons and years (Table 2). The highest abundance of ground squirrels found dead on surface was in study plots treated with anticoagulant baits in spring of 2008 and 2009, and strychnine baits in spring 2008 (Table 2). The least number of ground squirrels found dead on surface was in a study plot treated with anticoagulant baits in summer 2008. All study plots with numbers between those with the highest and lowest abundances of ground squirrels found dead on surface had similar ($P > 0.05$) abundances of dead ground squirrels on surface.

Secondary Poisoning

Anticoagulants: One American Badger (*Taxidea taxus*) and three Long-tailed Weasels (*Mustela frenata*) died nine days after the first day of treatment with chlorophacinone-treated baits, in spring 2008 and summer 2009, respectively. Signs of bleeding were present at the badger den. Long-tailed Weasels captured in study plots died while under observation. Autopsies confirmed the presence of intestinal hemorrhages, bleeding from the anus, and blood seeping from gums and underfoot pads.

One male weasel captured on July 6, 2009 in a poison-free pasture was radio-collared for further studies, but was found dead the next day with intestinal hemorrhages

Figure 3. Richardson's Ground Squirrels found dead on surface in a study plot treated with poison baits, southwest Saskatchewan, summer 2008.

Table 3. Frequencies and mean volumes (%) of food items in Burrowing Owl regurgitation pellets, southwest Saskatchewan, 2008.

Food item	May (n = 9)		June–July (n = 19)		August (n = 5)	
	Frequency %	Mean volume[1] % (SD)	Frequency (%)	Mean volume[1] % (SD)	Frequency (%)	Mean volume[1] % (SD)
MAMMALIA						
Richardson's Ground Squirrel	3 (33.3)	32.4 (48.7)	5 (26.3)	26.2 (45.1)	1 (20.0)	14.0 (–)
Deer Mouse	5 (55.6)	34.9 (41.5)	4 (21.1)	19.6 (39.8)	1 (20.0)	18.0 (–)
Western Harvest Mouse[2]	–	–	1 (5.3)	5.3 (22.9)	–	–
Unknown	–	–	5 (26.3)	26.9 (43.1)	–	–
Total	8 (88.9)	67.3 (39.3)	15 (78.9)	69.5 (43.6)	2 (40.0)	32.0 (–)
AVES						
Passeriformes	–	–	–	–	1 (20)	12.0 (–)
Galliformes	–	–	1 (5.3)	1.3 (5.7)	–	–
ARTHROPODA						
Beetles and crickets	7 (77.8)	32.1 (39.8)	11 (57.9)	29.2 (41.8)	5 (100)	56.0 (41.6)
VEGETATION						
Unknown	1 (11.1)	0.5 (1.7)	1 (5.3)	0.1 (0.2)	–	–

[1]Some pellets contained more than one food item; [2] *Reithrodontomys megalotis*

resulting from anticoagulant poisoning. Bait stations with anticoagulant-treated oats were found along roadsides a few hundred metres away from the edge of the pasture.

In July 2009, a juvenile Swainson's Hawk (*Buteo swainsoni*) was observed moving in a strange manner on the ground, near its nest tree. Its body was found a few days later but without the head and intestinal tract. Several regurgitation pellets with anticoagulant-treated oats were found at the base of the tree, located a few hundred metres from fields with these baits.

Strychnine: One Northern Harrier (*Circus cyaneus*) was found in spring 2009 in a study plot treated with 0.4% strychnine baits. One Deer Mouse (*Peromyscus maniculatus*) was found in its stomach. An autopsy of the mouse revealed the presence of at least two strychnine-treated kernels.

Burrowing owl food habits

In 2008, small mammal remains in regurgitation pellets from three nests were similar in frequency (Fisher, $P > 0.05$) and volume ($F_{2,30} = 1.588$, $P > 0.05$) from May to August. In May and June-July, however, small mammal remains were found in >78% of pellets, and represented, on average, > 67% of pellet volumes (Table 3). Ground squirrel remains were found in 33% and at least 26% (some bone remains could not be identified with certainty) of pellets in May and June-July, respectively.

Discussion

Because farmers fail to find carcasses after poisoning, they usually claim that non-target species poisoning is infrequent (G. Proulx, pers. observ.). Carcass detection rates may be low due to scavenging or difficulty in finding small animals in vegetation (McKinnon et al. 2002, G. Proulx, pers. observ.). Our findings are field evidence of poisoning of non-target species by both strychnine and anticoagulants.

Many Richardson's Ground Squirrels and other small mammals poisoned by strychnine and anticoagulant baits were found on surface. Small mammals are important prey of terrestrial carnivores (Proulx et al. 2009) and raptors (MacCracken et al. 1985, Schmutz and Hungle 1989), and secondary poisoning may be significant in landscapes with greater use of ground squirrel poison baits. As predators preferentially select for prey moving slowly and abnormally, they focus on ground squirrels, mice and voles displaying a pre-lethal anticoagulant-toxicosis-induced behaviour that increases exposure and vulnerability to predation (Wood and Phillipson 1977, Brakes and Smith 2005). This is true for Burrowing Owls, which are considered opportunistic predators (Gleason and Craig 1979, Green et al. 1993). Burrowing Owls nesting in agricultural fields may adopt a specialized diet (Moulton et al. 2005) centered on an abundance of poisoned ground squirrels. As MacArthur and Pianka

(1966) suggested, a species may specialize when prey availability is high and search time is low. Differential consumption and caching of prey, decomposition rate of remains, and age- or sex-based differences in foraging may bias pellet collections and composition (York et al. 2002, Moulton et al. 2005). However, when one considers food consumption and pellet formation rates (Marti 1973), the high frequency of Burrowing Owl pellets with mice and ground squirrel remains from May to July suggests multiple feedings, a necessary condition for anticoagulants to produce mortality (Marsh 1994). Burrowing owls may also feed on carrion (Coulombe 1971), and strychnine-killed ground squirrels may have an impact on the health of owls (James et al. 1990).

Because it is difficult to find carcasses and ascertain cause of death, proof of secondary poisoning is difficult to assemble. The death of a badger in 2008 was based on circumstantial evidence. The deaths of weasels in 2009, however, were indisputable field evidence of secondary poisoning by anticoagulants. The 2008 and 2009 field observations raise concerns about the sustainability of predator populations. Nearly 30 years ago, the Long-tailed Weasel was considered threatened in western Canada by COSEWIC (Proulx and Drescher 1993). This status was based on Gamble's (1982) report suggesting that population declines resulted from habitat loss and increased use of agricultural pesticides. Proulx et al. (2009) collected 197 weasel scats from April to September 2008. In 2009, Proulx et al. (2010) found only 33 scats in the same landscapes. Similarly, 41 American Badger scats were found in 2008 (Proulx et al. 2009) vs. nine in 2009 (Proulx et al. 2010). This drop in the presence of carnivore signs is worrisome and suggests that the intensive use of poison baits to control ground squirrels may have a severe impact on predators in southwest Saskatchewan.

Concern about the future of terrestrial predators in poisoned landscapes extends to species at risk. Undoubtedly, Burrowing Owls feed on Richardson's Ground Squirrels from May to August. In spite of valuable stewardship programs (e.g., Operation Burrowing Owl, Keel et al. 2001), owls may leave their protected nesting sites to hunt in poisoned fields. The likelihood of poisoning these birds is even greater as some landowners will not disclose the presence of Burrowing Owls on their land for fear of losing control over the management of their property (G. Proulx, pers. notes). Therefore, poison baits may be used by neighbours unaware of the nearby presence of nesting sites. The future of Swift Foxes (*Vulpes velox*) and Black-footed Ferrets (*Mustela nigripes*) may also be bleak outside the borders of Grasslands National Park where they have recently been reintroduced (Parks Canada 2009a, b).

In the past, attempts to control outbreaks of Richardson's Ground Squirrel populations have been ineffective (Proulx 2010). The control of ground squirrel populations, and the future of terrestrial and avian predators lies in the implementation of an Integrated Pest Management Program involving farmers, government agencies, conservation groups and professional wildlife managers (Proulx 2010). This is a long-term proactive program where monitoring, preventive cultural practices, and various control methods (mechanical, physical, biological and chemical) must be strategically coordinated to maintain rodent population at acceptable density levels (Witmer and Proulx 2010).

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