STRYCHINE-SALT BLOCKS FOR CONTROLLING PORCUPINES IN PINE FORESTS: EFFICACY AND HAZARDS

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ABSTRACT: Strychnine-salt blocks were evaluated for effectiveness in killing porcupines (Erethizon dorsatum) in pine forests in Oregon and California. Radio-collared porcupines were exposed to strychnine-salt bait located on trees and on the ground in covered bait stations called "cubbies." Bait blocks placed in trees and in cubbies were poorly accepted by porcupines. Only 4 of 32 marked porcupines exposed to bait were poisoned. Two died at cubbies and two died at trees. Other wildlife found poisoned at cubbies were seven unmarked porcupines, seven yellow-pine chipmunks (Tamias amoenus), five Nuttall's cottontails (Sylvilagus nuttallii), four deer mice (Peromyscus maniculatus) three golden-mantled ground squirrels (Spermophilus lateralis), and one Douglas' squirrel (Tamiasciurus douglasii). Fewer nontarget animals--two unmarked porcupines, two yellow-pine chipmunks, and one northern flying squirrel (Glaucomys sabrinus)--died at tree sets. Bioassays with caged porcupines further indicated that strychnine alkaloid is an ineffective toxicant for porcupines.

INTRODUCTION

Control of porcupine (Erethizon dorsatum) damage in western conifer forests has concerned foresters since 1940 (Lawrence 1957). Intensive programs to control porcupines were conducted in the 1950-60s. Hunting and baiting with strychnine-salt bait blocks on the ground in dens and in bait stations, called "cubbies," were most commonly used. In the late 1970s registration for placement of strychnine-salt blocks at ground level was cancelled because of concerns about hazards to nontarget wildlife. Since then registered use of strychnine for porcupine control has been restricted to placement of bait blocks in trees at least 3 m above snow level (Matheny 1980, EPA 1983).

Quantitative information on the effectiveness of tree sets and cubby sets with strychnine-salt blocks is lacking (Evans and Matthews 1972). The recent resurgence of concern about porcupine damage and the lack of a proven, cost-effective method of control stimulated our interest in comparing the currently registered use of strychnine-salt blocks in trees with the widely endorsed placement of bait in cubbies. We used radio telemetry to determine mortality rates of porcupines exposed to bait blocks in trees and in cubbies in two pine forests. Carcass searches were conducted in the vicinity of bait stations to locate other poisoned wildlife. Caged porcupines were used in bioassays to assess the efficacy of strychnine alkaloid and zinc phosphide baits.

METHODS

Field Study

Study areas - The study was conducted on the Fremont National Forest near Lakeview, Oregon, and, just to the south, on the Modoc National Forest near Willow, California. The Fremont study area occupied approximately 50 km^2 in forest communities of white fir-ponderosa pine/snowberry/starwort (Abies concolor-Pinus ponderosa/Symphoricarpos albus/Stellaria jamesiana) and white fir-ponderosa pine/manzanita-Oregon grape (Arctostaphylos patula-Berberis aquifolium) (Hopkins 1979). The similarly-sized Modoc study area was located in a white fir-ponderosa pine/manzanita-Oregon grape plant community. Both areas have long histories of porcupine damage.

Study animals - From 15-25 May 1984, 40 porcupines were captured by hand, equipped with radio transmitters, and released. Twenty-four were captured on the Fremont study area and 16 on the Modoc. Five animals were removed from roost trees during daylight searches. The rest were captured with hand-held fish nets while night-lighting along forest roads. Each captured porcupine was anesthetized with methoxyflurane, weighed, sexed, aged, ear-tagged, and fitted with a radio-transmitter collar. We relocated each animal three to five times during the 10-day period between capture and placement of bait stations to determine individual activity areas. After bait placement, porcupines were located at 2-day intervals during a 10-day period. Later, two locations per animal were made from 25-29 June, followed by one location per animal from 30-31 July, and on 22 August 1984 when tracking was terminated. General location of porcupines was determined by radio-tracking from vehicles with roof-mounted antennas. Specific location and condition of porcupines was verified by foot searches. Locations were plotted on aerial photos and recorded using Universal Transverse Mercator coordinates.

Bait and bait placement - Pine blocks containing 5.79% strychnine alkaloid in sodium chloride (EPA Reg. No. 5704-15) were used in all treatment sets. All were obtained from the Pocatello Supply Depot, Pocatello, Idaho. We made control blocks with materials from Pocatello Supply Depot using the same formula but without strychnine.

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To maximize exposure of bait to porcupines, we placed bait blocks in trees or in cubbies at the base of trees that were occupied by radio-equipped porcupines. A single bait block was nailed to a tree according to directions on the pesticide label. Two bait blocks were attached to the inside of each cubby. The cubby set was similar to that used in Oregon in 1984 by the Bureau of Land Management under a pesticide use exemption (exemption no. 83-DI-03, William Neitro, pers. comm.). Cubbies were constructed from 120 cm long by 40.6 cm diameter aluminum culvert halves according to Neitro (1970). Culvert halves were elevated with two 10-cm by 10-cm wood blocks at each corner and a 5-cm by 10-cm stringer along each side above the 10 by 10 blocks. Cubbies were anchored with wire between two steel fence posts to prevent access to the salt blocks by large nontarget animals.

For the evaluation, each porcupine was randomly assigned a tree set or cubby set within its home range. At each of the two study areas, eight porcupines received treated tree sets and eight received treated cubby sets. Control bait stations--four tree sets and four cubby sets with untreated salt--were included only in the Fremont study area.

Salt blocks were placed in trees or in cubbies from 24-28 May and removed on 21-22 August. Timing of bait placement was based on accessibility of study areas following snowmelt and results of a 1-year study indicating that salt is most attractive to porcupines during spring and summer (Campbell and LaVoie 1967a).

Concurrent with radio tracking, bait blocks were examined for signs of chewing by porcupines and other animals. The amount of wood and salt removed from each block was estimated visually. If blocks were chewed, a carcass search was conducted in a 50-m radius around the bait station to locate poisoned wildlife.

Cage Bioassays

At completion of fieldwork in August, 15 porcupines--seven males and eight females--were captured outside the study areas and transported to our laboratory facilities in Olympia, Washington. After a 5-day acclimation period on a salt-free diet of pelleted alfalfa, lettuce, apples, and water, each individually caged porcupine was presented a salt block. One group of ten animals received blocks containing 5.79% strychnine alkaloid; five control animals received blocks with the nontoxic formulation. Consumption of blocks was visually estimated daily for 3 consecutive days. Bait blocks also were weighed before and after the 3-day exposure period. Porcupines were observed for signs of intoxication for 5 days after the last day of exposure to bait. Fourteen of the same animals used in the strychnine test later were given 0.75% zinc phosphide-carrot bait (EPA Reg. No. 6704-521) under the same test regimen.

Analyses

A Chi-square test of independence was used to compare numbers of porcupines killed with strychnine and use of bait blocks by porcupines. Data from each study area were compared and pooled if not statistically different ($P>0.05$).

The geographic activity center (Hayne 1949) was computed for the location coordinates of each radio-equipped animal. Mean distance moved by porcupines between consecutive locations was compared with distance between bait stations and geographic activity centers to determine availability of baits to porcupines.

RESULTS

Radio Telemetry

We captured 16 male and 24 female porcupines. All but one of the animals were followed successfully to the end of the study. The one "missing" male porcupine left the area near completion of the study. Twenty (83%) of the 24 females had young. Of these, 6 were pregnant at capture and 14 were lactating indicating recent parturition.

Of the 458 total locations made, porcupines were found on the ground on 25 occasions; all other locations were in trees. Mean distance between consecutive locations of animals was 354 (± 105) m. Mean greatest distance between two consecutive locations was 811 (± 116) m; single greatest distance was 1726 m. Mean distance from activity center to bait set was 283 (± 65) m. Inspection of movement maps showed that the bait stations were located within the "home ranges" of all targeted porcupines.

Four (12.5%) of the 32 radio-equipped porcupines targeted for poisoning were found dead at bait stations. Two died at tree sets and two at cubby sets. All four (two males and two females) were on the Modoc study area. The other 36 porcupines--28 treated plus 8 controls--survived with no apparent signs of intoxication. Five unmarked porcupines were found poisoned at bait stations (three animals at cubbies) on the Modoc study area. Four unmarked porcupines died at bait stations (three at cubbies) on the Fremont study area. One porcupine found near a cubby set had been consumed by scavengers. The gastrointestinal tract, skin, and skull were the only remains found.

Because of the irregular schedule for locating porcupines, exact dates of the deaths of three of four of the poisoned animals are unknown. None died immediately after exposure, which is contrary to the expected performance of an acute toxic bait. One porcupine found dead at the base of a tree with a bait block died 3 days after bait placement. The other three carcasses were completely decomposed when located--estimated time of death after bait placement was 14 days for two of these animals and 71 days for the other one.

Use of Baits

Use of bait blocks in trees and cubbies was low in both total number of blocks affected and proportion of individual blocks removed (Table 1). Cubbies appeared more likely to be used by porcupines than tree sets, but no statistical difference in use occurred. Significantly more salt was dissolved by rain at tree sets than at cubby sets. Signs of use of blocks by other animals were limited to minor chewing on the wood of blocks at four cubby sets.

Table 1. Use of salt and wood by porcupines and condition of bait blocks exposed from May through August 1984: number affected/total available (mean percent of salt or wood gone).

	Control*		Strychnine	
	Cubby set	Tree set	Cubby	Tree set
Salt removed by porcupines	4/4 (74)	1/4 (40)	7/16 (11)	3/16 (4)
Wood removed by porcupines	3/4 (66)	1/4 (10)	6/16 (10)	6/16 (23)
Salt dissolved in blocks	0/4 (-)	2/4 (65)	0/16 (-)	10/16** (44)

* Sample size is inadequate for statistical analyses of differences.

** Number of blocks affected is significantly different (P>0.05) from paired value.

Nontarget Mortality

Carcass searches around tree sets with sign of bait block use produced two yellow-pine chipmunks (Tamias amoenus) and a northern flying squirrel (Glaucomys sabrinus). Dead animals found at cubby sets were seven yellow-pine chipmunks, five Nuttall's cottontails (Sylvilagus nuttallii), four deer mice (Peromyscus maniculatus), three golden-mantled ground squirrels (Spermophilus lateralis) and one Douglas' squirrel (Tamiasciurus douglasii). All animals were found under cubbies or next to bait blocks. All exhibited muscular tetany, which is characteristic of strychnine intoxication.

Cage Bioassays

None of the ten porcupines given strychnine-treated bait blocks died despite some high strychnine consumption rates (Table 2). Most porcupines consumed more than the estimated LD_{50} of strychnine alkaloid (8.2 mg/kg) (data on file at Denver Wildlife Research Center). None of the five control animals died. Fourteen of these same porcupines died within 24 hours when given zinc phosphide-carrot bait 1 week later. Mean consumption rate of zinc phosphide was 90.7 (± 19.6) mg/kg, well in excess of the estimated LD_{50} (8.3 mg/kg, CL_{95} 5.5-12.5 mg/kg) (data on file at Denver Wildlife Research Center).

DISCUSSION

Despite optimum baiting conditions--placement of bait directly under animals at the season when salt is supposed to be most attractive--strychnine-salt bait blocks failed to significantly reduce our population of radio-equipped porcupines. Our results suggest that sodium chloride is not an effective bait for porcupines. Other investigators have reported similar results. Bloom et al. (1973) found no preference for sodium chloride among either experienced or naive porcupines in cage tests. Campbell and LaVoie (1967b) concluded from field tests in northern California that acceptance of sodium chloride was variable and may be reduced when formulated with strychnine alkaloid. When Roze (1985) exposed wooden stakes impregnated with various sodium salts (sodium chloride, nitrate, sulfate, acetate, borate, and bicarbonate) to porcupines in New York, he found that sodium salts of bases were preferred to sodium salts of strong acids. He hypothesized that high acid and high potassium contents in vegetation eaten by porcupines in summer result in an internal ionic imbalance--low sodium and elevated pH. The sodium imbalance stimulates the salt-seeking behavior in porcupines, but the acid imbalance in their systems causes lower preference for acidic salts of sodium; e.g., sodium chloride. This may explain the variable acceptance of sodium chloride by porcupines in western forests and certainly suggests direction for future research.

Our cage tests also indicate that strychnine is an ineffective toxicant for porcupines. We do not know why porcupines did not die after consuming strychnine alkaloid in our cage tests. Lawrence (1957) observed that strychnine was relatively ineffective on porcupines feeding on junipers (Juniperus occidentalis) with high tannin content. Tannins cause alkaloids to precipitate (Windholz 1983) and therefore, may reduce absorption of strychnine alkaloid in the gastrointestinal tract. Although junipers were abundant in the area where we captured porcupines for toxicity tests, the acclimation period on tannin-free foods before testing should have eliminated any tannins that might have been consumed (R. Bullard, Denver Wildlife Research Center, pers. comm.).

Primary hazard to other wildlife is another factor that also discourages use of strychnine-salt blocks for porcupine control. Because of the methods used in this experiment, primary poisoning of nontarget wildlife was probably underestimated. Unknown risks to predators and scavengers from consuming

Table 2. Total consumption of salt and strychnine by caged porcupines during a 3-day bioassay. No animals died or showed any effects of strychnine intoxication. Numbers in parentheses are amounts consumed on first day only.

Porcupines			Amounts consumed		
			Sodium chloride (g)	Strychnine	
No.	Sex	Weight (kg)		mg	mg/kg
			- - - - - 5.79% Strychnine Alkaloid Salt Blocks - - - - -		
1	F	7.7	1.3 (0.7)	75.3 (38.2)	9.8 (5.0)
2	M	10.2	2.4 (1.2)	139.0 (69.5)	13.6 (6.8)
3	M	10.1	2.9 (0.6)	167.9 (34.7)	16.6 (3.4)*
4	F	5.7	1.7 (1.2)	98.4 (67.2)	17.3 (11.8)**
5	M	10.9	11.6 (1.5)	671.6 (89.4)	61.6 (8.2)**
6	M	9.1	11.4 (7.6)	660.1 (440.0)	72.5 (48.3)**
7	F	6.5	8.3 (8.3)	482.9 (482.9)	74.3 (74.3)**
8	M	9.5	20.5 (15.0)	1186.9 (868.5)	124.9 (91.4)**
9	F	7.3	16.9 (1.3)	978.5 (78.2)	134.0 (10.7)**
10	M	11.1	34.1 (14.2)	1974.9 (822.2)	177.9 (74.1)**
			- - - - - Untreated Salt Blocks - - - - -		
1	F	3.5	0.6 (0.6)	--	--
2	F	3.4	2.5 (1.9)	--	--
3	F	8.2	3.1 (1.8)	--	--
4	F	6.1	5.9 (5.9)	--	--
5	F	8.2	50.4 (37.8)	--	--

* Amount of strychnine consumed on day 3 exceeds estimated LD_{50}.

** First day consumption of strychnine equals or exceeds estimated LD_{50} (8.2 mg/kg, CL_{95} 3.7-18.5 mg/kg).

poisoned porcupines and other animals further increase concerns about hazards of baiting porcupines. We found only one poisoned porcupine that had been fed upon. The gastrointestinal tract, which usually contains the majority of consumed strychnine, was not removed. However, carcasses of other unmarked porcupines and small mammals may have been removed or consumed without detection. These particularly small mammals could present a high secondary hazard potential. The number of species of animals found poisoned (six) makes the concern about potential hazards a serious one.

Our results demonstrate that use of strychnine bait blocks for porcupine control in forests is ineffective. If marked and unmarked porcupines are considered, cubby sets appeared to be more effective than tree sets in killing porcupines. However, cubby sets were more hazardous to other wildlife than tree sets. Because of these problems and the sensitivity concerning use of strychnine, continued use of strychnine alkaloid bait blocks for porcupine control in forests is not recommended.

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