HAZARDS TO GRIZZLY BEARS OF STRYCHNINE BAITING FOR POCKET GOPHER CONTROL

VICTOR G. BARNES, JR.,1 U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Bend Field Station, 1027 NW Trenton Ave., Bend, OR 97701

R. MICHAEL ANTHONY,2 U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Bend Field Station, 1027 NW Trenton Ave., Bend, OR 97701

KATHLEEN A. FAGERSTONE, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Building 16, Federal Center, Denver, CO 80225

JAMES EVANS,3 U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Olympia Field Station, 3625-93rd Ave. SW, Olympia, WA 98502

The Targhee and Bridger-Teton national forests in Idaho and Wyoming provide habitat for grizzly bears (Ursus arctos) from the Yellowstone National Park population (Anonymous 1979). Portions of the forests contain reforestation units scheduled for pocket gopher (Thomomys talpoides) control with strychnine alkaloid-treated grain, a practice used commonly to reduce damage to conifer seedlings by pocket gophers (Northwest For. Pocket Gopher Comm. 1976). In 1979, the U.S. Forest Service (USFS) asked the U.S. Fish and Wildlife Service (USFWS) for an opinion on whether grizzly bears would be affected by pocket gopher baiting projects on those units. This request was made in compliance with Section 7 of the Endangered Species Act of 1973 and amendments (Johnson 1979, 1984) because grizzly bears feed on pocket gophers and their food caches (Kendall 1980, Mealey 1980, Blanchard 1983) and thereby could be exposed to strychnine.

We investigated the availability to grizzly bears of strychnine applied below-ground for control of pocket gophers. Specific objectives were to determine where pocket gophers died, levels of strychnine residues in poisoned animals, location and quantity of bait stored by pocket gophers, and levels of strychnine on recovered bait.

STUDY AREAS

Field data were collected in July 1979 on the West Bitch Creek (WBC) and South Antelope Flat (SAF) management units of the Ashton Ranger District, Targhee National Forest. The WBC site was a clear-cut of roughly 63 ha located about 25 km southeast of Ashton, Idaho; the SAF site was a series of 3 clear-cuts (4–12 ha) located 13–18 km north of Ashton. Before logging, each site was dominated by a subclimax stand of lodgepole pine (Pinus contorta). After logging, the flora consisted of lush herbaceous vegetation with scattered stands of lodgepole pine and aspen (Populus tremuloides). Based on criteria of Steele et al. (1979), probable climax of WBC would be subalpine fir (Abies lasiocarpa)/grouse whortleberry (Vaccinium scoparium) and that of SAF would be Douglas-fir (Pseudotsuga menziesii)/pine reedgrass (Calamagrostis rubescens).

WBC was harvested by clear-cutting from 1967 to 1969; slash was piled and burned in 1969 and 1970. Because natural conifer regeneration was unsatisfactory, the area was partially scarified for planting in 1978 and planted with lodgepole pine seedlings in 1979. WBC contained habitat that was considered important for survival and recovery of the grizzly bear (Anonymous 1979).

SAF was clear-cut in 1962 and slash was piled and burned in 1964 and 1965. Site preparation, tree planting, and pocket gopher baiting began in the early 1970s. Because tree survival was poor, the clear-cuts were site-prepared again in 1978 and replanted in 1979. Grizzly bears rarely used the SAF area (Anonymous 1979).

METHODS

Pocket gopher bait was steam-rolled oats containing 0.5% strychnine alkaloid (EPA Registration No. 6704-
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Relative abundance of each was visually estimated (nests) or determined by air-dried weight (food caches). Student’s t-test of difference between independent sample means was used to analyze depths of nests, depths of carcasses, and strychnine residues in carcasses.

RESULTS AND DISCUSSION

Fate of Pocket Gophers

We leg-banded and radio-instrumented 41 pocket gophers on each study area; adults comprised 71% of the sample. Sixty-two (76%) of the 82 radio-equipped pocket gophers were successfully monitored during bait application and several days post-treatment. Of these, 40 (65%) died from strychnine baiting—20 died ≤1 day after bait exposure and the remainder died within 4 days. Eight of the mortalities were from a group of 20 gophers baited a second time because they survived the original baiting. Radio-tracking data indicated that a few pocket gophers were not exposed to bait after the first application. However, others stored bait from the first and second applications but survived because they either did not ingest bait or consumed sublethal doses. Twenty-two radio-equipped pocket gophers were still alive when radio-tracking was terminated, 5–12 days after exposure to bait.

Recovery of Carcasses, Nests, and Food Caches

We excavated carcasses of 40 radio-equipped and 5 unmarked pocket gophers. Of the 45 pocket gophers, 2 were found in 1 nest, 3 in another nest, and 40 were found singly. In the latter group, 2 juveniles and an adult female were recovered from the same burrow system and the other 37 were found in separate systems. Two-thirds (30) of the carcasses were located >40 cm below ground and almost half (22) were ≤10 cm from a nest. Carcass locations ranged from 10 to 152 cm below ground (Table 1); we did not detect a difference in depths between study areas (P > 0.10).

Reference to trade names or companies does not imply U.S. Government endorsement of commercial products.
We found 64 pocket gopher nests. Depth from ground level to the base of nests ranged from 30 to 152 cm (Table 1); mean depth of nest sites at WBC ($\bar{x} = 54$ cm) did not differ ($P > 0.20$) from that at SAF ($\bar{x} = 60$ cm).

Bait, in amounts ranging from 0.1 to 18.3 g, was found in 88 and 26%, respectively, of nests of dead and surviving pocket gophers. Freshly clipped herbage was present in 55% of the nests at a mean air-dried weight of 6.4 g. Forage in nests was predominately stems and leaves, with lupine (Lupinus sp.) the most common species.

We found 10 food caches at locations 17 to 73 cm below ground (Table 1) and 1–5 m from nest sites. Although pocket gophers may store food near their nests (Tryon 1947), our data are biased toward nest locations because poisoned gophers often died in or near nests. Attempts to locate other caches by digging out runways were time consuming and largely unproductive. Similar difficulties in locating food caches were reported by Aldous (1945).

Below-ground vegetative parts (bulbs, corms, roots, and rhizomes) comprised 94% of the volume of food caches. The most abundant materials were yampah (Perideridia gairdneri) roots (75%), unidentified root material (11%), fritillary (Fritillaria sp.) bulbs (7%), and bluegrass (Poa spp.) rhizomes (3%). Air-dried weight of 10 food caches ranged from 20 to 196 g ($\bar{x} = 113$). Bait was found in 3 of the caches in quantities of 2.0, 3.8, and 16.5 g.

### Strychnine Residues

Pocket gopher carcasses contained relatively small amounts of strychnine (Table 2). The largest quantity detected was in an animal with 0.4 g of bait and 1.3 mg of strychnine in a cheek pouch. Lesser quantities of bait were found in cheek pouches of 5 other pocket gophers. As expected, residual strychnine was concentrated (69%) in gastrointestinal tracts (Copeman 1957). We cannot explain why the mean strychnine content of pocket gopher carcasses (0.23 mg at SAF and 0.11 mg at

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Carcasses</th>
<th>Nests</th>
<th>Food caches</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;11</td>
<td>3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>11–20</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>21–30</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>31–40</td>
<td>2</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>41–50</td>
<td>2</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>51–60</td>
<td>1</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>61–70</td>
<td>1</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>71–80</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>81–90</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>91–100</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>&gt;100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean depth (cm) 48 57 47

* Measurements taken ground level to bottom of location.
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Table 3. Strychnine alkaloid residues on steam-rolled oat bait collected before and after application for pocket gopher control on eastern Idaho forest plantations, July 1979.

<table>
<thead>
<tr>
<th>Source</th>
<th>Exposure time (days)</th>
<th>n*</th>
<th>Amount strychnine alkaloid on oatsb</th>
<th>Percentage active Mg</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacks from manufacturer</td>
<td></td>
<td></td>
<td>0.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bait dispensersc</td>
<td>0</td>
<td>10</td>
<td>0.47d</td>
<td>14.3</td>
<td>&lt;0.1-52.3</td>
</tr>
<tr>
<td>Bait sets</td>
<td>0</td>
<td>25 (12)</td>
<td>0.44d</td>
<td>15.7</td>
<td>&lt;0.1-69.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>24 (12)</td>
<td>0.44d</td>
<td>15.7</td>
<td>&lt;0.1-69.5</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>26 (11)</td>
<td>0.20</td>
<td>8.7</td>
<td>&lt;0.1-32.6</td>
</tr>
<tr>
<td>SAF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bait dispensers</td>
<td>0</td>
<td>10</td>
<td>0.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bait sets</td>
<td>0</td>
<td>25 (13)</td>
<td>0.36d</td>
<td>20.3</td>
<td>0.7-94.3</td>
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<tr>
<td></td>
<td>3</td>
<td>27 (11)</td>
<td>0.39d</td>
<td>19.8</td>
<td>0.3-99.4</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>21 (12)</td>
<td>0.30</td>
<td>15.0</td>
<td>&lt;0.1-76.2</td>
</tr>
<tr>
<td>WBC and SAF</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gopher nests</td>
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<td>42</td>
<td>0.25</td>
<td>11.2</td>
<td>0.2-51.2</td>
</tr>
<tr>
<td>Food caches</td>
<td>1-5</td>
<td>3</td>
<td>0.27</td>
<td>17.0</td>
<td>6.8-36.3</td>
</tr>
</tbody>
</table>

Table 3. Strychnine alkaloid residues on steam-rolled oat bait collected before and after application for pocket gopher control on eastern Idaho forest plantations, July 1979.

* Parentheses indicate subsample used to estimate percentage strychnine on bait sets.

b Percentage is based on weight of strychnine from total bait sample; mg values for bait sets based on weights of bait from total sample and percentage strychnine from subsample.

c Plastic containers carried by bait applicators.

d For each study area, means followed by a common letter are not different (P > 0.05).

WBC) differed (P < 0.01) between study areas (Table 2).

We detected little or no strychnine in carcasses of other animals recovered post-treatment (Table 2), and found no evidence that concentrations of poisoned animals were available to predators or scavengers. Small mammal populations were not adversely affected by baiting (Fagerstone et al. 1980) and animals captured alive post-treatment contained no detectable strychnine residues.

The mean strychnine concentration on bait recovered from nests and food caches was about half that of samples taken before application (Table 3). Two of 3 food caches and 26 (62%) of 42 nest deposits contained ≤10 mg. Causes of strychnine loss from bait are unknown, although we suspect that gathering and storing activities of pocket gophers caused sloughing of adhesive agent and strychnine.

We also considered the possibility that a grizzly bear might uncover >1 source of strychnine from a single burrow system. Of 34 burrow systems that yielded ≥1 pocket gopher, a nest and (in 3 cases) a food cache containing bait, the mean accumulation of strychnine was 12.4 mg; the maximum accumulation was 51.4 mg of strychnine.

The remaining source of strychnine sampled was on bait in bait sets. Strychnine concentration on bait decreased with time (Table 3), although mean quantities of 8.7 and 15.0 mg of residue were detected on bait sets collected 8 and 10 days after baiting on WBC and SAF, respectively.

BIOLOGICAL INTERPRETATION

The potential for adverse effects on grizzly bear caused by pocket gopher baiting with strychnine depends essentially on 3 factors: (1) foraging behavior of grizzlies, (2) sources of strychnine residues in relation to that behavior, and (3) susceptibility of grizzly bears to...
strychnine alkaloid. Grizzly bear food habits in the Yellowstone area have been investigated (Kendall 1980, Mealey 1980) and our study provides information on strychnine residues. Toxicity data for grizzly bears are lacking. Inukai (1969) reported a lethal dose of 0.5 mg/kg of strychnine nitrate for U. a. yesoensis, but the comparative toxicity of strychnine nitrate and strychnine alkaloid to U. a. horribilis is unknown (Tucker and Crabtree 1970:104-106). The lowest lethal dose of strychnine alkaloid reported for a mammal is 0.33 mg/kg (Schitoskey 1975); thus, we conservatively selected this value as the estimated minimum dose lethal to grizzly bears.

Although pocket gophers do not constitute a major component of the grizzly bear diet, they are at times taken by bears (Knight et al. 1978, Kendall 1980). Mealey (1980) noted that in some areas of Yellowstone National Park grizzlies intensively dug for rodents (pocket gophers and Microtus spp.). This digging behavior is probably reinforced by occasional success in catching rodents (Mealey 1980) and by chance encounters of food caches. Grizzly bears also may uncover pocket gopher nests.

We conclude that strychnine-poisoned gophers are a negligible hazard to grizzly bears. Pocket gophers died below ground, over a period of several days, and generally separate from each other. Most important, carcasses contained small amounts of strychnine. The lethal dose for a 45-kg bear at the assumed level of 0.33 mg/kg equates to 94 pocket gopher carcasses having a mean strychnine alkaloid content of 0.16 mg (the combined average of carcasses from SAF and WBC). Pocket gophers tend to occupy separate burrow systems and a bear would not be likely to consume enough carcasses during a period of continuous foraging to reach a toxic threshold. Strychnine is a fast-acting compound and mortality occurs from prompt ingestion of a lethal dose; prolonged consumption often leads to sublethal effects and learned aversion rather than death (Crabtree 1962).

We also conclude that bait in pocket gopher nests and bait sets presents a low risk to grizzly bears. The mean strychnine content of nests from SAF and WBC (11.2 mg) represents a potentially lethal dose for bears weighing ≤34 kg; the maximum amount found (51.2 mg) could effect a 155-kg bear. However, the chance of a bear consuming an entire nest seems remote because forage preferences of grizzly bears (Mealey 1980) suggest that they would consume carcasses and succulent vegetation but reject dry material. For the same reason, we would not expect grizzly bears to seek out bait sets.

The most serious threat of strychnine baiting to grizzly bears is bait stored by pocket gophers in food caches. Caches typically hold important components of the grizzly bear diet (Kendall 1980, Mealey 1980). Yampah root is a preferred food and was the principal item in caches we found. Grizzly bear foods found in caches by Youmans (1979) and Aldous (1945) include starwort (Stellaria spp.) tubers, lanceleaf springbeauty (Claytonia lanceolata) corms, onion grass (Melica spectabilis) bulbs, and common dandelion (Taraxacum officinale) roots. We located 1 food cache with 36.3 mg of strychnine—enough to potentially kill a bear weighing ≤110 kg, assuming 0.33 mg/kg is lethal. Our data indicated most bears would need to excavate ≥2 caches containing strychnine to be at risk. The probability of that event appears low, but cannot be dismissed.

Hazards to grizzly bears are most likely to occur immediately after baiting when strychnine content on bait is high. Within a few days after bait application a substantial amount of strychnine is lost from bait in nests, caches, and bait sets. This degradation of bait quickly lessens the hazards to grizzly bears.

We conclude that strychnine baiting of forest plantations generally poses a low risk to grizzly bears. Grizzly bear use of young, 1- to 5-year-old forest stands (normally baited for gophers) generally is low (Mealey et al. 1977,
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Blanchard 1983), and the few bears that might forage in baited plantations are not likely to consume lethal quantities of residual strychnine. This low risk assessment is supported by other studies (Hegdal and Gatz 1976, Fagerstone et al. 1980) but does not preclude the need to reduce or avoid potential baiting hazards reported by Anthony et al. (1984). Therefore, we urge forest managers to examine alternate, nontoxic approaches for control of pocket gopher damage in grizzly bear habitat. Increased tree stocking and mechanical tree protection (Anthony et al. 1978, Anthony, unpubl. data) are methods that merit consideration.

SUMMARY

Alkaloid residues of underground-baited strychnine in forest plantations baited to control pocket gophers were studied to assess possible effects on grizzly bears. Radio-equipped pocket gophers died from strychnine poisoning below ground ($\bar{x} = 48$ cm) and usually separate from each other; chemical analyses revealed mean residue levels of $<0.3$ mg in carcasses. Pocket gophers stored grain bait in nests and food caches commonly located $>40$ cm below ground; mean strychnine levels on bait in nests and food caches were 11.2 and 17.0 mg, respectively, and ranged from 0.2 up to 51.2 mg. The minimum lethal dose of strychnine alkaloid to grizzly bears is unknown; we conservatively estimated it at 0.33 mg/kg. Using that assumed toxicity level, we judged that carcasses of pocket gophers found on baited areas did not pose a hazard to grizzly bears. Also, bears are not likely to consume lethal amounts of strychnine from nests because of dispersal of bait through dry, unpalatable herbage of the nest. Strychnine bait in pocket gopher food caches could present a risk because some of the caches can contain high levels of strychnine along with roots, corms, bulbs, and other food items preferred by grizzly bears.

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LITERATURE CITED


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INEFFICACY OF SCENT-STATIONS FOR MONITORING RIVER OTTER POPULATIONS

MARK S. ROBSON,2 Department of Wildlife and Range Sciences and Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, FL 32611

STEPHEN R. HUMPHREY, Florida State Museum and Department of Wildlife and Range Sciences, University of Florida, Gainesville, FL 32611

The river otter (Lutra canadensis) once was common from northern Canada and Alaska to the southern tip of Florida but now is absent or rare in 16 states (Pursley 1980, Hall 1981, Towell and Tabor 1982). This population decline led to listing of the river otter in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (U.S. Dep. Inter. 1977). To fulfill treaty obligations, the U.S. Fish and Wildlife Service must provide evidence that harvesting river otters for export is not detrimental to the

1 Contribution No. 6507 of the Journal Series, Florida Agricultural Experiment Station, Gainesville, FL 32611.
2 Present address: Game and Fresh Water Fish Commission, 551 North Military Trail, West Palm Beach, FL 33415.