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PORCUPINE DAMAGE AND REPELLENT RESEARCH IN THE INTERIOR PACIFIC NORTHWEST

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ABSTRACT: Porcupines (*Erethizon dorsatum*) rely on trees and shrubs for winter food and can cause serious, localized damage to conifers. Twenty-two percent of ponderosa trees (*Pinus ponderosa*) examined in southeastern Washington were damaged by porcupines. Most damage involved complete girdling of the mid- to upper boles of the larger trees (12 to 30 cm dbh) in the stand. Preliminary repellent trials with captive porcupines suggested that several materials might reduce tree damage, especially predator-associated odors. Field trials are needed to assess efficacy and duration of protection under ambient winter conditions.

KEYWORDS: porcupine, *Erethizon dorsatum*, forest damage, repellents

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INTRODUCTION

Porcupines (*Erethizon dorsatum*) can cause significant localized damage to regenerating conifers in the western United States (Borrecco and Black 1990). They clip or girdle small seedlings, but also gnaw bark from the boles of well established pole-sized trees. They can also cause damage to crops, buildings, and other structures (Schemnitz 1994). Historically, porcupine damage has been controlled by population reduction through trapping, shooting or use of toxic bait (Evans 1987; Schemnitz 1994). However, many of those methods are no longer available or are very restricted in application. There are no registered repellents to reduce porcupine damage in the United States (Schemnitz 1994). Research is needed to develop effective, nonlethal methods to reduce porcupine damage (Evans 1987; Dodge and Borrecco 1992).

Efforts are underway to re-establish woody vegetation on the Palouse Prairie, a large region of southeastern Washington that was primarily native grasssland, but has largely been converted to intensive agriculture. Much of this effort is through the Conservation Reserve Program (CRP) to help reduce soil erosion; wildlife damage under such a scenario can be anticipated (Hughes and Gipson 1996). Most studies of porcupine use of woody materials have been conducted on commercial forestland. Hendricks and Allard (1988) studied porcupines in prairies of eastern Montana, but there were no conifer species present. Re-establishing conifers can be especially difficult in the interior Pacific Northwest because of low precipitation levels, vegetative competition, and animal damage.

The authors report levels of porcupine damage to regenerating ponderosa pine stands in the Palouse Region of southeastern Washington and the results of preliminary repellent trials with captive porcupines at Washington State University (WSU). Reference to trade names does not imply U.S. government endorsement of commercial products or exclusion of a similar product with equal or better effectiveness.

METHODS

Damage Survey

The authors surveyed porcupine damage to a 115 ha natural stand of ponderosa pine at Smoot Hill, Whitman County, about 12 km northwest of Pullman, Washington in December 1997. Stand elevation was 920 m, had a northeast aspect, and received about 40 cm of annual precipitation. Trees were rare except along major riparian zones and on some north-facing slopes. The most common plant association was *Festuca idahoensis/Symphoricarpos albus* (Franklin and Dyrness 1973). The dominant trees in the stand were about 100 years old and natural regeneration occurred within and around the periphery of the stand. The authors walked a transect along the major axis of the stand and established a 0.047 ha circular plot when a damaged tree was encountered. At each of 10 plots the diameter-at-breast-height (dbh) of each tree was measured and it was noted whether the tree had been damaged. For damaged trees, it was estimated the height of the tree and height(s) at which bark damage had occurred. It was also noted if the tree was alive or dead and whether the bole was completely girdled or merely had patches of bark removed. The tree density (stems/ha) of each plot was also determined.

The authors were also able to survey porcupine damage to four-year-old, planted ponderosa pine seedlings on a CRP project site in Whitman County, Washington. The focus of that study was to test methods to reduce vegetative competition and increase soil moisture availability to planted seedlings of various woody species; details and results of that study were reported in Sanders (1998). Here, the authors report only the observed levels of porcupine damage.

Repellent Pen Trials

Wild-captured porcupines, maintained individually in three 13x4 m outdoor pens at WSU, were used for repellent trials. Daily maintenance included water *ad libitum*, an apple, and pelleted rat chow. Straw for bedding was placed in wooden huts; periodically, pine branches for gnawing were added to each pen. An upright wooden post was placed in the front and rear of each pen with several upward angled holes drilled in each from an upward angle so that fresh-cut pine branches could be inserted for periodic feeding material or for treated branches during repellent trials. On trial days, food was withheld and two pine branches were placed on each of the front and rear posts. One post was randomly assigned branches with no treatment (control); the other post received branches that had been treated with a test repellent. The materials tested, with percent active ingredient, were: bobcat urine (diluted 1:2, urine:tapwater); encapsulated predator odor (EPO), (10 mg mixture of semiochemicals 3-Propyl-1, 2-dithiolane and 2-Propylthietane encapsulated in a clay matrix within a 7 cm plastic tube open at both ends); Deer-Away® (powder, 36% putrid egg solids); Hot Sauce® (liquid, diluted to 0.25% capsaicin); spearmint (liquid, 17% spearmint oil); Repel® (granular, 20% paradichlorobenzene); Chacon Liquid Animal Repellent® (liquid, 21% thiram); Sudbury Chaperone® (liquid, 7% thiram); Ro-pel® (liquid, 0.065% denatonium saccharide); Tree Guard® (liquid, 0.2% denatonium benzoate); and Plant Pro-Tec® (clip-on capsule, 10% garlic oil). Materials in a liquid formulation were sprayed on the branches; powdered materials were sprinkled on branches that had been misted with tap water; and capsules were simply clipped or wired to branches. Branches were placed in pens immediately after treatment. Porcupines were left undisturbed for 24 hours, after which the branches were examined for one of the following damage levels: no damage, slight damage (a few small bites taken from needles or bark, or pulled from the post but not fed upon), or heavy damage (most bark and needles removed with branches usually gnawed into numerous small pieces). All materials were removed and the animals returned to normal maintenance for at least two days before another trial was begun.

RESULTS AND DISCUSSION

Damage Surveys

Twenty-two percent (50 of 225) of the ponderosa pine trees examined had been damaged by porcupines (Table 1). Damage within the 10 plots ranged from 9.4 to 40.0% of the trees. The average dbh of damaged trees (20.9 cm, S.D.=8.7, range=7.6 to 45.7) was greater than that of undamaged trees (18.5 cm, S.D.=8.1, range=6.4 to 45.7). The difference, however, was only moderately significant ($P=0.065$). Several researchers have reported that damaged trees tended to be the largest trees in the stand (Table 1). While the damaged trees in the authors' survey were larger than average, damage occurred in trees of a wide array of size classes. The largest trees (>36 cm dbh) were rarely damaged; only 1 of 50 damaged trees was >36 cm dbh. The height of damaged trees averaged 9.9 m (S.D.=3.1 m), ranging from 4.6 to 16.8 m. Most damage was in the mid- to upper boles of trees at an average height of 4.7 m (S.D.=2.6 m, range=1.2 to 12.2 m). The type and amount of damage found was similar to that reported in other studies (Table 1). Most damaged trees (88%) had their boles completely girdled versus having only patches of bark removed. In contrast, Sullivan et al. (1986) reported that only 31% of all damaged trees, but 56% of damaged trees over 27 cm dbh, were girdled. The authors also found that almost half (42%) of the damaged trees were damaged in more than one spot on the bole. There was no correlation ($r^2=0.012$) between tree density (range=215 to 924 trees/ha) and percentage of damaged trees. Tenneson and Oring (1985) also found no relation between amounts of damage and tree density, although it has been speculated that more damage occurs in stands with lower tree density (Dodge and Borrecco 1992). All of the pole-sized damaged trees were alive (0% mortality), having had a lateral branch invariably assuming dominance in the case of larger trees. Roze (1989) reported low tree mortality rates in New England because few porcupine damaged trees (4%) were girdled at the base. The authors found no trees on their plots that had been girdled at the base. Typically, basal feeding becomes rare as the bark thickens and nutrients are concentrated farther up the bole (Dodge and Borrecco 1992; Sullivan et al. 1986). Concern has been expressed, however, that even with damage only occurring in the upper bole and not causing tree mortality, the quantity and quality of merchantable wood can be reduced and the likelihood of disease or insect infestation increased (Dodge and Borrecco 1992; Evans 1987; Hooven 1971; Schemnitz 1994).

Relatively few seedlings (about 20/ha) were observed in the understory of the Smoot Hill pine stand. A combination of reasons could account for low levels of natural regeneration: drought, vegetative competition, feeding by a variety of animal species, and antler rubbing by deer (*Odocoileus virginianus*). The authors suspect that porcupines could be responsible for a substantial portion of seedling mortality even though no quantification of seedling damage levels could be found in the published literature. Evans (1987) noted that substantial damage to three-year-old poderosa pine plantations can occur and Hooven (1971) reported that few seedlings or saplings survive once attacked by porcupines. Tenneson and Oring (1985) noted poor regeneration of white pine (*Pinus strobus*) in Minnesota, but did not attribute it to porcupines. The anthors noted fresh porcupine damage on 6% (10 of 175) of ponderosa pine seedlings surviving four years after planting on a CRP site in Whitman County. Only 56% of the original 312 seedlings were still alive at that site after four years, but the authors could not determine the portion of overall seedling mortality that was attributable to porcupine feeding because many of the seedlings were missing or had been dead too long to ascertain the cause of death. Nonetheless, the data suggest that porcupines can be an impediment to seedling establishment, especially because porcupine damage is usually chronic in an area (Evans 1987). Sanders (1988) reported that voles (*Microtus* spp.) were the most serious threat to woody vegetation establishment on CRP lands in southeastern Washington.

Repellent Pen Trials

Many (8 of 11) of the materials tested gave promising results in the preliminary pen trials (Table 2). A variety of predator-associated odors (based on urines, semiochemicals, or other sulfur-based, animal-generated

Table 1. Percentage and size class (dbh in cm) of conifer trees damaged by porcupines reported in this and other studies in North America.

Location	Stand Type	Percent Damaged; Size Class	Reference
Washington	ponderosa pine (*Pinus ponderosa*) mature stand	22%, 12 to 30 cm mid- to upper boles	This study
Wisconsin	eastern hemlock (*Tsuga canadensis*) pole-sized stand	30%; 25 to 36 cm	Krefting et al. 1962
Minnesota	scotch pine (*Pinus sylvestris*) small pole-sized	12%; 10 cm largest trees	Rudolf 1949
Minnesota	white pine (*Pinus strobus*) mature stand	42-66%; 30 to 52 cm largest trees	Tenneson and Oring 1985
South Dakota	ponderosa pine pole-sized stand	10%; 15 to 20 cm largest trees, upper boles	Van Deusen and Myers 1962
Idaho	ponderosa pine poles-sized stand	15%; 20 to 25 cm largest trees	Curtis and Wilson 1953
Alberta	Douglas fir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexilis*) pole-sized stand	22-37%; 17 to 26 cm largest trees, upper boles	Harder 1979
British Colombia	western hemlock (*Tsuga heterophylla*) large pole-sized	53%; 28 to 32 cm largest trees, mid- and upper boles	Sullivan et al. 1986

Table 2. Percentage of treated and untreated pine branches heavily damaged by porcupines 24 hours after branch placement in outdoor pens, southeastern Washington, 1997.

	Percent Branches Heavily Damaged	
Treatment	Treated (n=6)	Untreated (n=6)
Bobcat urine	0	100
Semiochemicals (see methods section)	0	33
Putrid egg solids (36%)	0	100
Capsaicin (0.25%)	0	100
Spearmint oil (17%)	0	100
Paradicholorobenzene (20%)	0	100
Thiram (21%)	0	67
Denatonium benzoate (0.2%)	17	67
Denatonium saccharide (0.065%)	67	67
Thiram (7%)	100	100
Garlic oil (10%)	100	100

materials) appeared promising. It may be significant that only 33% of the control (untreated) pine branches in the semiochemicals trial were heavily damaged (Table 2); perhaps the strong predator odor hindered overall feeding by porcupines. Only garlic tabs, 7% thiram, and 0.065% denatonium saccharide did not deter branch feeding for the 24 hour test period. Although no repellents are currently registered to deter porcupine damage, Schemnitz (1994) noted that thiram and wood preservatives may provide some protection. The authors note, however, that some wood preservatives have potential adverse effects to people, animals, or the environment. It is also important to avoid materials that contain salt or certain resins because these may stimulate feeding by porcupines which have a strong attraction to salt (Roze 1989; Schemnitz 1994).

FUTURE DIRECTIONS

The authors believe that the promising preliminary results warrant field trials with several of the materials. These would provide data on the efficacy and duration of repellency under the natural conditions that porcupines experience during winter, the period of most conifer feeding (Dodge and Borrecco 1992; Roze 1989). Weather conditions, snow depth, and forage alternatives—or the lack thereof—could greatly influence results. Conversely, additional pen trials could be conducted to stabilize formulations to increase the period of effectiveness before field trials. Perhaps a band of an appropriate repellent applied around the bole of the tree a few feet above the ground would deter climbing by porcupines. The cost of large-scale repellent application needs to be evaluated; presumably, only vulnerable tree species and size classes would be treated.

Physical barriers of various types could also be tried to restrict tree climbing by procupines. Metal flashing and wire mesh have been suggested by Schemnitz (1994), but the authors have found no published documentation of efficacy or cost-effectiveness. It is possible that expandable bands of barrier material such as bird-repelling "porcupine wires" used on building ledges may deter tree climbing by porcupines while not hindering tree growth. These approaches, however, may prove too costly or labor intensive.

Silvicultural methods might, in theory, be altered to reduce conifer damage by porcupines (Schemnitz 1994; Sullivan et al. 1986). In many cases, however, current silvicultural practices encourage higher densities of porcupines and more damage to conifers (Dodge and Borrecco 1992). Nonetheless, the influence of tree species selection for planting, thinning densities and species selection, tree harvest method, size of harvest area, brush and potential den site removal, tree pruning, stand juxtaposition with adjacent habitats, and other silvicultural practices should be investigated (Dodge and Borrecco 1992).

The authors are involved in porcupine nutrition trials with captive animals at WSU. These trials, being conducted by Dr. Lisa Shipley and graduate student Laura Felicetti, will help better understand not only the nutritional requirements and food passage rates of porcupines, but also their sensitivity to secondary plant compounds such as tannins and terpenes. This knowledge may assist foresters in selecting tree species or genetic varieties that are less susceptible to damage by porcupines (Linhart et al. 1989).

This and other studies have documented substantial cumulative damage to conifers by porcupines in various locations of North America. Attempts to establish conifer stands in the interior Pacific Northwest will continue to be problematic and risky unless effective and affordable solutions to porcupine damage can be developed.

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