Efficacy of Wolfin to Repel Black-Tailed Deer

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ABSTRACT: *Deer and elk provide many desirable recreational opportunities but also can cause severe conflicts with humans. Excluding them from agricultural resources or from roadways is desirable, but fencing is expensive. A chemical barrier would offer a feasible alternative to reduce damage caused by deer. A series of three tests was conducted to assess whether black-tailed deer avoided areas treated with Wolfin, a synthetic predator odor. Wolfin failed to repel deer during any of these trials. We conclude that Wolfin, as applied within this study, is unlikely to reduce problems caused by free-ranging deer. West. J. Appl. For. 16(4):182–186.*

Key Words: Black-tailed deer, chemical fence, *Odocoileus hemionus columbianus*, predator odor, repellents, Wolfin.

Deer (*Odocoileus* spp.) and other ungulates occur in much of the United States and provide many desirable recreational and aesthetic opportunities. Unfortunately, the activity of ungulates also can conflict with humans, particularly where population densities are high. Deer damage a variety of grain crops, forage crops, vegetables, fruit trees, nursery trees, and ornamentals (Craven and Hygnstrom 1994). Beyond the immediate damage from browsing, deer often cause residual crop damage (i.e., future yield reductions or growth deformities). Expanding ungulate populations are also widespread impediments to reforestation efforts in the Pacific Northwest (Rochelle 1992). Ungulate browsing suppresses growth and delays regeneration, and it can increase mortality among seedlings that are repeatedly browsed or uprooted (Crouch 1976, Evans 1987, Tilghman 1989).

Besides crop damage, ungulates can present significant hazards to motorists. Conover et al. (1995) estimated 726,000 vehicle and deer collisions occur annually at a cost of $1.1 billion and more than 200 human fatalities. Collisions are highest when roads cross travel corridors, and roadside landscaping may represent high quality forage. Plowed roads are attractive in winter because they allow easy movement and because road salt is strongly attractive. Although there are concerns for any animal struck by a vehicle, injuries may become ecologically important when threatened or endangered species are involved. Highway incidents in Alberta account for up to 11% of the annual mortality for the endangered woodland caribou (Brown and Ross 1994).

Ungulate-proof fence is the most effective measure to exclude animals from resources or from roadways (Nolte 1998). Fencing, however, can be cost-prohibitive to install ($13 to 100/km) and to maintain ($100 to 1000/km/yr)(Reed et al. 1982, Romin and Bissonette 1996). Other less successful techniques include reflectors, sonic repellents, warning signs and lights, vegetation clearances, and wildlife underpasses (Schafer and Penland 1985, Conover et al. 1995).

Repellents may offer a feasible approach to alleviate ungulate damage. Several products can provide some protection when applied directly to plants and where alternative forage is available (Andelt et al. 1991, 1992, Milunas et al. 1994, Nolte et al. 1995, 1998). However, an area repellent or a chemical "fence" would be more practical to protect large areas (e.g., reforestation sites) and to restrict ungulate presence along roadways. An effective area repellent must encourage ungulates to avoid or not linger in targeted areas. Several ungulate species, including *Capreolus* and *Cervus* (Abbott et al. 1990) and several species of *Odocoileus* (Muller-Schwarze 1972, Melchoirs and Leslie 1985, Sullivan et al. 1985, Swihart et al. 1991), avoid areas treated with predator odors. However,

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it is impractical to cover large areas with natural predator odor sources (e.g., urine, feces). A synthetic source of predator odors is desirable for operational applications. Pocket gophers (*Thomomys mazama*) have been shown to reduce activity in areas treated with synthetic semiochemicals of stoat (*Mustela erminea*, Sullivan et al. 1990).

Wolfin, a synthetic wolf urine, is commercially available (Pro Cell Biotenik, Hornefors, Sweden) for use as a chemical barrier to repel ungulates. The active ingredient of Wolfin is a di-(N-alkyl) sulfide with an oral LD_{50} of 5930 mg/kg for rats. Wolfin is enclosed within plastic capsules so that odors slowly permeate the capsules' wall. The manufacturer recommends attaching Wolfin to stakes, fenceposts, or trees about 1.5 m above ground, and spaced at 10 m intervals around the area to be protected. Unpublished promotional literature from the manufacturer states that Wolfin placed along highways in Sweden reduced ungulate crossings. However, the published literature is more ambivalent. In one study, wildlife and vehicle encounters were reduced by 25 to 30% along roadways with a Wolfin "fence" (Johansson 1994). In another, the Wolfin fence did not reduce road crossings by ungulates in Sweden and Alberta (Peers 1993, K. Smith, Alberta Natural Resources Service, pers. comm.).

This lack of clearcut results in impartial studies highlights the importance of efficacy testing of new repellents that appear on the market with almost no scrutiny of manufacturer claims by regulatory agencies. For this reason we conducted the present test of Wolfin with captive black-tailed deer under conditions that permitted unambiguous evaluation of the product claims for area repellency.

Materials and Methods

A series of three tests were conducted to assess whether black-tailed deer avoid areas treated with Wolfin. First, we monitored whether deer would move through 3 m corridors with Wolfin placed at the entrances. We then assessed the ability of Wolfin "fences" to restrict deer movements within pastures. In the third test, we examined whether Wolfin reduced deer browsing when placed close to tree seedlings.

A resident herd of black-tailed deer at the Olympia Field Station of the National Wildlife Research Center was used in the study. Deer were randomly assigned to six enclosures (4 to 5 animals/enclosure). Enclosures varied in size from 0.75 to 2 ha and contained natural habitat of Douglas-fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), and associated understory vegetation. Although natural forage was readily available, animals also were provided free access to deer pellets and water throughout the study. Prior to the study, deer were provided apple slices on a daily basis. Apples are a preferred food, and segments secured to the top of a 1 m stake were readily taken.

Wolfin capsules were purchased from Pro Cell Biotenik, Hornefors, Sweden. The product was attached to posts or stakes at 1.5 m above ground as suggested by the manufacturer.

Experiment One

Corridors (17 m) were created by constructing an interior fence 3 m from and parallel to an exterior fence within each enclosure. Ends of the corridors were not closed, and deer readily moved through these corridors as they walked along the exterior fence. Animal activity was observed throughout the study. Deer response to Wolfin capsules, however, was indirectly measured by the disappearance of 10 apple segments (1/4 apple) placed within the corridors. These segments were secured to 10 stakes (skewered on a small nail driven into the top of the stake) placed in the corridor. The two rows of stakes were 1 m apart, and the five stakes within a row also were placed at 1 m intervals. Thus, rows were 1 m from either side of the corridor, and the stakes at the end of each row were 6.5 m from an entrance to the corridor.

A single-choice test was used to assess efficacy of Wolfin in restricting deer movement through a corridor. First, deer were given a 4 day adaptation period to become accustomed to eating apples placed on the stakes in the corridors. A 4 day pretreatment period then was used to establish a baseline of deer activity (apple disappearance) within the corridors. On each pretreatment day, apple segments were placed on stakes within the corridors at 0900 hr. The number of apple segments present after 24 hr was recorded. Any apple segments remaining after 24 hr were removed, and an additional 10 new segments were set out. A 4 day treatment period immediately followed the pretreatment period. The treatment period was identical to the pretreatment period, except that Wolfin capsules were attached to the two fence poles on either side of both entrances to the corridor.

A two-factor repeated measures analysis of variance (ANOVA) was used to assess differences in deer activity between periods. There were two periods (pretreatment, treatment), and the repeated measures were days (four levels).

Results

Deer activity within the corridors did not vary between periods ($P > 0.35$), nor did activity levels within the corridors vary among trial days ($P = 0.15$) (Figure 1). There was not a period by day interaction ($P > 0.35$).

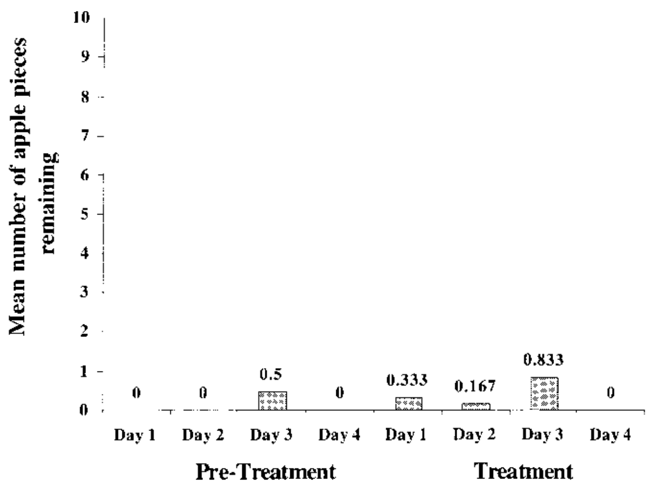

Figure 1. Mean number of apple pieces remaining after deer were presented 10 apple pieces daily during a 4 day pretreatment period and during a 4 day treatment period when the corridor was protected by Wolfin. Differences were not significant.

Experiment Two

The design of the Wolfin fence test was similar to that of experiment 1. Stakes (two rows of five at 1 m intervals) for apple segments (1/4 apple) were placed along an exterior fence within each enclosure on the side opposite from where deer were routinely given free access to feed and water. Wolfin fences were established 50 m distance from the apple stakes by attaching Wolfin capsules to metal fence poles (1.5 m height) placed at 5 m intervals across an enclosure. The primary difference between experiments 1 and 2 was the distance of apple cubes from the stimulus. Apple slices were not readily available to deer at the fence line; therefore, there was no immediate enticement for deer to cross the barrier. The intent was to repeat this test with increasing distances, at 5 m increments, between fence poles to determine the minimum distance necessary to create an impenetrable barrier for deer.

A single-choice test was used to assess the efficacy of Wolfin to inhibit deer from crossing the fence. The test was conducted as described for the corridor test, except the pretreatment and treatment periods were 2 consecutive days rather than 4 days.

A two-factor repeated measures ANOVA was used to assess differences in deer activity between periods. The repeated measures were days (2), and the periods were pretreatment and treatment.

Results

The number of apple slices remaining after 24 hr was similar across periods ($P = 0.26$) and days ($P = 0.26$), and there was no period by day interaction ($P = 0.26$)(Figure 2). The trial was conducted only at the 5 m spacing of fence post, because if the shorter distance did not impede deer crossings then there was no reason to expect that posts placed at greater intervals would impede deer movements.

Experiment Three

The third test assessed the efficacy of Wolfin in reducing deer browsing of western red cedar (*Thuja plicata*) seedlings relative to Big Game Repellent-Powder (BGR-P). BGR-P was included as a positive control for comparative purposes. The efficacy of BGR-P as an ungulate repellent to prevent browsing has been previously demonstrated (Conover 1987, Andelt et al. 1991, Andelt et al. 1992, Nolte et al. 1995, Nolte 1998), and it is a product generally known by timber managers. Thus, the three treatments in the test were Wolfin, BGR-P and a control (untreated).

Seedlings were planted in test plots immediately prior to treatment. Test plots consisted of 12 seedlings (approximately 35 cm tall) planted in three rows of four seedlings. Rows and seedlings within a plot were spaced at 1 m intervals, and plots were placed at least 25 m apart. Repellents were randomly assigned to plots, and all seedlings within a plot were treated with the same repellent. Stakes (2) with Wolfin attached were placed between seedlings 1 and 2 and between seedlings 3 and 4 in the center row. Thus, seedlings within the Wolfin plots were either within 0.5 m (four seedlings) or approximately 1.25 m (eight seedlings) of a Wolfin capsule. For the BGR-P treatment, seedlings were lightly misted with water before being dusted with BGR-P. Control seedlings were not treated.

Seedlings were examined for browsing damage at 24 and 48 hr after treatment and then at 1 wk intervals for 2 wk, or until 50% of the Wolfin treated seedlings were completely defoliated. Damage to the terminal bud and the number of lateral bites were recorded for each seedling. Lateral bite counts were limited to a maximum of 25, because during prior studies, seedlings generally were completely defoliated after 25 bites. Seedlings pulled out of the ground were regarded as completely defoliated and thereafter recorded as having terminal damage and 25 lateral bites.

The evaluation criteria for comparative analysis were: (1) the number of lateral bites taken (300 possible/plot), and (2) the number of seedlings with terminal damage (12 possible). The number of bites taken is probably a better indicator of efficacy to repel deer, but over time a tree can outgrow vulnerability to deer browse if the terminal bud is not damaged. A two-factor repeated measures (ANOVA) was conducted separately for each criterion to assess differences in deer responses. The factor was treatment (three levels) and the repeated measure was days (four levels).

Results

The number of bites varied among treatments ($P < 0.0001$) and increased over time ($P < 0.0001$)(Figure 3). There also was an interaction between treatment and days ($P < 0.0001$). Terminal bud damage also varied among treatments ($P < 0.0001$) and increased with time ($P = 0.0001$), but there was not a treatment by day interaction ($P = 0.24$). Tukey tests conducted post hoc revealed that BGR-P treated seedlings received fewer bites, and fewer terminal buds were removed than seedlings in the Wolfin or control plots. Deer damage was similar for seedlings on Wolfin and control plots at all monitoring intervals.

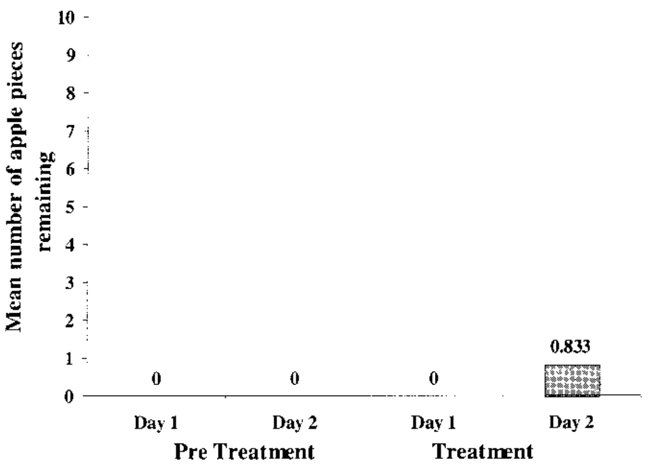

Figure 2. Mean number of apple pieces remaining after deer were presented 10 apple pieces daily during a 2 day pretreatment period and during a 2 day treatment period when apples were placed behind a "fence" created by hanging Wolfin capsules on post at 5 m intervals. Differences were not significant.

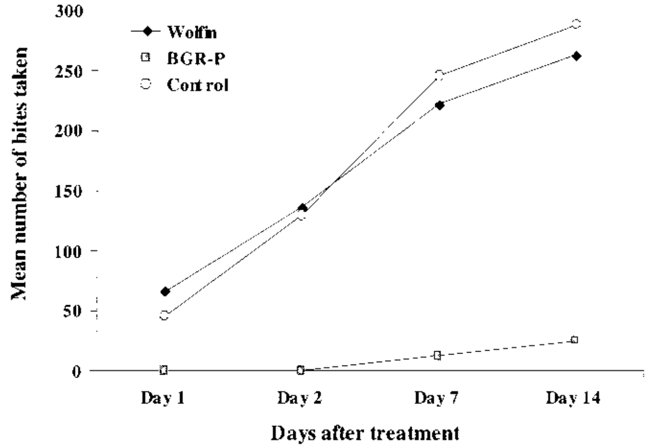

Figure 3. Mean number of bites (maximum possible was 300) taken by deer from 12 seedlings at 1, 2, 7, and 14 days after being treated with Wolfin or Big Game Repellent-Powder and control seedlings.

Discussion and Management Implications

Our study indicated that interspersed Wolfin capsules, a synthetic predator odor, did not reduce black-tailed deer browsing of western redcedar seedlings or restrict their movements through a targeted area. These results are fairly consistent with other experiments conducted in Sweden and Canada (Peers 1993, K. Smith, Alberta Natural Resources Service, pers. comm.). Brown and colleagues demonstrated no avoidance of Wolfin by caribou; rather they reported that caribou chewed on the Wolfin capsules. These results fall far short of the success reported for preliminary tests conducted by the company, where animals either returned to the forest or traveled parallel to the fence until it ended before crossing. Johansson (1994) also showed a significant reduction in vehicle accidents involving ungulates when the Wolfin fence was installed. Reasons for the differences in ungulate responses to Wolfin fences among these studies are unknown, but the response differences may reflect behavioral differences in the animals encountering the fence or the resource being protected by the fence.

First, black-tailed deer were the subjects within our study, and it is possible that they are less responsive to predator odors than other animals. Black-tailed deer, however, have demonstrated avoidance of areas contaminated with predator scats (Muller-Schwarze 1972). Other ungulate species also failed to avoid Wolfin in other reported tests (Peers 1993, Brown et al. in press). Because predator odor avoidance is mediated by chemicals that represent a generalized meat-eater cue (Abbott et al. 1990, Epple et al. 1993), or predator "Leitmorf" (Stoddart 1980), it is unlikely that one ungulate species would avoid the cue while another species would not avoid the cue.

Prey species usually avoid predator odors on initial contact (Nolte et al. 1994). Encounters with predators are not necessary before avoidance is practiced; however, negative experiences associated with a stimuli are necessary to reinforce and sustain avoidance (Nolte and Mason 1998). Deer in our study had never been confronted by wolves, though they had been attacked by domestic dogs and coyotes (*Canis latrans*) that crossed through the deer pen fences, and deer do become agitated when dogs are near.

Repellent efficacy also reflects the desirability of the resource to be protected (Nolte and Mason 1998). The test foods used in our study, apple and western redcedar seedlings, are both readily consumed by deer. Foraging pressure may have been less intense if less desirable food items had been used. However, the deer were not food-deprived, and the apple slices and tree seedlings contributed little more than variety to daily dietary intake. Since BGR-P virtually eliminated deer browsing of the seedlings, we infer that Wolfin does not appear to repel black-tailed deer, either from areas or from individually treated items.

Literature Cited

Abbott, D.H., D.A. Baines, C.G. Faulkes, D.C. Jennens, P.C.Y.K. Ping, and A.J. Tomlinson. 1990. A natural deer repellent: Chemistry and behavior. P. 599–609 *in* Chemical signals in vertebrates 5, Macdonald, D.W., et al. (eds.). Oxford University Press, Oxford, United Kingdom.

Andelt, W.F., K.P. Burnham, and J.A. Manning. 1991. Relative effectiveness of repellents for reducing mule deer damage. J. Wildl. Manage. 55:341–347.

Andelt, W.F., D.L. Baker, and K.P. Burnham. 1992. Relative preference of captive cow elk for repellent-treated diets. J. Wildl. Manage. 56:164–173.

Brown, W.K., W.K. Hall, L.R. Linton, R.E. Huenefeld, and L.A. Shipley. Repellency of three compounds to caribou. Wildl. Soc. Bull. (in press).

Brown, W.K., and I. Ross. 1994. Caribou-vehicle collisions: A review of methods to reduce caribou mortality on Highway 40 in west-central Alberta. Alberta Environ. Protect. and Alberta Transport. and Util., Edmonton. 69 p.

Conover, M.R. 1987. Comparison of two repellents for reducing deer damage to Japanese yews during winter. Wildl. Soc. Bull. 15:265–268.

Conover, M.R., W.C. Pitt, K.K. Kessler, T.J. DuBow, and W.A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. Wildl. Soc. Bull. 23:407–414.

Craven, S.R., and S.E. Hygnstrom. 1994. Deer. P. D25–D40 *in* Prevention and control of wildlife damage, Hygnstrom, S.E., et al. (eds.). Univ. of Nebraska Coop. Ext., Lincoln.

Crouch, G.L. 1976. Deer and reforestation in the Pacific Northwest. P. 298–301 *in* Proc. of the seventh vertebrate pest conf., Siebe, C.C. (ed.). Univ. of California, Davis.

Epple, G., J.R. Mason, D.L. Nolte, and D.L Campbell. 1993. Effects of predator odors on feeding in the mountain beaver (*Aplodontia rufa*), J. Mammal. 74:715–722.

Evans, J. 1987. Animal damage and its control in ponderosa pine forests. P. 109–114 *in* Symp. proc., Ponderosa pine: The species and its management, Baumgartner, D.M., and J.E. Lotan (eds.). Spokane, WA.

Johansson, L.O. 1994. Scent fences of synthetic wolf urine. Unpubl. rep. of Swedish Nat. Road Admin., Borlange, Sweden. 6 p.

Melchoirs, M.A., and C.A. Leslie. 1985. Effectiveness of predator fecal odors as black-tailed deer repellents. J. Wildl. Manage. 49:358–362.

Milunas, M.C., H.F. Rhoades, and J.R. Mason. 1994. Effectiveness of odor repellents for protecting ornamental shrubs from browsing by white-tailed deer. Crop Protect. 13:393–397.

Muller-Schwartze, D. 1972. Responses of young black-tailed deer to predator odors. J. Mammal. 53:393–394.

Nolte, D.L. 1999. Behavioral approaches for limiting depredation by wild ungulates. P.60–69 *in* Grazing behavior of livestock and wildlife, Launchbaugh, K.L., et al. (eds.). Idaho Forest, Wildl. and Range Exp. Sta. Moscow.

Nolte, D.L. 1998. Efficacy of selected repellents to deter deer browsing on conifer seedlings. Internat. Biodeter. Biodegrad. 42:101–107.

Nolte, D.L., J.P. Farley, and S. Holbrook. 1995. Effectiveness of BGR-P and garlic in inhibiting browsing of western redcedar by black-tailed deer. Tree Plant. Notes 46:4–6.

Nolte, D.L., and J.R. Mason. 1998. Bioassays for mammals and birds. P. 326–395 *in* Methods in chemical ecology, Haynes, K.F., and J.G. Millar (eds.). Chapman and Hall, Norwell, MA.

Peers, G. 1993. Wildlife conflict in Banff National Park, annual report. Warden Service, Banff National Park, Banff, Canada. 13p.

Reed, D.F., T.D.I. Beck, and T.N. Woodard. 1982. Methods of reducing deer-vehicle accidents: benefits-cost analysis. Wildl. Soc. Bull. 10:349–354.

Rochelle, J.A. 1992. Deer and elk. P. 333-349 *in* Silvicultural approaches to animal damage management in Pacific Northwest Forests, Black, H.C. (ed.). USDA For. Serv. PNW-GTR-287.

Romin, L.A., and J.A. Bissonette. 1996. Deer-vehicle collisions: status of state monitoring activities and mitigation efforts. Wildl. Soc. Bull. 24:276–283.

Schafer, J.A., and S.T. Penland. 1985. Effectiveness of Swareflex reflectors in reducing deer-vehicle accidents. J. Wildl. Manage. 49:774–776.

Stoddart, D.M. 1980. Some responses of a free living community of rodents to the odors of predators. P. 1–10 *in* Chemical signals: Vertebrates and aquatic invertebrates, Muller-Schwarze, D., and R.M. Silverstein (eds.). Plenum Press, New York.

Sullivan, T.P., D.R. Crump, H. Wieser, and A. Dixon. 1990. Responses of pocket gophers (*Thomomys talpoides*) to an operational application of synthetic semiochemicals of stoat (*Mustela erminea*). J. Chem. Ecol. 16:941–949.

Sullivan, T.P., L.O. Nordstrom, and D.S. Sullivan. 1985. Use of a predator odors as repellents to reduce feeding be herbivores: Black-tailed deer (*Odocoileus hemionus columbianus*). J. Chem. Ecol. 11:921–935.

Swihart, R.K., J.J. Pignatello, and M.J.I. Mattina. 1991. Aversive responses of white-tailed deer, *Odocoileus virginianus*, to predator urine. J. Chem. Ecol. 17:767–777.

Tilghman, N.G. 1989. Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. J. Wildl. Manage. 53:524–532.