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Comparative Analysis of Deer Repellents

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ABSTRACT

The deer repellent literature is fragmented and hard to interpret because there is no standard method to measure repellent effectiveness. Instead, studies differ in (1) which repellents were tested, (2) which plant or food was used as a carrier, (3) repellent concentration, (4) test duration, (5) experimental design, and (6) criteria for success. Despite these difficulties, we analyzed the literature seeking over-arching trends in repellent effectiveness. Deer-Away Big Game Repellent® (BGR) and predator odors were usually more effective than other repellents. In most field tests, the best repellents usually reduced deer damage by $<60\%$. There was no significant difference in the effectiveness of area repellents and contact repellents. Factors affecting repellent effectiveness include relative palatability of the plant to be protected, size of local deer populations, availability of alternative forage, weather, amount and concentration of repellent used, and test duration. White-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*) may respond differently to predator odors; with the exception of this, differences among deer and elk (*Cervus canadensis*) in their responses to various repellents were not statistically significant.

KEY WORDS

BGR, Cervus, deer, elk, herbivory, mule deer, Odocoileus, predator urine, repellents, white-tailed deer, wildlife damage management

INTRODUCTION

White-tailed deer and mule deer cause more damage to North American crops than any other wildlife species (Conover and Decker 1991, Conover 1994, Conover et al. 1995). These two species damage row crops (Decalasta and Schwendeman 1978, Lyon and Scanlon 1987); orchards (Harder 1968, 1970; Conover and Kania 1988; Austin and Urness 1989); landscaping plants, nurseries, and tree plantations (Conover 1984, 1987; Scott and Townsend 1985); pastures and alfalfa fields (Austin and Urness 1993); and reforestation areas (DeYoe and Schaap 1987, Brown and Doucet 1991, Conover et al. 1995). Numerous odor and taste repellents have been developed to reduce deer damage, and several studies have evaluated them. Unfortunately, no standard

method to test repellent effectiveness has been adopted. Hence, studies differ in subjects (free-ranging versus captive animals), the plant or food upon which the repellent is placed, duration, concentration, experimental design, statistical analysis, and criteria of success. Comparative studies are lacking. In this study, we examined the literature to answer broad questions, such as which repellents are most effective, whether mule deer and white-tailed deer respond similarly to repellents, and what variables influence repellent effectiveness.

METHODS

We searched the literature for articles related to the effectiveness of deer repellents and the conditions under which those repellents best performed. Because of variability in the material to which the repellent was applied, damage assessment, experiment duration, and subjects (captive versus free-ranging or single animals versus groups), one cannot directly compare numbers from different studies. However, for studies that evaluated >1 repellent, we believed that the relative rankings of the repellents were comparable. Hence, for those studies that directly compared ≥ 3 different repellents to each other, we ranked each repellent on a 0–4 scale, with 0 assigned to repellents which the authors considered ineffective and 4 to highly effective repellents.

We used an unpaired t-test to compare the effectiveness rating of area repellents to those of contact repellents. The Spearman Rank Correlation Coefficient was used to compare the response of different ungulate species to repellents.

RESULTS AND DISCUSSION

Relative Effectiveness of Different Repellents

Table 1 summarizes the relative effectiveness of selected repellents on a 0–4 scale. Repellents rated effective (i.e., mean score of ≥ 3 using data from all studies in which that repellent was evaluated) included BGR ($\bar{x}$ score = 3.0), bobcat (*Lynx rufus*) feces (3.5), chicken eggs (3.0), and coyote (*Canis latrans*) urine (3.0). Repellents rated intermediate in effectiveness (mean scores between 2.0 and 2.9) included blood meal ($\bar{x} = 2.0$), bobcat urine (2.5), coyote feces (2.5), feather meal (2.0), Hinder® (2.3), human hair (2.1), meat meal (2.0), soap (2.7), and thiram (2.0). Ineffective repellents (mean scores < 2.0) included Hot Sauce® (1.4), Magic Circle® (1.5), and Ro-Pel® (0.0).

Absolute Effectiveness of Different Repellents

In a number of field tests, BGR was found to be the most effective repellent, with an average of 50% reduction in browsing (Conover 1984, 1987, DeYoe and Schaap 1987, Conover and Kania 1988). However, several authors reported thaç this reduction was still unacceptably high. No other repellent has consistently reduced deer damage by $>50\%$ in field trials.

Table 1. Ranking of Different Repellents by Authors of Studies Which Compared >2 Repellents to Each Other

	Andelt et al. (1991)	Andelt et al. (1992)	Conover & Kania (1988)	Conover (1987)	Conover (1984)	Harris et al. (1983)	Melchoirs & Leslie (1985)	Palmer et al. (1983)	Scott & Townsend (1985)	Sullivan et al (1985)	Swihart & Conover (1990)	Swihart et al. (1991)
Field Test?	no	no	yes	yes	yes	no	no	no	no	no	yes	yes
Species	MD	Elk	WTD	WTD	WTD	WTD	MD	WTD	WTD	MD	WTD & MD	WTD
Plant	deer pellet	alfalfa & apple twigs	apple trees	J. yews	J. yews	shelled corn	salal branches	dogwood	orchards	salal branches & Doug. fir	J. yews & apple	J. yews & eastern hemlock
BGR	3	3	3	3	3	3	3 (powder)	3				
Blood Meal			3			1						
Bobcat Odor												
Feces							3			4		
Urine										1		3
Chicken Eggs	3	3										
Coyote Odor												
Feces	2						1			4		2
Urine	3	3								4		
Feather Meal						3		1				
Hinder	2	2		3	3	3		1				
Hot Sauce		1–2			1	3		1	2	0 (salal)		
Human Hair			3		2	1			2–3			
Magic Circle					2	1			1–2			
Meat Meal						3		1				
Ro-Pel	0	0									0	
Soap	1								2–3		2	
Thiram	2	2			3	3		1	1			

WTD = white tailed deer, MD = mule deer
0 = ineffective, 1 = slightly effective, 2 = intermediate, 3 = effective, 4 = highly effective

Repellent Type

Repellents were classified by type according to how they normally were applied. Repellent types include area, contact, and systemic repellents.

Area Repellents

These repellents act mainly by odor. Examples of area repellents include human hair balls, Magic Circle (bone tar oil), soap bars, blood meal, feather meal, and meat meal. Typically, area repellents are poured onto cloth or bag and suspended above the ground at densities of up to 3,000/ha (Conover and Kania 1988). Thus, use of area repellents may be labor- intensive. No instances of phytotoxicity or toxicity have been reported.

Contact Repellents

These repellents are sprayed or dusted on the foliage to protect plants from deer browsing. Examples of contact repellents include BGR, Hot Sauce, thiram (tetramethylthiuram disulfide), Hinder (ammonium soaps of higher fatty acids), and Ro-Pel (0.065% benzyldiethyl [2,6 Xylyl carbamoyl] ammonium saccharide and 0.35% thymol and solvents). ZAC (zinc dimethyldithiocarbamate cyclohexylamine complex) and TMTD (tetramethylthiuram disulfide) also are contact repellents; and although they were effective, they have been banned by the U.S. Environmental Protection Agency. One of the biggest problems with contact repellents is that they only protect the foliage to which they are applied—not new growth that emerges after treatment (Allan et al.1984). Another problem is that these repellents may lose their effectiveness after rainfall. In addition, some of them, such as BGR and thiram, are expensive.

In theory, contact repellents should be more effective than area repellents because they can adversely affect deer through both taste and odor, while area repellents only work through olfaction. Yet the effectiveness score (Table 1) for area repellents ($\bar{x}$ = 2.4, n = 10) and contact repellents ($\bar{x}$ = 1.5, n = 6) were not significantly different (t = 0.88, P = 0.39).

Systemic Repellents

These repellents may hold the solution to the problem of repellents being washed away with rain. Systemic selenium, which is absorbed by the plant and transported to the foliage, can even be formulated in time-release pellets that can provide protection for new growth (Allan et al. 1984). Unfortunately, selenium has shown problems with phytotoxicity. In a study of quadrivalent selenium's effectiveness at protecting Douglas-fir seedlings (*Pseudotsuga menziesii*) from captive deer, Allan et al. (1984) found that a foliar level of 100 ppm was fatal to the seedlings. White pine (*Pinus monticola*), Ponderosa pine *(Pinus ponderosa)*, and Western red cedar (*Juniperus scopulorum*) showed symptoms of phytotoxicity at 5–10 ppm. Still, the same study showed that a foliar concentration of 1–2 ppm was sufficient for protection and far below the phytotoxic level. Engeman et al. (1995) found no systemic efficacy for selenium, but reported some repellency from topical applications of sodium selenite. This was applied along

with two bacterial formulations (*Corynebacterium* spp. and *Pseudomonas flrorecens)* under the hypothesis that metabolic decomposition of sodium selenite by the bacteria would produce dimethyl selenite, which would repel deer.

Factors Influencing Repellent Effectiveness

Availability of Alternative Forage

We hypothesize that repellent effectiveness will depend upon the availability of alternate forage. There is some support for this hypothesis. For instance, Conover (1987) and Conover and Kania (1988) have found that repellent effectiveness declined during the winter despite repellent reapplication. Presumably forage availability declined during the winter due to forage depletion from deer browsing. Andelt et al. (1991) tested chicken eggs, BGR, and coyote urine on captive mule deer fed commercial deer pellets; these repellents were effective when alternate foods were available but not when presented to hungry deer that lacked alternative forage. Food deprivation also was a determining factor in repellent effectiveness with captive elk. In this study, even 100% coyote urine and 6.2% Hot Sauce (which is 100 times the labeled concentration for deer) did not completely suppress browsing by hungry elk (Andelt et al. 1992).

Relative Palatability

In theory, repellents work by reducing the palatability of the treated plant to a level lower than other available forage. Consequently, repellents should be more effective on unpalatable plant species than on those which are highly palatable. Support for this hypothesis comes from several studies that evaluated the same repellent on more than one plant species. ZAC and TMTD were more effective at protecting aspen (*Populus tremuloides*) than chokecherry (*Prunus virginiana*), which the authors reported was one of the most palatable shrubs (Dietz and Tigner 1968). Angradi and Tzilkowski (1987) found that sodium selenite was more effective in protecting white ash (*Fraxinus americana*) seedlings than the more palatable seedlings of black cherry (*Prunus serotina*). Swihart et al (1991) found that bobcat and coyote urine were more effective when used on eastern hemlock (*Tsuga canadensis*) than on the more palatable Japanese yews (*Taxis cuspidata*). Conover and Kania (1988) found human hair to be effective in protecting young apple trees during the winter but not during the summer. They believed that browsing increased in the summer because then deer are foraging on apple leaves and fruit which are more palatable than apple stems which are the target of their winter browsing.

Species of Deer

We are unaware of any studies that have directly compared repellent effectiveness among ungulate species. But, Andelt et al. (1991) and (1992) used a similar experimental design to test mule deer and elk, respectively. They found little difference in how these two species responded to the repellents (Table 1).

When we compared each repellent's mean score (on a 0–4 scale) for all tests involving white-tailed deer to those involving mule deer, we found that Spearman Rank Correlation Coefficient (r_s) equaled 0.34. This value is not considered to be statistically significant. The variation appeared to result from interspecific differences in how these deer responded to bobcat and coyote urine. In general, coyote urine was more effective against mule deer, whereas bobcat urine was more effective against white-tailed deer (Table 1). If predator odors are removed from the data set, then $r_s = 0.83$: a value that is statistically significant.

Weather

Rain can drastically reduce the effectiveness of many repellents. Sullivan et al. (1985) found that BGR or the feces of coyotes, cougars (*Felis concolor*), and wolves (*Canis lupus*) completely suppressed feeding by captive mule deer on salal (*Gaultheria shallon*) branches, Douglas-fir seedlings, and western red-cedar (*Thuja plicata*) for 20 days. However, after just 1 day of heavy rain, the repellents were no longer effective. Andelt et al. (1991) reported that chicken eggs, BGR and coyote urine were effective in reducing browsing of apple twigs by captive mule deer, but when the twigs were sprinkled with water to simulate rainfall, the repellency of those compounds decreased.

Repellent Concentration

Bullard et al. (1978) showed that the repellency of synthetic fermented egg could be increased considerably by increasing its concentration. In a study evaluating the effectiveness of predator fecal odor on mule deer, Melchoirs and Leslie (1985) found that repellency of fecal extracts from five predators was correlated with concentration. Repellent concentration also was a determining factor in decreasing browsing damage for captive elk (Andelt et al. 1992).

Size of Treated Area

One hypothesis is that in field trials, repellent effectiveness will decrease as the size of treated plots increases because the deer must expend more time and energy traveling to untreated forage as plot size increases. Support for this hypothesis comes from the finding that BGR, Hinder, and thiram were effective at protecting small plots of Japanese yews from browsing by free-ranging white-tailed deer—but not large plots (Conover 1984).

Test Duration

Many authors have noted that repellent effectiveness declined over time. Hence, repellents may have to be reapplied repeatedly each year to retain their effectiveness (DeYoe and Schapp 1987). Reapplying repellents, however, is not always successful in lowering browsing rates. Conover and Kania (1988) found that even a mid-winter reapplication of BGR was not sufficient to stop deer browsing on young apple trees.

MANAGEMENT IMPLICATIONS

Although some repellents, such as BGR, consistently reduced browsing, none eliminated it entirely. Growers, therefore, should expect some browsing damage with any repellent. If the level of protection provided by repellents is unacceptable, growers might consider using other control methods such as deer fences and selective hunting of problem deer. Predator odors showed promise as repellents, but more field tests are needed, and they are not yet registered by the EPA for use as repellents. We found that repellent effectiveness was influenced by repellent concentration, test duration, field size, plant palatability, availability of alternate forage, season of use, and weather. Repellents also differed considerably in terms of expense, both in initial price and labor-intensiveness; when choosing repellents, cost-effectiveness should also be considered.

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