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THE EFFECTIVENESS OF SOAP IN PREVENTING DEER BROWSING

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Abstract: A series of bioassays was performed to evaluate the effectiveness of soap and soap components as deer (Odocoi virginianus) repellents. Sweet-corn plots protected with tallow-based soap bars, nontallow bars, and those sprayed with commercial repellent Hinder', experienced significantly reduced browsing compared with untreated plots. Damage top protected with tallow-based soap was less than damage to nontallow soap plots, while Hinder'-treated plots had intermediate damage. In a second bioassay, 2 spray applications of soap were found to be as effective as soap bars in preventing browsin native vegetation over a 126-day period. The addition of perfume did not enhance the repellent effect of the soap sprays. Finally a range of individual soap components were evaluated on apple prunings for their repellent properties. All components pro ' at least limited repellent effects, and plots protected with tallow fatty-acid soap bars, commercial soap bars, and soap perfume significantly less damage than untreated plots. Tallow fatty-acid soap reduced damage significantly more than coconut fattysoap, and tallow appeared to be a major component responsible for soap's repellent properties. Soap-bar applications to newly planted apple trees were estimated to cost $94/ha (2.74 acre), and were less expensive than typical commercial repellent pro during the first growing season. However, growers should consider alternative repellents after that time, as soap's cod effectiveness decreased due to the small sphere-of-influence of individual bars, and the increased labor costs associated with applying multiple bars to individual trees. Growers using soaps should practice aggressive vole management, as field observation suggest soap-treated trees are more susceptible to vole damage.

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Deer browsing is a substantial problem of increasing concern to many New York apple growers (Purdy et al.1987). Deer may significantly reduce crop yields of bearing trees (Katsma and Rusch 1979), but damage is believed to be most detrimental to newly-established orchards (Matschke et al. 1984). Deer may alter tree growth rates, interfere with scaffoldbranch training programs, delay central leader development, or kill trees outright (Harder 1968).

Commercial apple growers rely on population control, physical barriers, and repellents to prevent deer damage (McAninch et al. 1983, Scott and Townsend 1985, Purdy et al. 1989). In New York, growers hang motel-size soap bars (21.3 g) on apple trees to repel deer, and this is reported to be the most common mitigation technique used to protect young trees (Purdy et a1.1989). For example, Phillips et al. (1987) reported that 13% of the total apple acreage in New York's Hudson Valley was treated with soap bars, at an annual cost of $61,400. This cost amounted to 80% of the growers' expenditures on deer control. In spite of the widespread use of soaps, little research has been directed at testing its effectiveness as a repellent, or at identifying soap's repellent component(s). We examined these questions using 3 bioassay techniques during 1989-1991. In the first bioassay, we compared the effectiveness of 2 types of soap bars with that of a commercially available repellent. In the second bioassay, we evaluated the effectiveness of soap sprays in preventing browsing, and investigated whether perfume enhanced soap's repellent effect. In our third bioassay, we examined the repellent properties of individual soap components.

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METHODS

Studies were conducted in Ulster and Dutchess counties in southeastern New York during 1989-1991. The standing corn bioassay took place in a 0.5-ha field of unharvested sweet corn at the Cornell University test plot in New Paltz. The sumac bioassay was conducted on the IES Cary Arboretum in Millbrook. Plots were located in abandoned fields that had been mowed previously to promote regrowth of smooth sumac *(Rhus* glabra), a preferred deer browse. The apple prunings bioassay was conducted in 2 commercial apple orchards in Ulster Co.

Statistical analyses were conducted with the SAS statistical package (S AS Institute 1985) using the GLM and NPAR 1 WAY procedures. Proportional data gathered from the standing corn and sumac bioassays were converted using an arc-sine transformation prior to analysis, with percentages equal to zero converted to 1/(4n) (Steel and Torrie 1980). Counts of browsed

apple stems in Bioassay 3 were converted with the square-root transformation (transformed data = square-root [count data + 0.5]; Steel and Torrie 1980). Separation of means was accomplished in all experiments using Duncan's multiple range test. Further separation of treatment means was attempted in the standing corn bioassay using Duncan's multiple range test on the ranked untransformed data (RANK procedure, SAS Institute 1988).

Standing Corn Bioassay

Twenty-eight 2 x 3-m plots were established within the corn field with plots located >10 m apart to avoid interactions between adjacent treatments. Individual plots consisted of 20 plants, each supporting a single mature corn ear. The treatments evaluated were Ivory bars, Lava bars, and the commercial deer repellent Hinder' (Table 1). Soap bars were wired to corn stalks 10 cm above the point of ear attachment. Hinder' was applied to individual corn ears using a hand sprayer. Plots were assigned as controls or to one of the treatments using a completely randomized design. A 3-m strip of soil was cultivated around the corn field to aid in tracking wildlife activity to and from the planting.

Assessments of damage were conducted 3 times at 14-day intervals following the initial repellent application on 2 November 1989. During each assessment, corn ears damaged by deer were counted and removed, and we monitored the field for signs of wildlife activity. We eliminated data from corn ears damaged by other wildlife. Individual assessments were pooled to calculate the proportion of corn ears damaged per plot over the 42-day study period.

Sumac Bioassay

Ten sumac blocks of 1- to 2-year-old stems were located in separate fields. Four 4-m-diameter circular plots were located in each sumac block, with plots separated by >5 m to avoid interactions between treatments. Individual plots contained from 14-69 unbrowsed sumac stems.

We compared the repellent properties of Ivory bars, Ivory Snow soap solution, and,an Ivory Snow plus perfume solution (Table 1). Individual plots within each sumac block were assigned randomly as either a control or one of the 3 treatments. Soap bars were wired 20 cm from the top of the central stem in each barplot. Liquid applications were made to all stems within appropriate plots using a backpack sprayer. Initial treatment applications were made on 5 January 1990, with liquid treatments reapplied after 63 days to simulate a typical winter orchard repellent spray program.

Damage assessments were conducted 6 times at 21-day intervals. During each assessment, we countedrecently-browsed stems on all plots, and recorded the distance between recentlybrowsed stems and plot centers on Ivory bar and untreated plots. Browsed stems were clipped during each visit to facilitate identification of future damage. We pooled data from all assessments to calculate the proportion of stems browsed in each plot over the 126-day study period. Bar plots where soap bars disappeared were eliminated from our analyses.

Apple Prunings Bioassay

We compared the repellent properties of tallow-based fatty-acid soap, coconut oil-based fatty-acid soap, soap perfume concentrate, and Ivory soap bars (= tallow + coconut oil fattyacid bases) using an apple prunings bioassay in 1991. Fattyacid soap bases (Table 1) were neutralized to a pH of 8-9 over heatusing aconcentratedNaOH solution (RiesgrafandFessock, pers. commun.). The products of this saponification process were poured into trays and oven-dried for 24 hours at 80 C. This soap material was cut into pieces of similar volume, and placed in 3-cm x 3-cm x 8-cm cheese-cloth bags.

The perfume treatment (Table 1) was prepared by drilling a 0.64-cm hole in the plastic cap of a 1.9-cm x 7.6-cm glass specimen vial. We inserted a 0.95-cm x 3.8-cm dental cotton fiber pad through the cap until 0.5 cm of pad extended outside the vial. Each vial was filled with perfume concentrate, and inverted until the pad was saturated. Individual perfume vials were placed in cheese-cloth bags similar to those used for the soap treatments.

Ivory bartreatmentswerepreparedbyplacinganunwrapped bar in a cheese-cloth bag. We included empty cheese-cloth bags as a fifth treatment to determine whether deer were repelled by visual cues.

Individual treatments were wired to the central stem of bundles of 10 first-year water sprout prunings from McIntosh trees. Dormant prunings were collected and held in cold storage until used. Prunings were cut to 46-cm lengths and bundled together using plastic wire cable ties. Pruning bundles were placed in 15.2-cm x 20.3-cm plastic pots filled with soil, and held upright by driving a 30.5-cm spike vertically through each bundle. Pruning bundles were spaced at 5-m intervals in a 6 x 6 block, and were assigned to treatment or control groups using a latin-square design. Treated blocks of prunings were placed in 2 commercial apple orchards on 30 January 1991.

Data were collected weekly for a 7-week period. Counts of the number of stems browsed by deer were recorded during each period. We replaced missing soap bars with bars weathered in the field for equivalent periods. We dropped plots from our analysis if they had prunings browsed while a soap bar was missing. Counts of browsed stems were pooled over the study for data analysis.

RESULTS

Standing Corn Bioassay

Significant differences in damage existed between treatment and control plots, with all treatments averaging significantly fewer damaged corn ears than untreated plots (Table 2). Mean damage levels did not differ between treatments when the aresine transformed data were compared using Duncan's test. In contrast, the results of Duncan's test using ranked untransformed

Table 1. Materials tested during repellent bioassays in southeastern New York, 1989-91.

Bioassay	Treatment (rate)	Ingredients	Source
Standing corn	Hinder" (1:20 HZO ratio)	15% ammonium soaps of higher fatty acids	Leffingwell Corp.
	Lava bar (21.3 g)	coconut oil, pumice, perfume, glycerine	Proctor & Gambl
	Ivory bar (21.3 g)	tallow, coconut oil, perfume, preservative	Proctor & Gamble
Smooth sumac	Ivory bar (21.3 g)	tallow, coconut oil, perfume, preservative	Proctor & Gamble
	Ivory Snow 2% solution)	tallow, coconut oil, perfume, fabric whiteners	Proctor & Gamble
	Ivory Snow (2°!o solution) + perfume (2 ml/1)	tallow, coconut oil, perfume, + 2 mIJl Irish Spring perfume complex	Proctor & Gamble
Apple pruning	Tallow bar (10 g) in cheese-cloth bag	531 tallow fatty acid	Henkel Corp.
	Coconut bar (10 g) in cheese-cloth bag	662 coconut fatty acid	Henkel Corp.
	Ivory bar (21.3 g) in cheese-cloth bag	tallow, coconut oil, perfume, preservative	Proctor & Gamble
	Perfume (2.5 ml) vial in cheese-cloth bag	Irish Spring perfume	Colgate-Palmolive
	Cheese-cloth bag		

data revealed plots protected by tallow-based Ivory bars averaged significantly less damage than plots protected by nontallow Lava bars.

Sumac Bioassay

The average number of sumac stems browsed by deer differed significantly between untreated and treated plots, but differences in damage were not found between treatments (Table 3). Soap bars disappeared from 3 Ivory plots that subsequently were dropped from our analysis. The distance of browsed stems from control plot centers ranged from 5-199 cm (n =162). In contrast, the distances between browsed stems and soap bars ranged from 38-198 cm in Ivory bar plots (n = 47). The distance from browsed stems to plot centers was significantly greateron Ivory plots compared with control plots (t-test, P <0.002).

Apple Pruningrs Bioassay

Damage levels differed between treated and untreated plots, as damage averaged significantly less on perfume, Ivory bar, and tallow fatty-acid soap plots than on untreated plots (Table 4). In addition, damage was significantly less on tallow fatty-acid-bar plots compared with coconut fatty-acid-bar plots. Significant differences in damage also existed among blocks, rows, columns, and within blocks according to rows and columns (Table 5). Browsing occurred in one Ivory bar and one coconut fatty-acid soap-bar plot on which treatments were missing, and these plots were excluded from our analysis.

DISCUSSION

Commercial soap bars were effective at protecting a variety of frequently-browsed food items from deer damage, based on our results, may provide protection equal to commer cial repellent sprays. However, damage did take place on some soap-protected plots in each bioassay. Swihart and Conover (1990) reported commercial soap bars, including Ivory, significantly reduced deer browsing on apple trees compared with controls; however, one-third of all twigs in soap-protected plots were still damaged by deer. Byers et al. (1989) reported soaps protected apples and apple branches, but only for a few days under intense deer pressure. The failure of soaps to provide complete damage control in this and other studies is not unexpected, as repellents are believed to be most effective under light deer pressure (McAninch et a1.1983).

We reported Ivory soap bars containing tallow were more effective at repelling deer than nontallow Lava bars. Swihart and Conover (1990) found no differences in soap brand effectiveness, but their study included only brands with tallow bases. Apple growers might enhance damage control by selecting commercial soap brands based on their tallow component, as bars with a greater proportion of tallow may be more effective. Tallow fatty-acid bars in our apple prunings study had slightly, but not significantly, reduced damaged when compared with commercial tallow-plus-coconut-based Ivory bars.

We found that perfume alone was an effective repellent, but we were unable to show enhanced repellency of soap with perfume versus without perfume. However, the application method used in our sumac bioassay may have been inadequate to address this question, as the volatile compounds in perfume added to liquid soap were unlikely to be present over the 126

Table 2. The proportion of corn ears damaged by deer in treated and untreated plots in the standing corn bioassay, southeastern New York, 1989-91.

Treatment	n	X	Range	CV	Trans. Mean•b	z Rate°.a
Control	7	37.9	20-50	29.4	0.659 A	24.9 A
Lava bar	7	7.4	0-20	89.1	0.268 B	15.0 B
HinderR	7	2.9	0-5.3	93.6	0.211 B	11.3 B, C
Ivory	7	0.7	0-5	264.5	0.195 B	6.8 C

' Significant main-effect model, ANOVA, F = 56.9, P = 0.0001. b Mean arc-sine square root transformed percentages with the same letter are not significantly different. ` Significant main-effect model, Kruskal-Wallace test, chi-square = 19.89, P < 0.001. d Mean treatment rank percentages with the same letter are not significantly different.

Table 3. The proportion of stems damaged by deer in treated and untreated plots in the sumac bioassay, southeastern New York, X89-91

Treatment	n	Z'	Range	CV	Trans. z b
Control	10	53.7	16.2-92.9	57.4	0.835 A
Ivory bar	7	13.0	0.0-37.5	100.4	0.321 B
Ivory solution	10	7.4	0.0-47.4	194.7	0.189 B

` Significant main-effect model, F = 15.3, P = 0.001. b Mean arc-sine square root transformed percentages with the same letter are not significantly different.

day trial. Yet, as in our study, Byers et al. (1989) reported that cm from branch terminals that require absolute protection, such soap perfume repelled deer, but perfume added to soap failed to as the central leader of young fruit trees. increase its repellent efficacy.

In addition to providing an odor-based repellent, soap bars may also reduce deer browsing through visual cues. Swihart and Conover (1990) reported empty soap-bar wrappers alone reduced deer browsing, and in this study we found that empty cloth bags had repellent properties. However, in both studies, these visual cues seemed less effective than the soap's odor repellent properties.

Soap bars offer some advantages over commercial repellents as they provide long-lasting odor and visual cues which extends protection to tree parts beyond the immediate bar location. Swihart and Conover (1990) reported browsing on apple trees was significantly lower within 1 m of a soap bar compared with branches >2 m away from the bar. Although some protection may be provided out to 1 m, we found soaps failed to provide absolute protection to sumac branches located at or beyond 38 cm from the bar. Damage also took place to apple pruningslocated <38 cm from soap treatments in that bioassay. These data suggest bars may need to be less than 38

We found soap sprays were effective at controlling damage, and might provide more complete coverage of trees than that obtained with bars. Soap sprays could be used as an alternative to bar applications, as growers are equipped to manage their orchards using sprays. However, the use of soap sprays could have resulted in increased damage by other wildlife species. We observed several instances where wild canids or birds removed and/or fed upon soap bars. In addition, during 1989 we documented that meadow voles (Microtus pennsylvanicus) damaged the trunks of newly-planted apple trees that were protected from deer by soap bars. Vole damage was most frequent and extensive in the quadrant directly below the soap bar, and least frequent and extensive on the side of the tree opposite the bar (Fig. l). These observations suggest voles were attracted to the trees and will girdle them, due to the presence of a rain-runoff soap film, visible on many trees.

The popularity of soap-bar repellents among apple growers may result from the perception that soaps are less expensive controls than commercial repellent programs. Soap applica

Table 4. The number of stems damaged by deer in treated and untreated plots in the apple prunings bioassay, southeast York, 1989-91.

Treatment	n	x	Range	CV	Trans. X'[e]
Control	12	4.08	0-9	102.03	1.89 A
Coconut bar	11	3.55	0-10	101.98	1.78 A, B
Cloth bag	12	2.67	0-9	122.13	1.55 A, B, C
Perfume vial	12	1.92	0-7	128.68	1.37 B, C
Ivory bar	11	2.00	0-10	162.79	1.32 B, C
Tallow bar	12	0.92	0-4	135.28	1.10 C

[e] Mean-square-root-transformed stem counts with the same letter are not significantly different.

Table 5. Analysis of variance for the number of stems damaged by deer in the apple prunings bioassay, southeastern New Y 1989-91.

Source	Sum of Squares	df	*F*	*P* > *F*
Model	41.67	31	4.19	0.0001
Block	14.04	1	43.74	0.0001
Treatment	5.28	5	3.29	0.014
Row	4.58	5	2.85	0.027
Column	3.43	5	2.14	0.081
Row within block	5.55	5	3.46	0.011
Column within block	6.40	5	3.99	0.005
Treatment within block	1.15	-1	0.71	0.62
Error	12.19	38		

Table 6. Estimated per-acre repellent program costs to protect apple trees with soap bars or commercial repellents during 0-6 and 7-12 months after planting, in southeastern New York'

Time after Planting (months)		Material cost ($)[b]	Labor + fuel costs ($)[c]	Total applications[d]	Total cost ($)
0-6	Soap bar	14	24	1	38
	Commercial repellent	35	10	2-4	90-180
7-12	Soap bar	41	72	1	113
	Commercial repellent	35	10	2-3	90-135

[a] Based on planting 180 whips per acre. [b] Costs of $0.075 per 21.3-g soap bar at 1/tree on 0- to 6-month-old trees, and 3/tree on 7- to 12-month-old trees. Commercial repellent at $0.70/gallon of spray mixture and handgun application rates of 50 gallons/acre/application. Adapted from Castaldi 1987. [d] Number of commercial repellent applications based on currently recommended practices.

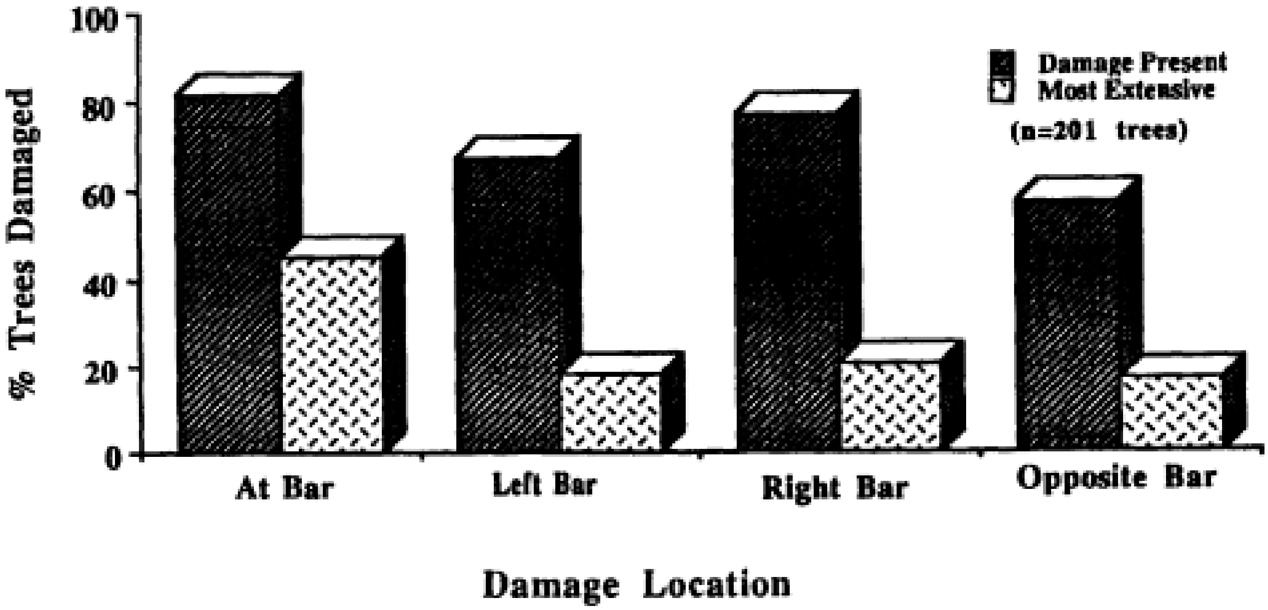

Fig. 1. The position of meadow vole girdling damage to young apple trees in relation to soap-bar placement, southeastern New York.

dons **are** less costly during the first growing season (Table 6). However, vigorous apple tree varieties like McIntosh may exceed heights and diameters of 1.6 m and 0.6 m, respectively, during this time (Fargione, unpubl. data). Up to 3 soap bars would be needed around each tree of that size to provide complete protection of all dormant buds. The increased labor requirements of such applications would result in control costs comparable to some spray programs using an inexpensive commercial repellent (Table 6). With increased tree growth, multi-bar soap applications would likely be more costly than spray programs during the second growing season.

MANAGEMENT IMPLICATIONS

Hanging soap bars on newly planted trees appears to be a cost-effective, deer damage mitigation technique for apple growers suffering light deer pressure. Growers using soaps should select tallow-based brands, and attach them so that bars are located < 38 cm from growing points in need of complete protection.

Growers should practice aggressive vole management to reduce the likelihood of soap-induced vole damage, and soap sprays should not be used until further information becomes available on the attractiveness of these sprays to voles. Growers using soap bars should switch to commercial repellent sprays as trees grow in volume in order to avoid costly multiple-bar applications.

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