RODENT REPELLENT VALUE OF ARASAN–ENDRIN MIXTURES APPLIED TO ACORNS

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Abstract: A mixture of Arasan 75 and Endrin 50W was tried in two concentrations on acorns of Shumard oak (*Quercus shumardii*) and swamp chestnut oak (*Q. michauxii*) to determine its effectiveness in protecting acorns from damage by gray squirrels (*Sciurus carolinensis*) and cotton rats (*Sigmodon hispidus*). Treated and untreated acorns were exposed to 12 gray squirrels and 12 cotton rats in a series of cage tests. The repellent was effective against both squirrels and cotton rats when untreated acorns were also available. It was quite effective against cotton rats, but not against squirrels, when only treated acorns were available. In periods of abundant alternate food supplies, a direct seeding of treated acorns should produce a good stand, but this may not be true under adverse food conditions.

Attempts to restock cutover hardwood land by direct seeding with acorns have often failed. Many biological factors may contribute to these failures, but rodents, which search out and dig up planted acorns, are probably most important (Klawitter 1959:157). Certain chemicals have shown promise for protecting tree seed from a variety of predators, including rodents. Mann (1957:12), D. G. Spencer (1959:1–2), H. J. Spencer (1959:63–64), and others determined that a mixture of Arasan 75 and Endrin 50W coated on pine seeds would repel both birds and rodents. Tests of the effectiveness of this mixture in protecting acorns from squirrels and cotton rats and its effects on seed germination were made near Charleston, South Carolina, at the Santee Experimental Forest of the Southeastern Forest Experiment Station in the fall of 1959. Tests of preferences of the squirrels and cotton rats for the acorns of Shumard and swamp chestnut oak were also made.

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METHODS

Twelve eastern gray squirrels and 12 cotton rats, all from the Santee Experimental Forest, were used in the tests. Other rodents, including the white-footed mouse (*Peromyscus* sp.), harvest mouse (*Reithrodontomys* sp.), and meadow mouse (*Microtus* sp.), important seed eaters, were

Table 1. Acorn species preference of 12 gray squirrels and 12 cotton rats.

Rodents	Oak Species	Acorns Damaged Daily			
		Weight		Numbers	
		Grams	Percent	Count	Percent
Squirrels	Shumard oak	78.2	58	16.7	72
	Swamp chestnut oak	57.8	42	6.5	28
	Difference	20.4*		10.2†	
Cotton rats	Shumard oak	29.7	42	5.7	58
	Swamp chestnut oak	40.3	58	4.1	42
	Difference	10.6		1.6	

* 5 percent level of significance.
† 1 percent level of significance.

present but were not captured in sufficient quantities for test purposes. The cotton rats were trapped in September, 1959, the squirrels in late October. They were fed pelleted dog food until initiation of the experiments.

The animals were kept in separate cages throughout the study. The squirrel cages were 24 × 24 × 36 inches, the rat cages 18 × 18 × 24 inches. They were constructed of ¼-inch-mesh hardware cloth. Each cage was equipped with three feeders and a water bottle. Squirrel cages contained Spanish moss for nesting material, cotton rat cages a small tin can each for a refuge site.

Average weight of the squirrels (five females, seven males) was 464 grams and of the cotton rats (nine females, three males) 117 grams. Each of the 24 animals was used in each set of tests.

RESULTS

Acorn Preference Test

Acorns were gathered locally from Shumard oaks and swamp chestnut oaks. The acorns were float-tested and hand-sorted to eliminate most of the unsound ones (Lotti 1959). In the tests, each animal was given 500 grams of acorns of each kind mixed together and placed on one hopper. The experiment was stopped when the animals had eaten or damaged a sizable proportion of their rations but still had some uninjured acorns of each species from which to choose. This required 66 hours for the squirrels and 148 hours for the cotton rats. At the end of the test periods, undamaged acorns were counted and weighed. In order to put final acorn weights on a fresh-weight basis, a percentage weight loss from drying was calculated by placing several 1-kilogram lots of acorns on top of the cages and weighing the lots after the test. The consumption rates shown in Table 1 include both completely and partly eaten acorns.

Squirrel consumption of Shumard oak acorns exceeded that of swamp chestnut oak acorns in both weight and numbers (Table 1). Cotton rats showed no significant preference; they consumed a greater quantity of swamp chestnut oak acorns by weight, but a larger number of Shumard oak acorns. The average weight of a swamp chestnut oak acorn is about twice that of a Shumard oak acorn. Size did not appear to influence the rodents' choice of acorns. Cotton rats handled the largest acorns without difficulty. The squirrels manipulated all acorns with ease but still fed more heavily on the smaller Shumard oak acorns.

Table 2. Damage of treated and untreated acorns by squirrels and cotton rats.

RODENTS	TREATMENT	ACORNS DAMAGED DAILY			
		Weight		Numbers	
		Grams	Percent	Count	Percent
Squirrels	Untreated	90.4	90	17.5	92
	Treated				
	1 percent Endrin 50W and 5⅓ percent Arasan 75	4.9	5	0.8	4
	1 percent Endrin 50W and 10 percent Arasan 75	5.4	5	0.8	4
	Difference between treated and untreated categories	80.1*		15.9*	
Cotton rats	Untreated	40.3	96	7.3	96
	Treated				
	1 percent Endrin 50W and 5⅓ percent Arasan 75	1.4	3	0.2	3
	1 percent Endrin 50W and 10 percent Arasan 75	0.4	1	0.1	1
	Difference between treated and untreated categories	38.5*		7.0*	

* 1 percent level of significance.

Repellent Tests

Two repellent formulations were compounded on the basis of acorn weight. One was a mixture of 5.33 percent Arasan 75 and 1 percent Endrin 50W, the other a mixture of 10 percent Arasan 75 and 1 percent Endrin 50W. (Arasan 75 is 75 percent thiram by weight, Endrin 50W a wettable powder containing 50 percent technical endrin.) The acorns were coated with a slurry made by blending the chemical powders with an emulsion of 1 part Dow latex 512R adhesive and 9 parts of water. For later identification, the cup scars of acorns tested in one formulation were marked with black wax pencil.

The animals were given treated and untreated acorns in the first test. Each cage was equipped with three hoppers containing a mixture of equal weights of Shumard oak and swamp chestnut oak acorns. Acorns in two of the hoppers were treated with repellent (one formulation for each species); the third hopper contained untreated acorns. Each squirrel was given 500 grams of untreated acorns and two 250-gram lots of treated acorns. Each cotton rat was given 300 grams of untreated acorns and two 100-gram lots of treated acorns. The squirrels were allowed 3 days of feeding time, the cotton rats 6 days.

Undamaged acorns were counted and weighed at the end of the experiment. Weight loss in drying was compensated for as in the preference test. Both treatments effectively repelled squirrels and cotton rats to about the same degree (Table 2). Acorn species preference in this phase of the experiment confirmed the previous results. Statistical analysis of data on the effect of repellents was carried out as a split-plot design by usual analysis-of-variance methods, treating the separate squirrels and cotton rats as *blocks*.

Occasionally, rodents face a shortage of food, and under such conditions repellent-treated acorns might be eaten more readily. Therefore, further tests were made to determine the effectiveness of the repellents when only treated acorns were provided. Fewer acorns were available for this second test, so the feeding time was reduced to 22 hours for squirrels and 66 hours for cotton rats. The squirrels readily accepted

Table 3. Rodent consumption of repellent-treated acorns when no other food was available, compared with normal consumption of untreated acorns. There was no significant difference between the two repellent treatments for either squirrels or cotton rats. The normal consumption figures were obtained from the preference test and first repellent test.

Rodents	Treatment	Acorns Damaged Daily			
		Weight		Numbers	
		Grams	Percent	Count	Percent
Squirrels	1 percent Endrin 50W and 5⅓ percent Arasan 75	55.3	54	8.5	54
	1 percent Endrin 50W and 10 percent Arasan 75	47.6	46	7.2	46
	Totals	102.9	100	15.7	100
	Normal consumption of untreated acorns	113.2		20.3	
Cotton rats	1 percent Endrin 50W and 5⅓ percent Arasan 75	5.9	54	0.8	50
	1 percent Endrin 50W and 10 percent Arasan 75	5.1	46	0.8	50
	Totals	11.0	100	1.6	100
	Normal consumption of untreated acorns	55.1		8.5	

the treated acorns, husked off the shell before eating the meat, and apparently avoided ill effects. The squirrel consumption of treated acorns in this test differed little from consumption of untreated acorns in the previous tests (Table 3). Cotton rats were more sensitive to the treated acorns. One rat ate no treated acorns, four gnawed into only one acorn each, and three other rats fed more heavily on the treated acorns and died. Among caged rats held for more than 30 days, only these three died. The four remaining test rats appeared to be less vigorous and alert than they had been prior to this experiment.

Germination Tests

The Arasan–Endrin mixtures used in these tests can cause a serious loss of pine seed viability under certain conditions (Swofford 1959:69). Therefore, greenhouse tests were made to compare the germination of treated and untreated acorns. With both acorn species combined, average germination of acorns treated with the mixture of 5.33 percent Arasan 75 and 1 percent Endrin 50W was 91 percent; germination was the same for paired untreated controls. Acorns treated with the mixture of 10 percent Arasan 75 and 1 percent Endrin 50W had 80 percent germination, compared with 88 percent for untreated acorns. Statistical analysis of the data showed that neither the main effects of the repellents nor their interaction with acorn species was significant. We also concluded that the latex sticker does not affect acorn germination, since it is also a component of the repellent coating.

DISCUSSION

The tendency for squirrels to be selective in their feeding habits is not unusual. Trippensee (1948:135) and Wing (1951: 165) point out that gray squirrels seem to prefer acorns, hickory nuts, and soft-shelled pecans. In Britain, according to Shorten (1954:169), gray squirrels often display a preference among species of oak mast. In the preference test of the present experiment, total daily consumption of both species of acorns for each squirrel averaged 136 grams, close to the 129.6 grams of daily food consumption estimated

by Wing (1951:105). There appeared to be little selectivity in feeding by the cotton rats in this study; white oak acorns were fed upon nearly as often as red oak acorns. Daily food consumption on the preference tests averaged 29.7 grams for Shumard oak and 40.3 for swamp chestnut oak per rat.

The tested chemical coatings effectively repelled squirrels and cotton rats from treated acorns when an untreated supply was near at hand. Yet when only repellent-treated acorns were offered, the squirrels fed on them without noticeable ill effects, whereas the cotton rats were partially or completely repelled or killed. Perhaps the differences may be explained by the dissimilar feeding habits of squirrels and cotton rats. Squirrels started at the cup scar and rapidly tore away the acorn seed coat, sometimes removing it entirely before eating the kernel. Cotton rats gnawed into the acorn and probably consumed much more repellent, both in total amount and in proportion to body weight.

Acorns planted in the field must survive through a period when natural food supplies are low, and winter plantings often coincide with the annual peak of small-rodent populations. At such times, even if each rodent sampled only three or four acorns before it was poisoned or learned better, the planting might be destroyed. Direct seeding of acorns is not altogether comparable with that of pine in this respect, because many more pine seeds can be economically sown per unit area. Moreover, repellent treatments tend to become less effective as seed size increases (H. J. Spencer 1959:66). Since the ratio of seed surface area to volume is smaller for acorns than for pine seeds, rodents feeding on acorns risk less exposure to repellents relative to the quantity of food involved.

Although cotton rats were repelled from treated acorns, this fact should not be interpreted to mean that the Arasan–Endrin formulations will always effectively prevent acorn damage in the field. The repellent effect may not be great enough to prevent considerable damage to treated acorns even when untreated acorns are available. In an exploratory field test on a large cutover area, nearly all acorns, whether repellent-treated or not, were pilfered. Future needs for quality hardwoods may demand forest reproduction secured through the planting or seeding of select-quality seed. The use of systemics or seed repellents to reduce losses from animal and/or bird depredations will become increasingly important. Further exploration is necessary in this field.

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