TESTS OF REPELLENTS TO PROTECT LOBLOLLY SEEDLINGS FROM BROWSING BY WHITE-TAILED DEER[1]

by
D. LAMAR ROBINETTE[2]
and
M. KEITH CAUSEY
Department of Zoology-Entomology
Auburn University Agricultural Experiment Station
Auburn, Alabama 36830

ABSTRACT

Repellents were tested in 1970 in an effort to control white-tailed deer (Odocoileus virginianus) *damage to planted loblolly pine* (Pinus taeda) *seedlings on areas converted from mature pine with hardwood understory to large even-aged pine plantations. Test sites represented various site preparation methods that, after planting, were receiving extensive deer damage in Sumter County, Alabama. The most promising chemical deer repellents, according to previous studies, and two non-chemical deterrents (plastic bags and clipped seedlings) were tested. In this study, Arasan, Z.I.P., and ZAC were found to be effective treatments. Plastic bags and copper carbonate were even more effective, but the labor involved in the use of plastic bags were prohibitive and copper carbonate had a toxic effect on young pine seedlings. The clipped seedling treatment prevented deer from pulling these seedlings out of the ground. Seedlings treated with Arasan, Z.I.P., and ZAC had the best survival after two growing seasons.*

White-tailed deer (*Odocoileus virginianus*) damage to planted pine seedlings has historically been a problem in regenerating pine (Dixon 1934, Aldous 1937, Petrides 1941, Adams 1949, Champagne 1953, McNeel and Kennedy 1959, Little and Mohr 1961, Heidmann 1963). Damage to planted pine seedlings has been observed in the Southeast but has not appeared to be an economically significant problem. This study was initiated because of the observed intensity of damage on areas being converted from mature pine with hardwood understory to large even-age pine stands. Previous studies on these areas indicate that the use of pine by deer did not inhibit regeneration under the single-tree selection type of management (Ruggles 1938).

A great deal of research has been conducted in attempts to discover an effective, economical repellent for controlling deer browsing damage to trees and agricultural crops. Developmental research on deer repellents has been underway for 25 years at the Denver Wildlife Research Center (Dietz and Tigner 1958). In a summary of deer control studies, Welch (1947) listed 20 potential repellent compounds. Denton et al. (1969) listed five repellents that were tested in Europe and reported effective. Most of these repellents tested in the United States have been ineffective (Welch 1947, Carpenter 1966, Denton et al. 1969, Tierson 1969). Arner (1969) tested eight chemical repellents, including four of those tested in this study, and found only Pensalt OMPA systemic repellent and bone tar oil (Magic Circle) to show promise. Dietz and Tigner (1958) evaluated ZAC and TMTD and reported them to be successful. ZAC is commercially available as improved Z.I.P., and TMTD is marketed as Penco Thiram animal repellent. Champagne (1953) also found that a commercial deer and rabbit repellent containing an amine complex of zinc dimethyldithiocarbonate was an effective repellent for deer in Iowa.

Ryker (1961) recommended the use of Arasan 42-S thiram fungicide (TMTD) with a latex sticker (Rhoplex A-33 or Plyac) as a deer browsing repellent. Duncan and Whitaker (1958) conducted a three-year study in search of an effective repellent to keep cattle from damaging planted pines. They tested ZAC, TMTD, Z.I.P., and a mixture of copper carbonate and asphalt emulsion. All were found to be equally effective. Copper carbonate

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[2] Present address: Department of Entomology and Economic Zoology, Clemson University, Clemson, South Carolina 29631.

had a phytotoxic effect on the seedlings when they were baled for shipping and storage. In all tests, copper carbonate caused some needle burning.

Beckwith and Smith (1967) tested improved Z.I.P., Arasan 42-S, Double H Brand, and Phillips Petroleum Product R-1580 on citrus groves in south Florida. All of these formulations were reported to have significantly discouraged browsing deer. Improved Z.I.P. (0.8 percent and 1.6 percent ZAC), Phillips Petroleum Product R-1580, and Arasan 42-S (4.0 percent and 8.0 percent TMTD) were most effective and reduced damage from 76.0 to 70.0 percent.

DESCRIPTION OF THE STUDY AREA

The study area was located in Sumter County, south of Bellamy, Alabama. This area is in the Southern Red Hills Physiographic Province (Copeland 1968). Hodgkins (1965) identifies the area as part of the Interior Flatwoods Region and describes two major groups of soils here:

1. "Acid soils (Mayhew, Wilcox of the *interior flatwoods* or *grey post oak prairies*). This is an extensive area of the flatwoods located south of and parallel to the western segment of the Black Belt Region. The subsoils are stickly or plastic."
2. "Calcareous clay soils (Houston, Sumter). These are scattered patches of Black Belt soils located south of the Black Belt Region. These are characterized by cedar-hardwood forests and prairie vegetation."

The flatwoods is a lowland varying from 8 to 13 km in width, forming a narrow belt extending from east Mississippi across Alabama to the Alabama River; these being the only two states that it is found (Copeland 1968, Harper 1913). Reports of intensive deer damage to planted pine seedlings in the flatwoods areas of Alabama and Mississippi indicate that this problem may be related to the unique soils and to the plant succession on these areas. The flat, rather smooth surface of the flatwoods has an altitude of about 61 m and is derived from the Porter's Creek formation (Copeland 1968). Smith and Meeker (1905) stated that the area was sparsely settled due to the lack of good water and the fact that the soil was too heavy to cultivate. Most of these lands remained in native forest growth.

The flatwoods area was purchased in 1900 by Allison Lumber Company. Selective logging was practiced from 1926 until 1960. Natural regeneration of pine occurred under this system even though pine was heavily browsed by deer, Ruggles (1938).

American Can Company purchased these lands in 1960 and continued to selectively harvest the timber for four years. Clear cutting was initiated in 1964 to remove the mature overstory and release established advanced natural regeneration. On areas of insufficient natural regeneration, site preparation was accomplished by aerial spraying of 2, 4, 5-T or injection and burning. A limited amount of mechanical site preparation was employed from 1969 through 1971. Direct seeding attempts failed to produce adequate stands on these cut areas, so pine seedlings were planted by hand or machine.

A vegetational survey of the flatwoods study area revealed a scarcity of winter deer food plants (Robinette 1973). Deer were found to use pine from November through March, and grasses accounted for most of the contents of rumen samples containing pine (34.0 and 24.0 percent by volume, respectively) (Robinette 1973).

Deer browsing on planted pine seedlings on the study area was severe, ranging from 4.0 to 60.0 percent in plantations throughout the flatwoods (Robinette 1973).

METHODS

On February 6, 1970, a repellent test was installed in an area known to contain about one deer per four to five hectares (Robinette 1973). This 140 hectare area was clear-cut in 1967, burned in 1968, and was open except for a few dead snags on the east side.

The following five commercial deer repellents were used:

1. Arasan 42-S-Thiram fungicide and repellent. Active ingredients Thiram (Tetramethylthiuramidsulfide), 42 percent.
2. NIBONEX-ZAC. Active ingredient zinc dimethyldithiocarbonate cyclohexlamine, 23 percent.

3. Magic Circle—bone tar oil (odor repellent).
4. Z.I.P.—1.6 percent ZAC.
5. Copper Carbonate—Made from 1.3 kilograms of 12 percent asphalt emulsion (Flinkote C-13HPC) mixed with .95 liter of water, .91 kilograms of copper carbonate (55 percent metallic copper, diluted with 7.57 liters additional quarts of water).

These chemical repellents were mixed according to manufacturers' recommendations and applied using Rhoplex AC-33 latex sticker. The pine seedlings were dipped into a solution containing the selected repellent and allowed to dry overnight with the seedling roots covered with wet burlap.

Two non-chemical browse deterrents were tried. Plastic bags were stapled over the terminal buds of the seedlings similar to the method used by Wakelin and Kennedy (1959). Other seedlings were clipped in the nursery before planting to prevent browsing deer from pulling them out of the ground.

The February 6, 1970 repellent test was installed using four replications of eight different treatments, including the check. Twenty-five seedlings were used for each treatment or 200 seedlings per application in a randomized block design. This test was evaluated June 1970. The two-way analysis of variance test (Scnedecor and Cochran 1967) and Duncan's New Multiple Range Test (Steel and Torrie 1960) was applied to resulting data.

RESULTS AND DISCUSSION

The test seedlings were inspected in June of 1970 for the number of pine seedlings browsed (dead and alive), the number of seedlings alive and in satisfactory condition, the number of dead seedlings, and the number of seedlings missing. Seedling deaths were not considered when evaluating the repulsion success of the treatments because it was not possible to determine the cause of mortality of the dead, browsed seedlings. Also, since the seedlings were dormant, they were alive for several weeks after planting, being exposed to browsing deer. A two-way analysis of variance test was applied to these data, and a significant ($P<0.05$) difference in the numbers of browsed seedlings was found among treatments (Table 1).

Table 1. Number of browsed loblolly pine seedlings four months after repellent test in Sumter County, Alabama, 1970.

*Blocks**	*Check*	*Clipped seedlings*	*Plastic bags*	*Z.I.P.*	*Magic circle*	*Arasan*	*Copper carbonate*	*ZAC*	*Total*
I	5 (4)**	N.A. (2)***	0 (1)	1 (1)	0 (8)	0 (1)	0 (3)	2 (4)	8
II	12 (1)	N.A. (6)	0 (4)	3 (2)	2 (16)	0 (0)	0 (12)	2 (3)	19
III	10 (4)	N.A. (1)	0 (2)	3 (1)	6 (8)	2 (2)	0 (2)	1 (3)	22
IV	7 (2)	N.A. (5)	0 (1)	3 (1)	1 (18)	4 (1)	2 (4)	5 (2)	22
Total	34 (11)	N.A. (15)	0 (8)	10 (5)	9 (50)	6 (4)	2 (21)	10 (12)	71
Mean	8.5a	N.A.	0b	2.5c	2.3c	1.5c	0.5b	2.5c	

*Two hundred seedlings per block; twenty-five per treatment.
**Number of dead or dying seedlings in the treatments.
***N.A. - not applicable.
a,b Means not followed by common letter significantly different P = 0.05).

The means of the numbers of browsed pine seedlings for all treatments were compared using Duncan's New Multiple Range Test. This test showed that significantly ($P<0.05$) more browsed seedlings were found in the check plots which contained untreated seedlings than any of the other treatment plots (Table 1). Deer damage to seedlings in the plastic bag treatment was significantly ($P<0.05$) less than deer damage to seedlings treated with ZAC, Magic Circle, and Arasan. The treatment means for copper carbonate were significantly ($P<0.05$) different from ZAC, Z.I.P., and Magic Circle in having fewer seedlings browsed.

According to this test all of the treatments repelled deer and prevented deer damage to pine seedlings; however, damage to pine seedlings resulted from the use of Magic Circle, plastic bags, and copper carbonate. Of the seedlings treated with Magic Circle, 34.0 percent were found dead. Magic Circle was not recommended for very young seedlings by the manufacturer of this product. The copper carbonate treatments also had a large number (16.0 percent) of dead seedlings, and failure to remove the plastic bags from the seedlings before spring growth began probably caused some seedling mortality in this treatment.

There was also a significant (P<0.05) difference among certain treatments in the numbers of satisfactory seedlings (Table 2). Browsed seedlings were considered to be satisfactory if they were healthy, vigorous, and growing. Magic Circle had significantly (P<0.05) fewer satisfactory seedlings than all other treatments. Copper carbonate treatments also had significantly (P<0.05) fewer satisfactory seedlings than the other treatments except ZAC and clipped seedlings. Due to the apparent toxicity of Magic Circle and copper carbonate to young pine seedlings in this study, these chemicals appear to be unsuitable for use as deer repellent dips for pine seedlings.

Table 2. Number of satisfactory* browsed and unbrowsed loblolly pine seedlings four months after deer browsing repellent tests in Sumter County, Alabama, 1970.

*Blocks***	*Check*	*Clipped seedlings*	*Plastic bags*	*Z.I.P.*	*Magic circle*	*Arasan*	*Copper carbonate*	*ZAC*	*Total*
I	21	23	24	24	17	24	22	21	176
II	24	19	21	23	9	25	13	22	156
III	21	24	23	24	17	23	23	22	177
IV	23	20	24	24	7	24	21	23	166
Total	89	86	92	95	50	96	79	88	675
Mean	22.25a	21.50ab	23.00a	23.75a	12.50c	24.00a	19.75b	22.00ab	

*Satisfactory seedlings included all browsed and unbrowsed seedlings that were not dead or obviously dying.
**Two hundred seedlings per block; twenty-five per treatment.
abc Means not followed by common letter significantly different (P = 0.05).

Percentages of seedlings which were found to be both satisfactory and unbrowsed are presented in Table 3. Seedlings protected by plastic bags were 92 percent satisfactory and unbrowsed. Arasan and Z.I.P. treatments were 90 and 85 percent satisfactory and unbrowsed, respectively. The check plots contained only 57 percent satisfactory and unbrowsed seedlings.

Table 3. Number of satisfactory and unbrowsed loblolly pine seedlings four months after deer browsing repellent tests in Sumter County, Alabama, 1970.

Treatments	*Number planted*	*Number satisfactory and Unbrowsed*
Plastic Bags	100	92.0
Arasan	100	90.0
Z.I.P.	100	85.0
ZAC	100	79.0
Copper Sulfate	100	77.0
Check	100	57.0
Magic Circle	100	42.0

No significant (P<0.05) difference was found between blocks of replications for both the number of seedlings satisfactory and the number browsed, indicating that deer fed randomly through the study area.

Treatments were re-examined in April 1971. Of the 800 seedlings planted in the fall of 1969, 597 or 74.6 percent were alive (Table 4). Z.I.P.-treated seedlings had the best survival with 89 percent. Arasan and ZAC were second and third having 85 and 82 percent survival, respectively. It was observed that 45 percent of these surviving seedlings had been recently damaged by deer during the winter of 1970-71.

Table 4. Number of loblolly pine seedlings surviving 14 months after deer browsing repellent tests in Sumter County, Alabama, 1970

Treatment	*Number planted*	*Number surviving*
Z.I.P.	100	89.0
Arasan	100	85.0
ZAC	100	82.0
Clipped Seedlings	100	78.0
Plastic Bags	100	78.0
Check	100	74.0
Copper Carbonate	100	69.0
Magic Circle	100	42.0

SUMMARY AND CONCLUSION

According to this test, Z.I.P., Arasan, and ZAC were the most effective treatments. Plastic bags and copper carbonate were the most effective deer repellents, but the time involved in the use of plastic bags was prohibitive, while copper carbonate had a toxic effect on young pine seedlings. The clipped seedling treatment prevented deer from pulling these seedlings from the ground, but Z.I.P., Arasan, and ZAC treatments had the best survival when checked the second year.

It appears from previous published work on various deer repellents and from the experience gained in conducting this study that what works one time in a particular place does not necessarily work again in the same or other areas. Situations where deer are damaging agricultural crops, be it pine seedlings, cotton, soybeans, etc., may be the result of circumstances that are not duplicated regularly. Therefore, each situation should be carefully considered before much time or money is spent on repellents. It seems safe to assume that there is no one repellent at this time which can be recommended as a consistently effective means of preventing browsing damage by deer in all situations. Land managers must realize that conversion of large acreages of deer habitat to row crops of trees or any other edible greenery will probably create a short-term problem with browsing damage that be alleviated only by near-complete removal of the deer.

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GENETIC SUBDIVISION IN A HERD OF WHITE-TAILED DEER AS DEMONSTRATED BY SPATIAL SHIFTS IN GENE FREQUENCIES

by
MICHAEL N. MANLOVE[1]
Department of Fisheries and Wildlife
Michigan State University
East Lansing, Michigan 48824

MICHAEL H. SMITH
Savannah River Ecology Laboratory
Drawer E
Aiken, South Carolina 29801

HILBURN O. HILLESTAD
Institute of Natural Resources
University of Georgia
Athens, Georgia 30602

SUSAN E. FULLER
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon 97331

PAUL E. JOHNS
Savannah River Ecology Laboratory
Drawer E
Aiken, South Carolina 29801

DONALD O. STRANEY
Department of Zoology
University of California at Berkeley
Berkeley, California 94720

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ABSTRACT

Allele frequency data for the β-hemoglobin locus from 452 white-tailed deer (Odocoileus virginianus) *from the Savannah River Plant were examined for spatial subdivision of the herd. The usefulness of electrophoretic techniques to gather genetic information for analysis of spatial subdivision is demonstrated. Significant spatial heterogeneity was found; thus, the herd probably consists of more than one functional population. The potential use of these populations as independent management units is discussed.*

The management unit is an extremely important concept in wildlife management. Its operational definition is seldom based on functional characteristics of the population(s) included. Ideally a population should form the basis of a management unit if it has functional characteristics (e.g., reproductive rate) which differ from those of adjacent populations and are of importance in determining population number and dynamics. Spatial boundaries of management units should, wherever practical, be based on functional characteristics of the populations of interest. The question of recognizing and defining a population then becomes of utmost importance.

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[1]Reprint requests should be sent to M. H. Smith, Savannah River Ecology Laboratory, Drawer E, Aiken, S.C. 29801.