Field Tests of Insecticides to Protect Ponderosa Pine from the Mountain Pine Beetle (Coleoptera: Scolytidae)[1]

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ABSTRACT

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Individual ponderosa pines, *Pinus ponderosa* Lawson, can be protected from *Dendroctonus ponderosae* Hopkins attacks by spraying the boles with 2% carbaryl-water suspension. Although lindane emulsion at 2% gives equal protection, numerous pitch tubes leave trees cosmetically inferior. Other dose rates and materials are considered inferior. Insecticides tested kill a broad spectrum of insects, including predators of the mountain pine beetle. Predators may have been attracted to certain insecticide formulations.

A mountain pine beetle, *Dendroctonus ponderosae* Hopkins, epidemic has existed along much of the front range of the Colorado Rocky Mountains for the past 17 years. Millions of ponderosa pine trees, *Pinus ponderosa* Lawson, have been killed, and others near summer homes and picnic and scenic sites have been jeopardized. Although direct chemical control over large areas might be applied to reduce tree losses, effective, safe insecticides were needed to protect individual trees.

Massey (1960) and Smith (1967) protected pines from beetle attacks by using DDT or lindane, respectively. Smith et al. (1977) reported successful tree protection tests from several locations in the western United States. Part of those tests was made in Colorado, and the data reported here reinforce the earlier data by much larger tests and report on some different insecticides.

My specific objectives were to determine the effectiveness and minimum dose rate of several insecticides for protecting at least 90% of individual ponderosa pines from mountain pine beetle attacks and to obtain data on insecticide-caused predator mortality from which a least-harmful material could be selected.

Materials and Methods

The field tests were conducted at Lory State Park, 11 km W of Fort Collins, Colo. This area sustained a loss of almost 60,000 trees in 3 years, two of which were years of the study.

Insecticides and Application

Insecticides tested in 1976 were: carbaryl, as Union Carbide Sevimol-4; lindane, as Ortho Isotox Lindane Spray no. 200; chlorpyrifos, as Dow Chemical Dursban 2E; and chlorpyrifos-methyl, as Dow Chemical Reldan (Dowco 214). Applications were made between 2 June and 7 July at 0.5, 1, and 2% AI, by weight, in water. Materials tested in 1977 were: carbaryl and lindane, as noted previously; chlorpyrifos-methyl, as Dow Chemical Reldan 4E; and methoxychlor, as DuPont Marlate 50 WP. These insecticides were mixed at one or more strengths; namely, 2, 2.5, 3, and 4% AI in water and applied from 31 May to 6 July.

A 10-ml sample of each spray formulation was taken as soon as mixed, and another before applications. These samples were immediately frozen and later analyzed by gas chromatography[2] to determine if correct concentrate had been applied. The amount of insecticide applied and the formulation number were recorded for each tree sprayed.

Insecticides were applied under low pressure to the point of runoff, which is ca. 1 liter/1.2 m^2 of bark. Technicians on extension ladders used small air pressure sprayers to apply the insecticides to 9 m, or to a 12.7-cm diameter, whichever was lower. Previous tests had shown that trees could not be protected when sprayed to 3.0, 4.5, or 6.0 m.

Test trees ranged in dbh from 15.2 to 52.0 cm (mean, 29). Height of such trees was 12 to 18.6 m (mean, 13.1).

Stegmiller and Hawthorne (1975) reported that the half-life of carbaryl was prolonged when the pH of water used in formulations was lowered. Therefore, I reduced the pH of water used, normally 6.5 to 7.8, to 6.0 by adding 3.2 g of monobasic and 0.3 g of dibasic sodium phosphate per liter of water. Subsequent measurements showed the actual pH of carbaryl sprays was ca. 4.6; lindane was ca. 5.6.

Test Design

Forty groups of 15 uninfested trees, scattered throughout 400 ha of ponderosa pine forest, were selected for tests in 1976. Forty groups of 16 trees were selected for the 1977 tests. Average density of trees within the groups larger than 10 cm was ca. 865/ha. There were ca. 15,000 infested trees in the area in 1976 and ca. 10,000 in 1977.

Three trees within each group were designated attractant trees. These were as evenly distributed among the remaining test trees as possible. Treatments were then assigned to each remaining tree by random selection.

Each 1976 attractant tree was established by hanging on it a short log, which had been artificially infested with 35 female beetles, at eye level height. In 1977, attractant trees were made by placing an open glass vial

[1]This paper reports the result of research only. Mention of a proprietary product or pesticide does not constitute an endorsement or recommendation by the USDA.
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[2]All chromatographic analyses were performed by the Institute of Rural Environmental Health, Colorado State University, Fort Collins. Details of procedures will be furnished upon request from the author.

containing 0.5 ml of synthetic trans-verbenol and another with 0.5 ml of myrcene in a perforated film can which was then nailed to each designated tree. Studies by S. A. Mata, Jr., (personal communication) showed this combination of materials as good as, or better than, logs infested with female beetles.

Also in 1977, three unsprayed trees were included in all test groups to help maintain site attractiveness. This was felt necessary because 1977 treatments were of higher dosages, and some trees might not become infested. Lack of attraction was not a problem with the 0.5% sprays of 1976.

Trees in the experimental groups were occasionally close together. To avoid serious contamination while insecticides were applied, unbleached muslin was wrapped around the basal 6 to 8 m of threatened trees when wind drift was evident. Contamination was not eliminated, but its effects were minimized.

Evaluation of Effectiveness

Scattered pitch tubes on a tree, but no successful egg gallery construction or dead beetles in the duff around the tree, were evidence the tree was protected. Trees were not protected if fine, dry, or coarse boring dust was seen around the base of the tree and brood was established. A tree was dropped from the test if there was no evidence beetles had reached it.

Mortality of Associated Insects

Circular cloth trays[3] (1 m) were attached to one tree of each treatment at each of three test sites in 1977 to determine what insect fauna were killed in addition to mountain pine beetles. Trays encircled the trees at a height of ca. 1 m, and all were installed soon after spray application. Insects were collected from the trays at biweekly intervals throughout the summer. Data collected would help to select the least environmentally damaging of equally effective insecticides.

Results

Carbaryl or lindane at 2% AI in water protect green ponderosa pines from successful mountain pine beetle attacks. Dose rates higher than 2% do not increase protection success. χ^2 analysis of data presented in Table 1, for materials >0.5% strength, show all lindane and all carbaryl dose rates for each given year are not significantly different. Chlorpyrifos-methyl appears promising at higher dose rates, but I feel the data are inconclusive.

Methoxychlor was ineffective in 1977 tests as a 2% AI WP. In additional tests in 1978, it was ineffective at either 2 or 4% EC (0 trees protected, n = 7, and 13% protected, $n = 7$, respectively). Chlorpyrifos was not sufficiently effective in 1976 to warrant further testing.

Buffering the fairly neutral water used for the tests did not influence protection.

Table 2 presents the sum of beetles collected from three traps on each treatment. Clerid beetles are the most frequently encountered predators, consisting of the redbellied, *Enoclerus sphegeus* (F.), and the blackbellied,

[3]Designed by K. E. Gibson, USDA, Forest Service, Ogden, Utah.

Table 1.—Tree protection tests, Lory State Park, Colo., 1976 and 1977[a]

Treatment (%)	1976 No. protected	1976 No. killed	1976 % Protected[b]	1977 No. protected	1977 No. killed	1977 % Protected
Lindane EC						
0.5	16	20	44			
1.0	29	6	83a			
2.0	32	0	100a	24	2	92a
2.5				21	2	91a
Carbaryl suspension						
0.5	14	24	37			
1.0	22	11	67ab			
2.0	28	3	90a	31	0	100a
2.5				23	1	96a
3.0				33	0	100a
3.0 Unbuffered				26	0	100a
Chlorpyrifos-methyl EC						
0.5	2	33	6			
1.0	5	32	14b			
2.0	18	15	55ab	18	12	60a
4.0				28	4	88a
4.0 Unbuffered				26	4	87a
Chlorpyrifos EC						
0.5	2	33	6			
1.0	4	32	11b			
2.0	9	30	23b			
Methoxychlor WP						
2.0				6	28	18b
Check				0	89	
Attractant	0	115		0	114	

[a]Percentage of test trees reached by beetles: 1976, 91%, 1977, 75%.

[b]Percentages followed by the same letter, same column, are not different at $\alpha = 0.05$; χ^2 analyses. Tree protection for materials at 0.5% was considered unsatisfactory, and data were not analyzed.

Table 2.—Total number of Coleoptera collected between 15 July and 15 September 1977, Lory State Park, Colo.

Insecticide	% Of tree infested	No. of insects							
		Buprestids	Cerambycids[a]	Clerids[a]	Ips	Mountain pine beetles[a]	Trogositid[a]	Other	Total
2% Methoxychlor	100	2	2a	64b	4	598a	49b	582[b]	1,301
2% Lindane	0	2	9a	12a	0	111a	0a	32	166
2.5% Lindane	0	1	5a	12a	2	254a	0a	50	324
2% Carbaryl	0	7	47c	40ab	0	559a	4a	66	723
2.5% Carbaryl	0	3	45c	22a	0	300a	1a	79	450
3% Carbaryl	0	2	38bc	16a	1	373a	4a	59	493
3% Carbaryl, unbuffered	0	3	13ab	11a	3	201a	1a	59	291
2% Chlorpyrifosmethyl	33	6	12ab	12a	0	1,119a	1a	95	1,245
4% Chlorpyrifosmethyl	0	1	13ab	23a	1	692a	5a	96	831
4% Chlorpyrifosmethyl unbuffered	0	1	2a	12a	0	236a	2a	84	337
Attractant tree	100	1	6a	18a	3	262a	3a	19	312
Check tree	100	0	5a	6a	0	173a	0a	16	200

[a]Numbers followed by the same letter, same column, are not significantly different, χ^2, $P < 0.05$. No comparisons between columns were made.
[b]Of this total, 524 were tenebrionids.

E. lecontei (Wolcott); these were collected in a ratio of ca. 7:1, respectively. Analysis of variance showed the numbers of clerids collected in traps on trees sprayed with 2% methoxychlor were significantly different ($F = 5.8$, $P < 0.01$) from other insecticides, with the exception of 2% carbaryl. Since all attractant trees and checks were likewise infested with mountain pine beetles, attraction to infested trees per se does not explain the predator catch at methoxychlor treated trees. The same can be said of the trogositid predators *Temnochila chlorodia* (Mannerheim) also found at the methoxychlor-treated trees.

Traps under trees sprayed with buffered carbaryl contained fairly uniform and significantly greater numbers of cerambycids than from all other treatments. Since none of the carbaryl-treated trees became infested, cerambycids were not attracted by successfully attacking mountain pine beetles.

Mountain pine beetles in traps were not statistically different between treatments or between sites.

Discussion

The most practical treatments, listed in Table 1, for protection of healthy ponderosa pines from mountain pine beetle attacks are water sprays of either 2% lindane or 2% carbaryl. Many lindane-treated trees, although protected from successful beetle attacks, develop numerous pitch tubes over their trunks as a result of unsuccessful infestation. This situation is seldom seen on trees sprayed with carbaryl; consequently, they look better, and escape the risk of being cut down because of the presence of pitch tubes.

The death of predators of the mountain pine beetle resulting from use of protective sprays must be evaluated by the potential user of an insecticide. Blackman (1931) and others have concluded that predators and parasites alone are not effective in reducing epidemics of the mountain pine beetle. Furthermore, protective sprays will be used on a small percentage of trees during any epidemic. Unprotected trees that become beetle infested will provide adequate hosts to sustain natural enemies.

The congregation of cerambycids to carbaryl-treated trees and clerids and trogositids to trees sprayed with methoxychlor needs follow-up study to see if attraction is real. Lack of attraction would certainly be a major factor in selecting between equally effective insecticides.

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