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PACIFIC SOUTHWEST Forest and Range Experiment Station

LOW CONCENTRATION OF LINDANE plus induced attraction traps mountain pine beetle

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Greater understanding of the behavior of bark beetles in response to attractants has encouraged attempts to attract beetles to specified trees. Pitman¹ used trans-verbenol plus α -pinene to attract mountain pine beetle (*Dendroctonus ponderosae* Hopk.) to western white pines (*Pinus monticola* Dougl.) sprayed with lindane. Knopf and Pitman² used a mixture of frontalinal, camphene, and α -pinene to attract Douglas-fir beetle (*D. pseudotsugae* Hopk.) to Douglas-firs (*Pseudotsuga menziesii* [Mirb.] Franco) which were to be logged soon afterwards. Copony and Morris³ employed frontalure to attract southern pine beetle (*D. frontalis* Zimm.) to loblolly pine (*P. taeda* L.) treated with cacodylic acid. Dyer⁴ was able to induce the spruce beetle (*D. rufipennis* Kirby) to attack white spruce (*Picea glauca* [Moench] Voss) and Engelmann spruce (*P. engelmannii* Parry); portions of these trees were sprayed with lindane emulsion.

In 1974 I made an exploratory field test with mountain pine beetle in lodgepole pine (*P. contorta* Dougl.). Freshly infested bolts readily attracted beetles to tree trunks sprayed with 0.2 percent lindane aqueous emulsion. The trees were adjacent to a group of attacked trees from which beetles would emerge in 1974. The sprayed trees were successfully attacked and killed, but hundreds of dying beetles were caught in traps at the base of these trees; no beetles were caught beneath nearby attacked, unsprayed trees. There was, also, an apparent reduction in the incidence of attacked trees in the area in 1974.

In a second field experiment in 1975 I attempted to improve the techniques and the data. The objectives were 1) to select a concentration of lindane that would kill many beetles and yet permit the establishment of a natural, prolonged, strong source of attraction; 2) to reduce the beetle population and the subsequent incidence of attack. Such a procedure might be suitable for direct control of mountain pine beetle.

Smith, Richard H.

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Mountain pine beetles were induced to attack lodgepole pine sprayed with 0.2 percent or 0.3 percent lindane emulsion. Large numbers of beetles were killed and fell into traps at the base of the tree. The few successfully attacking beetles caused the sprayed trees to remain attractive to beetles for about two months. The incidence of attacked trees in the immediate area of the sprayed trees was apparently reduced.

Oxford: 145.7x19.66 *Dendroctonus ponderosae*: 147.7 *Pinus contorta*: 414.11.

Retrieval Terms: mountain pine beetle; lodgepole pine; lindane; pheromones.

The effectiveness of lindane against bark beetles has been well established by previous work as reviewed by Smith⁵ and substantiated by recent reports by Dyer⁴ and Smith and others⁶. Pitman¹ did find 2.3 percent to be ineffective against mountain pine beetle, but in that paper, dosage is not given and the location of attacks on sprayed trees is not clearly fixed; the concentration is stated as a "... 2.3 percent solution of lindane in water." Lindane was also reported ineffective against western pine beetle (*D. brevicornis* Lec.) by Vité and Pitman⁷; but they gave no information on the type of spray, concentration, dosage, or data for judging effectiveness.

METHODS AND MATERIALS

Two concentrations of lindane emulsion were applied to a group of 10 lodgepole pines in a stand which was predominantly uneven-aged lodgepole pine with a smaller number of red fir (*Abies magnifica* A. Murr.): 0.3 percent was applied to one key tree central to the group, and 1.0 percent was applied to the nine surrounding trees. The 0.3 percent was to kill beetles but not protect the tree. The 1.0 percent was to protect the trees. The dosage used on all trees was about 1 gallon per 50 square feet applied to the basal 25 to 28 feet. The spray was applied on July 1 when weather was warm and dry. Sprayed trees ranged from 13 inches to 28 inches d.b.h. with a mean of 18 inches. The treated group was adjacent to a group of 17 trees that had been attacked in 1974 and from which beetles would emerge in 1975. A 60-acre area around the sprayed group was defined as the experimental plot to follow the development of the infestation in 1975 (fig. 1).

The source of attraction was 50 to 70 beetles caged with freshly cut bolts. Four such cages were placed around the key tree and around four of the trees sprayed with 1.0 percent emulsion. The logs and beetles were replaced weekly but the replaced logs were aggregated into one large cage near the plot center for 2 to 3 additional weeks. This attraction procedure was maintained through the whole flight period from July 16 to September 17.

Four traps of heavy cotton cloth were placed at the base of the key tree; these were 1 foot wide and extended 6 feet out from the tree at the four cardinal directions on stakes 1 foot high. Weights were placed in the traps to produce a V-shaped configuration with a depth of about 8 inches. At the point of contact with the tree, the four traps occupied nearly the full circumference. Smaller traps, about 1 foot wide and 1 foot long, were placed at the base of each of the

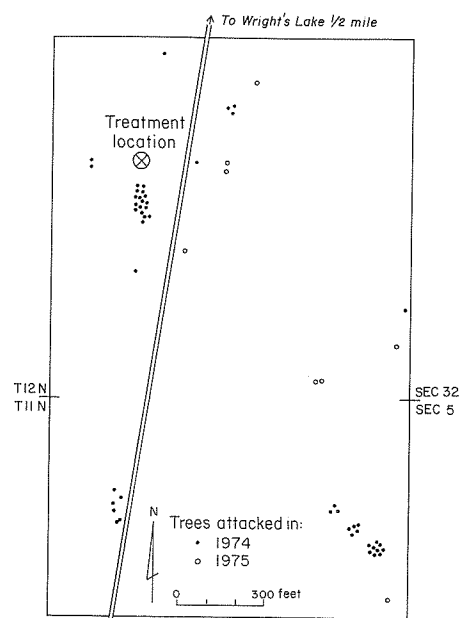


Figure 1—The trees studied were within a 60-acre area near Wright's Lake, Eldorado National Forest, California.

other trees treated with 1.0 percent lindane emulsion and each of the untreated trees that was subsequently attacked in the experimental plot. These traps, of course, sampled a much smaller area under the tree. Beetles falling into the traps and unable to get out were counted as dead. To sample outside the test area, one trap with an area of about 6 square feet was placed under several nearby lodgepole pine trees from which beetles were emerging and two traps with an area of 12-square feet were placed underneath untreated lodgepole pine trees.

Fifty-one brood trees, attacked in 1974, were found in the experimental plot in July 1975. Each week a one-hour search was made of the area to locate other trees being attacked. In July, a 5 percent cruise of the 60-acre area was made of dead lodgepole pine which had been killed in the past 10 years. On August 26 and September 17, a thorough search was made for currently attacked trees on the 60-acre area.

The sequence of attack on the trees and the number of beetles in the traps at sprayed and unsprayed trees were observed and recorded. To determine the total number of dead or moribund beetles falling around the central tree, the numbers counted in the traps were multiplied by factors determined by the proportional area occupied by trap. The first 2 feet of the 6-foot trap represents about one-third of that circular area under the tree; the next 2 feet, one-sixth, and the last 2 feet, one-ninth. Thus, factors of 3, 6, 9 were applied respectively to the trap

catches at 0 to 2 feet, 2 to 4 feet, and 4 to 6 feet. A conversion factor of 8 was applied to the smaller traps at the base of the other nine trees; this is a conservative estimate based on the data from the traps around the primary tree.

RESULTS AND DISCUSSION

On July 16 several pitch tubes were noted at the base of the key tree and four dead or moribund beetles were in the traps around it. The number of pitch tubes and the number of beetles in traps increased weekly through mid-August and then declined, although some beetles were caught in these traps throughout the entire flight period (fig. 2). A

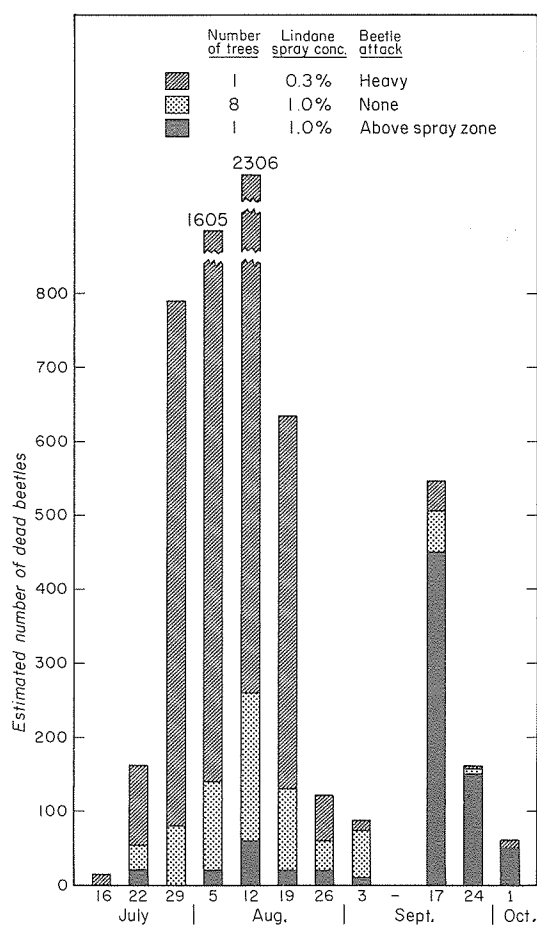


Figure 2—Beetles killed in traps varied in numbers with the lindane emulsion spray concentrations.

total of 4950 beetles—determined by applying the conversion factors to the trap catch—were killed and

fell to the ground under this tree (table 1). No parasites were found in any of the traps and an estimated total of 12 specimens of the common predator *Enoclerus spegeus* were killed by the treatment. In the many hours spent servicing the traps during the summer, not one beetle was seen leaving a trap.

Table 1—Distribution of beetles in traps around base of key tree sprayed with 0.3 percent emulsion of lindane

Item	Distance from tree			
	1 foot	3 feet	5 feet	Total
Traps:				
North	130	14	2	146
East	270	114	15	399
South ¹	428	99	5	532
West	220	35	4	259
All	1048	262	26	1336
Conversion factors ²	3	6	9	
Total	3144	1572	234	4950
Percent	63	32	5	100

¹ Tree had a noticeable lean to south.

² To convert trap catch to full area under tree.

Beetles attacked the tree sprayed with 0.3 percent lindane over a much longer period of time than in the previous year, though the tree was eventually killed. The 0.3 percent lindane appeared to make the tree more difficult to overcome than the 0.2 percent; this prolonged its attractiveness to the beetles, a very desirable characteristic of the procedure.

Sixty-three percent of the beetles in traps were within 2 feet of the tree, 32 percent between 2 and 4 feet, and only 5 percent between 4 and 6 feet (table 1). The traps ended at 6 feet, but had they been longer it is not likely that significant numbers of beetles would have been trapped beyond that distance. The disproportionate number of beetles within the first 2 feet from the tree seems to be caused by a close-in attractiveness of trees under attack. It was observed that as affected beetles fell from the tree sprayed with 0.3 percent, they would correct their trajectory of fall, which was seemingly taking them to a point several feet from the tree, and would drive back into the tree. Thus, at least some of them reached the base of the tree by a series of short parabolic trajectories.

Starting on July 22 and for the duration of the

Table 2—Sex ratio of adult mountain pine beetles (F=female, M=male) falling in traps at base of three types of treated trees

Date	1 Key tree ¹		Ratio(F:M)	8 Protected trees ²		1 Protected tree ³	
	Number			Number		Number	
	F	M		F	M	F	M
July 16							
22	21	7	3:1				
29	111	46	2.4:1	7	2		
August 5	230	144	1.6:1	14	6		
12	225	108	2.1:1	15	8		
19	56	51	1.1:1	6	3		
26	11	4	2.7:1	5	3		
September 3	2	1	2.0:1	6	3		
17	7	4	1.8:1	3	4	29	16
24	1	1	1.0:1	0	1	10	4
October 9	2	1	2.0:1	—	—	4	1
All dates	666	367		56	30	43	21
Ratio	1.8:1			1.9:1		2.0:1	

¹ Sprayed with 0.3 percent lindane emulsion.

² Sprayed with 1.0 percent; no successful attacks.

³ One of the nine sprayed with 1.0 percent; attacks above the sprayed portion starting between September 3 and 17.

flight period, some beetles were caught in the traps at one or more of the trees sprayed with 1.0 percent lindane but no pitch tubes appeared on the sprayed portion of these trees. In mid-September, however, pitch tubes appeared above the sprayed zone of one of these trees (28 inches d.b.h.). This was accompanied by a large increase in the number of beetles in the trap (*fig. 2*). The heavy attack on this tree did not occur until the key tree had lost its strong attractiveness as evidenced by the decrease in beetles caught in the traps.

An improvement in the method would be to maintain an attractive center for the full period of flight. This could be accomplished by using two or three key trees instead of just one. Increasing the concentration of lindane is another possibility, but there is the chance that the higher dosage would be too effective so that the tree would be too lightly attacked to become attractive.

About 500 beetles were killed by the protective spray, as estimated from the conversion factor applied to the trap catch. No beetles were caught in 12-square feet of traps under adjoining untreated, uninfested lodgepole pine. Two beetles were caught in the 6-square foot trap under the lodgepole pines from which beetles were emerging during the course of test.

The sex ratio of the trapped beetles was quite consistent throughout the full attack period at approximately 2 females to 1 male (*table 2*). This ratio was about the same for three types of trees: those sprayed with 0.3 percent and showing attacks through the sprayed bark, 1.0 percent without attacks, 1.0 percent with attacks above the sprayed zone. This result is consistent with previous work which reports a greater number of females than males⁸, but differs from Pitman's report¹ of 1.0 male to 0.4 to 0.8 female.

Not until after mid-August were attacked trees found on the 60-acre plot area outside the sprayed group (*fig. 1*). This seems to coincide with the decline in attractiveness of the key tree. By the end of the season nine trees were under attack on the 60-acre plot area outside the sprayed group. Thus, there was a marked reduction in the number of attacked trees in the general vicinity of the sprayed group. Data from the 5 percent cruise of the plot showed that about 50 trees had been killed each year for the past decade. (Trees were classed as killed within the past 10 years if the bark or smaller limbs were still intact or if there was no sign of decay.) It cannot be said with full confidence that the reduction in 1975 was caused by the sprayed trees, but presumably the thousands of beetles killed could have had some effect on the

capabilities of the population, particularly since only those beetles which were able to fly to and attempt to attack a tree were killed and not those which were in the brood tree. It is obvious that similar tests should be made in conjunction with more detailed and comprehensive population and tree mortality studies.

Although the results are inconclusive, the procedure used combines a number of desirable features: (1) it markedly reduces the number of trees to be treated: apparently a ratio of one sprayed tree to every five to ten brood trees is applicable for the procedure; (2) it eliminates the need to locate all currently attacked trees, a laborious and uncertain factor of control directed toward treating infested trees; (3) it minimizes the release of insecticide into the biologically active portions of the environment (that is, the procedure can be viewed as transferring the insecticide from one container, the can, to another container, the outer bark of a living tree); (4) it apparently has limited impact on parasites and predators; and (5) it utilizes the highly potent attractiveness of trees under attack.

NOTES

¹ Pitman, G. B. 1971. *Trans-verbenol and alpha-pinene: their*

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⁴ Dyer, E. D. A. 1975. *Frontalin attractant in stands infested by the spruce beetle, Dendroctonus rufipennis (Coleoptera: Scolytidae).* Can. Entomol. 107:979-988.

⁵ Smith, Richard H. 1976. *Effectiveness of lindane against bark beetles and wood borers.* In: *Lindane in Forestry—a continuing controversy.* USDA Forest Serv. Gen. Tech. Rep. PSW-14, 30 p. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

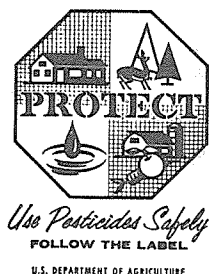
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⁷ Vité, J. P., and G. B. Pitman. 1970. *Management of western pine beetle populations: use of chemical messengers.* J. Econ. Entomol. 63(4):1132-1135.

⁸ Billings, Ronald Forrest. 1974. *Host selection and attack behavior of Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae) in ponderosa pine of eastern Washington.* Ph.D. thesis, Univ. Wash., Seattle.

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