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ABSTRACT: The insecticide lindane, applied on bark any time of the year, can effectively destroy broods of the western pine beetle. It may also be effective the year round on the mountain pine beetle, the California five-spined ips, and probably other California species of bark beetles. In tests on the Sierra National Forest, lindane sprays formulated at 1.5 percent concentration in diesel oil killed 86.9 to 99.4 percent of western pine beetle broods overwintering in ponderosa pine logs.

RETRIEVAL TERMS: *Dendroctonus brevicomis*; *Dendroctonus ponderosae*; *Ips confusus*; *Pinus ponderosa*; Lindane- γ -isomer; residual life; bark beetles; chemical controls; BHC.

OXFORD: 453--414.12 Lindane- γ -isomer [--174.7 *Pinus ponderosa* + 145.719. 92 *Dendroctonus brevicomis* + 145.719. 92 *Dendroctonus ponderosa* + 145.719. 92 *Ips confusus*] + 174.7 *Pinus ponderosa* --453--414.12 Lindane- γ -isomer.



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Field Test of Reference File No. 453
Lindane Against Overwintering Broods
of the Western Pine Beetle

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Lindane (1,2,3,4,5,6-hexachlorocyclohexane, 99 percent or more gamma isomer) is widely used in California as a bark spray for bark beetle control.¹ But until recently, its residual life in bark had not been studied enough to warrant use of the insecticide in late fall and winter when beetles overwinter and a long delay separates spray application and beetle emergence. During these months, ethylene dibromide, a fumigant and penetrating spray, has usually been used because of its proved effectiveness--even though it costs more than lindane.²

In 1962-63, the Pacific Southwest Station and the Forest Service's California Region³ joined forces to determine if lindane could be used in place of ethylene dibromide in fall and winter. The use of lindane would reduce the cost of suppressing bark beetles in the State. We found that lindane at 1.5 percent concentration in diesel oil, if carefully and thoroughly applied, can kill overwintering broods of western pine beetle (*Dendroctonus brevicomis* LeConte). The formulation should be equally effective any time of year against the California five-spined ips (*Ips confusus* [LeConte]), the mountain pine beetle (*D. ponderosae* Hopkins), and perhaps other species.

Methods

Twelve ponderosa pine trees infested with the western pine beetle were selected near Bass Lake on the Bass Lake District, Sierra National Forest. We scheduled sets of three trees for spraying in each of 4 months (November to February 1962-63) to evaluate the effectiveness of lindane when applied 5, 4, 3, and 2 months before insects began emerging in

April 1963. The trees were felled immediately before treatment, and 12 feet of the most heavily infested part of the bole of each tree were cut out, blocked up off the ground, and marked into 3, 4-foot sections.

Sprays were formulated at two concentrations--1 and 1.5 percent--by weight (w/w) in diesel oil.⁴ They were applied with a pressure-type garden-sprayer until the bark was thoroughly wet.⁵ Each log section received either (a) no treatment, (b) a 1 percent lindane spray, or (c) a 1.5 percent spray. Strips of heavy Kraft paper were wrapped around the bole to avoid contaminating one treatment with another. The treatments and checks were assigned to the log sections so that they were equally represented in the lower, middle, and upper portions of the boles. We assumed that this arrangement gave similar populations in the check and treatment sections. If this assumption is correct, we can properly call the reduced emergence in the treated bolts the proportion of insects killed in place by the insecticide.

The insects were medium to full-grown larvae and pupae at the time of spraying in nearly all treatments. In November treatments, a few very young larvae were noted.

Toxicity of the sprays was assessed by cutting 16-inch long bolts from the center of each 4-foot test section on April 19, 1963. The bolts were shipped to the laboratory in Berkeley, Calif., and placed in 15- by 15- by 28-inch and 18- by 18- by 18-inch cardboard box cages where beetles were reared. Bolt diameters ranged from 9.1 to 17.5 inches. The 18- by 18- by 18-inch cages were used for bolts more than 14 inches in diameter.

Each bolt was placed separately in a cardboard cage and sealed. The beetles were attracted by light to a wide-mouth, pint-size canning jar attached to the front, near the bottom of the cage. The emerging beetles

were collected twice daily and held in petri dishes with moist filter paper at 71 to 77°F. and 40 to 60 percent R. H. Mortality counts were made 3 days after collection. Mortality figures include moribund insects, that is, insects sluggish, unable to walk, or make coordinated movements.

Selected cages were bioassayed for possible contamination by the insecticide. They were emptied when emergence was complete and reused for caging untreated ponderosa pine bark containing western pine beetle adults. Six cages were selected from the November tests, three from the January tests, and six from the February tests. We hoped to show if enough vapors of lindane had adsorbed on the cage interior to make this surface toxic to emerging beetles.

Results and Discussion

We found no obvious trend--either increasing or decreasing--in the mortality of beetles, corresponding to month of spray treatment (table 1). Samples sprayed in January provided the low point in mortality estimates, but we have no logical explanation for this finding.

Lindane at 1-1/2 percent concentration was highly toxic to overwintering beetles. Mortality, by month of treatment, ranged from 86.9 to 99.4 percent, averaging 94.8 percent from all data pooled. The 1 percent spray was less toxic. It produced mortalities ranging from 81.8 to 97 percent and averaging only 83.6 percent.

Mortality in the bark was almost always higher than mortality among beetles that emerged (table 1). Previous findings⁶ have also shown that lindane bark sprays act chiefly by killing in place or in the bark--either soon after spraying or when the insects attempt to bore out.

Bioassay of "used" cages holding western pine beetle adults showed no significant contamination of the cage surface by lindane vapors (table 2). The "contamination" mortality was only

Table 1.--Mortality of western pine beetle sprayed with lindane in diesel oil at two concentrations, fall and winter 1962-1963

CONCENTRATION (w/w): 0.0									
Date (1962-63)	Bark area	Beetles emerged		Drop in emergence ¹	Post emergence mortality		Beetles surviving		Total re- duction
	Sq. ft.	Total	No./sq. ft.	Pct.	No./sq. ft.	Pct.	Total	No./sq. ft.	Pct.
Nov. 20	11.6	2,100	181.0	--	37.0	20.4	1,671	144.0	--
Dec. 18	^{2/} 7.7	111	14.4	--	4.3	29.9	78	10.1	--
Jan. 17	11.9	1,429	120.1	--	38.4	32.0	972	81.7	--
Feb. 20	15.5	1,004	64.8	--	14.2	21.9	783	50.5	--
Sum	46.7	4,644	--	--	--	--	3,504	--	--
Average	--	--	99.4	--	--	--	--	75.0	--
CONCENTRATION (w/w): 1.0									
Nov. 20	11.4	501	43.9	75.8	26.6	60.6	198	17.4	88.0
Dec. 18	^{2/} 7.5	7	.9	93.8	.7	77.8	2	.3	97.0
Jan. 17	12.0	498	41.5	65.4	26.6	64.1	179	14.9	81.8
^{3/} Feb. 20	--	--	--	--	--	--	--	--	--
Sum	30.9	1,006	--	--	--	--	379	--	--
Average	--	--	32.6	67.2	--	--	--	12.3	83.6
CONCENTRATION (w/w): 1.5									
Nov. 20	10.9	316	29.0	84.0	19.5	67.2	103	9.4	93.5
Dec. 18	^{2/} 7.3	1	.1	99.3	.0	.0	1	.1	99.0
Jan. 17	12.0	563	46.9	61.0	36.2	77.2	128	10.7	86.9
^{3/} Feb. 20	30.7	121	3.9	94.0	3.7	94.9	8	.3	99.4
Sum	60.9	1,001	--	--	--	--	240	--	--
Average	--	--	16.4	83.5	--	--	--	3.9	94.8

¹Computed from check logs.

²One of 3 trees omitted owing to accidental treatment with lindane during a routine control operation.

³Combined with data on 1.5 percent sprays. A laboratory analysis showed the 1.0 percent spray mixture was actually 1.6 percent.

Table 2.--Bioassay of cages that held western pine beetle for use as a check of cage contamination by lindane vapors

Spray concentration (pct.)	Cages tested	Insects	Dead and moribund insects	Mortality (3-day)	
				Observed	Corrected ¹
	No.	No.	No.	Percent	
0	5	1,673	405	24.2	--
1	3	902	236	26.2	2.6
1.5	7	2,693	834	31.0	9.0

¹Abbot's formula.

9 percent for the heaviest 1-1/2 percent sprays. If the pooled average mortality for these sprays were corrected by this 9 percent figure (Abbott's formula), the average mortality would change little: from 94.8 percent to 94.3 percent.

In this study, we have not accounted for mortality caused by vapors strong enough to kill by fumigation. But we believe these vapors to be very low owing to the long aging period experienced by the treated bolts. This long lapse would permit the loss of most of the part of the lindane deposit that would freely volatilize from the bark surface. In future studies we suggest that fresh air be piped through emergence cages as an added precaution against the possibility of contamination.

Besides killing overwintering broods of the western pine beetle, lindane at 1.5 percent concentration in diesel oil should be effective the year round on other California species of bark beetles, but this needs further testing. In laboratory and field tests, the California five-spined ips and the mountain pine beetle were even more susceptible to lindane than the western pine beetle.^{7,8} Swain and Wickman (1968) reported that 1.5 percent lindane sprays in diesel oil are highly effective against the California flatheaded borer (*Melanophila californica* Van Dyke).⁹

Sprays, applied from November to April, all produced greater than 99 percent kill.

In recent tests, water emulsions of lindane have been used rather than diesel oil. A 1.5 percent lindane emulsion was found to be just as effective as a diesel oil spray in destroying overwintering broods of the western pine beetle.¹⁰

FOOTNOTES

- ¹Lyon, Robert L. *Structure and toxicity of insecticide deposits for control of bark beetles*. U.S. Dep. Agr. Tech. Bull. 1343, 59 pp. 1965.
- ²Eaton, C.B. Memorandum in files of Pacific SW. Forest and Range Experiment Station, Berkeley, Calif. Dec. 21, 1962.
- ³The authors gratefully acknowledge the assistance given by members of the Bass Lake Ranger District (Sierra National Forest, U.S. Forest Service) on field phases of this study.
- ⁴Samples of each spray batch were checked by a commercial laboratory, for accuracy of formulation.
- ⁵Lyon, Robert L. *Directions for using lindane sprays to control Ips beetles in California*. U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Misc. Paper 33, 8 pp. Rev. 1960. U.S. Forest Service. Region 5 Supplement 344. *Forest Service Handbook 5241.2*. March 1962.
- ⁶Lyon, op. cit. 1965.
- ⁷Lyon, Robert L. *Toxicity of several residual-type insecticides to selected western bark beetles*. J. Econ. Entomol. 52(2):323-327. 1959.
- ⁸Lyon, op. cit. 1965.
- ⁹Swain, Kenneth M. and Wickman, Boyd E. *Lindane can help control California flatheaded borer in Jeffrey pine*. U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Res. Note PSW-162. 5 pp. 1968.
- ¹⁰Brenton H. Teillon, U.S. Forest Service, Branch of Forest Pest Control, San Francisco, California, personal communication. April 1968.

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