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P.O. BOX 245, BERKELEY, CALIFORNIA 94701

CONTACT TOXICITY OF 17 INSECTICIDES

applied topically to adult bark beetles

Robert L. Lyon

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Abstract: Thirteen insecticides were tested against *Ips paraconfusus* Lanier, and six against the western pine beetle *(Dendroctonus brevicomis* Lec.*)*. The ranking of toxicity at LD_{90} by topical application to *I. paraconfusus* was: SD 3450 > endosulfan > malathion > lindane > phorate > carbaryl > carbophenothion = Imidan > crotoxyphos > dimethoate > DDT > Dilan > trichlorfon. The ranking of toxicity to *D. brevicomis* was: Zectran = dichlorvos > Dursban > malathion > pyrethrins = lindane. Five compounds—Zectran, Dursban, malathion, dichlorvos, pyrethrins—show promise for study as possible alternatives to lindane, which is now commonly used for bark beetle suppression.

Oxford: 145.7x19.92 *Ips paraconfusus:*453–414.12 + 145.7x19.92 *Dendroctonus brevicomis:* 453–414.12. *Retrieval Terms: Ips paraconfusus; Dendroctonus brevicomis;* toxicity tests; Zectran; Dursban; malathion; dichlorvos; pyrethrins; lindane.

Ips paraconfusus Lanier, formerly known as *Ips confusus* (LeConte),[1] is one of the most aggressive bark beetles in California. It does the most damage to ponderosa pine *(Pinus ponderosa* Laws.*)* from sapling size to 24 inches d.b.h., but attacks all pine species within its range.[2] *I. paraconfusus* also attacks the limbs and tops of larger trees. An infestation is soon followed by the tree-killing western pine beetle *(Dendroctonus brevicomis* LeConte*)*, the most destructive insect to ponderosa pine.[2]

The toxicity of lindane to bark beetles has been well established.[3] This insecticide, either pure or as the active ingredient of benzene hexachloride (BHC), is now used in California and elsewhere as a bark spray for suppression of bark beetles or for protection against their attack. Nationwide, ethylene dibromide is the only other insecticide which is also used for bark beetle suppression.[4]

The dependence on such a small arsenal for bark beetle suppression poses risks which are compounded by the current disfavor expressed toward chlorinated hydrocarbons, such as lindane.

As part of a large-scale study to find alternatives to chlorinated hydrocarbons, we tested 13 insecticides against *Ips paraconfusus* Lanier and 6 against the western pine beetle. The results suggest that five of the chemicals tested—Zectran, Dursban, malathion, dichlorvos, pyrethrins—show promise as possible alternatives to lindane. Further research and field testing would be necessary before the most suitable candidate insecticide is decided on.

MATERIALS AND METHODS

The insecticides tested were formulated in acetone on the basis of the active ingredient in the technical grade product. Fresh solutions were made on each day of testing. Common and proprietary names and chemical definitions used in this report are those given by the Committee on Insecticide Terminology,

Entomological Society of America.[5] The insecticide SD 3450 is not cited. Its chemical name is: 5,6,7,8,9,9-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanophthalazine.

Testing procedures were similar to those described by Lyon.[6,7] Acetone solutions were applied topically to the venter of the adult beetle at the rate of 1 μl/10 mg. body weight. The insects were held after treatment singly in size No. 000 gelatin capsules. Dead insects were counted 3 days later.

The insecticides were tested on *I. paraconfusus* at four to six different concentrations and replicated usually two to five times. Full dosage-mortality regression curves were obtained for this insect by using a computer program of probit analysis.[8] Additional candidate insecticides were tested at three concentration levels aginst the western pine beetle.

RESULTS

At LD_{90}, three insecticides–SD 3450, endosulfan, and malathion–were more toxic than lindane to *I. paraconfusus,* though the differences were not large *(table 1; fig. 1).* Malathion was less toxic at the LD_{50} level.

All six insecticides tested on the western pine beetle were as toxic as or slightly more toxic than lindane *(table 2).* On the basis of average insect mortalities, the ranking of toxicity was Zectran = dichlorvos > Dursban > malathion > pyrethrins = lindane.

Table 1–*Toxicity of 13 insecticides applied topically to Ips paraconfusus adults*

Insecticide	Insects	Dosage needed[1] for . . .		Toxicity index[2] at . . .	
		LD_{50}	LD_{90}	LD_{50}	LD_{90}
	Number	*μg./g. body weight*			
SD 3450	380	0.11	0.41	2.91	5.15
Endosulfan	600	.24	1.18	1.33	1.79
Malathion	220	.73	1.78	.44	1.18
Lindane (standard)	1,411	.32	2.11	1.00	1.00
Phorate	370	2.60	4.30	.12	.49
Carbaryl	599	1.25	8.66	.26	.24
Carbophenothion	235	6.80	12.5	.047	.17
Imidan	180	4.18	12.6	.076	.17
Crotoxyphos	240	8.30	15.1	.038	.14
Dimethoate	415	4.56	31.9	.070	.066
DDT	300	5.63	48.4	.057	.044
Dilan	340	19.0	55.7	.017	.038
Trichlorfon	240	43.2	118.	.007	.018

[1] LD_{50} = dose lethal to 50 percent of sample; LD_{90} = dose lethal to 90 percent of sample.

[2] Toxicity relative to lindane:

$$\frac{LD_{50\ (or\ 90)}\ \text{lindane}}{LD_{50\ (or\ 90)}\ \text{candidate}} = \text{toxicity index.}$$

Table 2–*Mortality of western pine beetle adults treated with six insecticides at three dosage levels*

Insecticide	Insects	Mortality[1] at dosage of (μg./g. body weight)		
		5	10	20
		Percent		
Zectran	110	100	100	100
Dichlorvos	60	100	100	–
Dursban	110	96	100	100
Malathion	110	85	100	100
Pyrethrins	110	53	100	100
Lindane	180	62	95	100

[1] Corrected for natural mortality by Abbott's formula; natural mortality from treatment with acetone alone was 14 percent.

The five compounds–Zectran, Dursban, malathion, dichlorvos, and pyrethrins–appear to be the most promising candidates for further study. They are at least as toxic as lindane and, unlike chlorinated hydrocarbons, do not have the troublesome quality of persistence in the environment. They may, however, have insufficient persistence in bark. Residual action in bark is of considerable importance in bark beetle suppression, as it tends to increase the effectiveness of sprays and their flexibility of use. Residual life of these five compounds, when applied to bark, is not now known. Laboratory and field tests with deposits in bark are needed to assess fully their potential for use against bark beetles.

NOTES

[1] Lanier, G. N. *Biosystematics of North American Ips (Coleoptera: Scolytidae) Hopping's group IX.* Can. Entomol. 102(9): 1139-1163, 1970.

[2] Struble, George R., and Hall, Ralph C. *The California five-spined engraver–its biology and control.* U.S. Dep. Agr. Circ. 964, 21 p., illus. 1955.

[3] Lyon, Robert L. *Structure and toxicity of insecticide deposits for control of bark beetles.* U.S. Dep. Agr. Tech. Bull. 1343, 59 p. 1965.

[4] Lyon, Robert L. *Formulation and structure of residual insecticides for bark beetle control. In,* Advances in Chemistry Ser. 86: 192-206. R. F. Gould, ed., Washington, D.C.: Amer. Chem. Soc. 1969.

[5] Billings, Samuel C. *Consolidated list of approved common names of insecticides and certain other pesticides.* Bull.

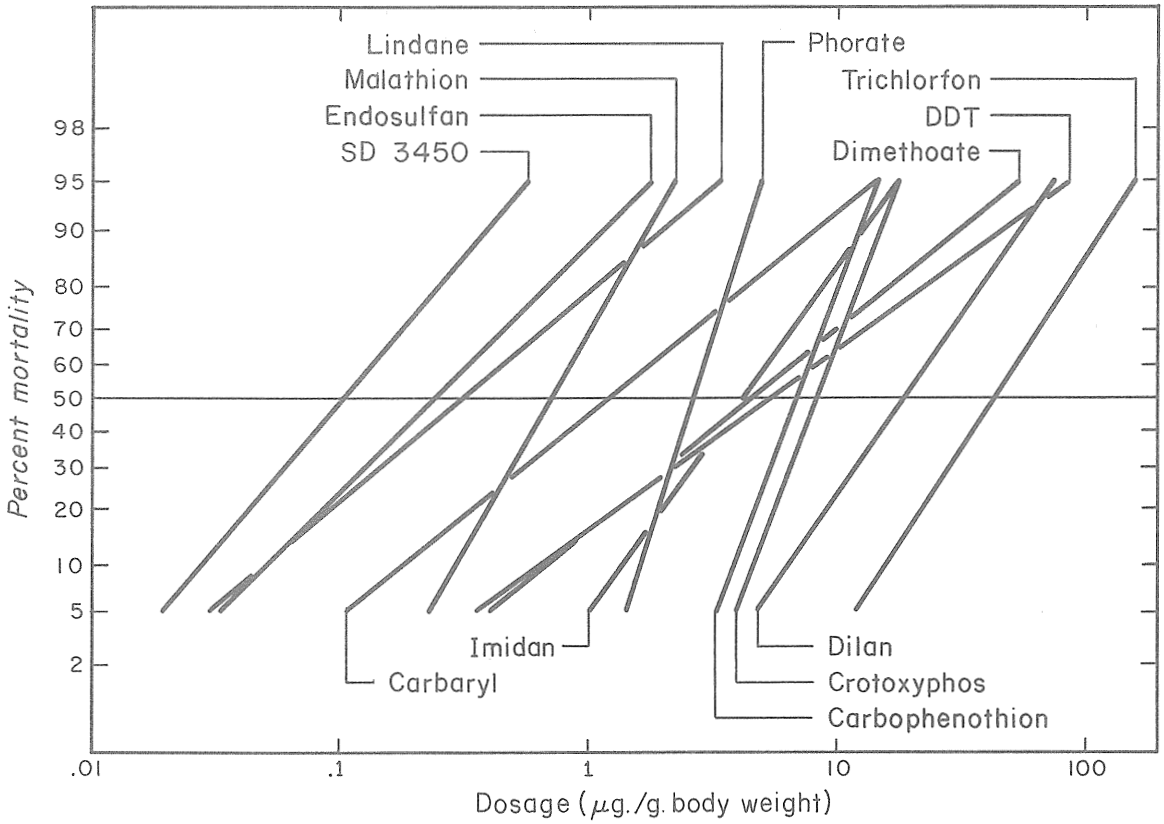

Figure 1—*Dosage-mortality curves for 13 insecticides applied topically to Ips paraconfusus adults.*

Entomol. Soc. Amer. 11(3): 204-213, 1965; 12(3): 356-357, 1966; 13(4): 342, 1967; 14(4): 289, 1968; 15(4): 380, 1969.

[6]Lyon, Robert L. *Toxicity of several residual-type insecticides to selected western bark beetles.* J. Econ. Entomol. 52(2): 323-327, 1959.

[7]The assistance of Burton D. Combs and Peter Letchworth in the bioassay is gratefully acknowledged.

[8]Provided by Gerald S. Walton, U.S. Forest Service, Upper Darby, Pa.

The Author

ROBERT L. LYON, a research entomologist, is responsible for insect culture and bioassay in the Station's studies in the evaluation of chemical insecticides. He attended New York State University College of Forestry, where he earned B.S. (1953) and M.S. (1954) degrees. He received a doctorate in entomology (1961) from the University of California, Berkeley.

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