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Contact Toxicity of 14 INSECTICIDES TESTED ON PINE BUTTERFLY LARVAE

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Abstract: Fourteen insecticides were evaluated for contact toxicity to 3rd and 4th stage pine butterfly larvae *(Neophasia menapia* F. & F.*)* in a laboratory spray chamber. All candidate insecticides except trichlorfon were more toxic than the standard DDT. The ranking of toxicity at LD_{90} and toxicity indexes (times more toxic than DDT) were: SBP-1382 (117), pyrethrins (62), Dowco 214 (22), methomyl (6.2), chlorpyrifos (6.2), Gardona (4.5), Sumithion (3.8), phoxim (2.8), Zectran (2.4), aminocarb (2.2), malathion (1.6), carbaryl (1.6), DDT (1.0), and trichlorfon (<1.0).

Oxford: 453:145.7x18.63 *Neophasia menapia*: 414.4–015.
Retrieval Terms: Neophasia menapia; insecticide evaluation; contact toxicity; pyrethrins; SBP-1382; environmental effects.

The pine butterfly *(Neophasia menapia* F. & F.*)* is generally found throughout the coniferous forests of Northwestern United States and British Columbia. Its preferred host is ponderosa pine *(Pinus ponderosa* Laws.*)*, but it also attacks other conifers—particularly during outbreaks in stands of mixed species.[1,2] Infestations by the pine butterfly can lead to tree mortality, and its attacks sometimes are followed by those of the tree-killing bark beetles.[2]

The insecticide used in the past to suppress this insect was usually DDT.[2] Because DDT is now banned for insect control on public lands, new chemicals are under study as substitutes.

As part of that work, we tested 14 insecticides on the pine butterfly larvae in the 3rd and 4th stages. We know of no previous reports of laboratory studies of insecticides applied to this insect. Among the 14 insecticides we tested by spraying in a chamber, the most toxic was SBP-1382. This synthetic pyrethroid was 117 times more toxic than DDT. And among the 14, only one—trichlorfon—was less toxic than DDT.

METHODS

Pine butterfly eggs were collected from the Bitterroot Valley near Missoula, Montana in October 1969[3] and shipped to Berkeley, California. They were refrigerated immediately on arrival at 10°C. for 4 days, and then at 4°C. for 3 months to break diapause.

The eggs were removed from refrigeration at regular intervals from February to May 1970 to provide a continuous supply of larvae for insecticide evaluation. Eggs were disinfected by washing them 15 minutes in 10 percent formaldehyde, then were rinsed twice in distilled water. Eggs were then placed on cut branches of ponderosa pine in containers of water and kept in sleeve cages at a temperature of 23

to 26°C. and ambient humidity. Attempts to rear the larvae on two different artificial diets[4,5], resulted in less than 10 percent survival. Survival on the ponderosa pine foliage exceeded 80 percent.

The chemical names and structural formulas for the 14 insecticides tested[6] are given by Kenaga and Allison,[7] except for SBP-1382. This synthetic pyrethroid has the chemical name of (5-benzyl-3-furyl) methyl 2,2-dimethyl-3-(2-methylpropenyl) cyclopropanecarboxylate. The other 13 insecticides tested were:

Pyrethrins	Zectran
Dowco 214	Aminocarb
Methomyl	Malathion
Chlorpyrifos	Carbaryl
Gardona	DDT
Sumithion	Trichlorfon
Phoxim	

The insecticides were formulated fresh in tripropylene glycol monomethyl ether (TPM) for each day of testing. Serial dilutions were made to provide four to five different concentrations for each insecticide. Tests on each insecticide were replicated three to five times using 20 insects per concentration in each replication.

To assure that only 3rd and 4th stage larvae were used in the evaluation, head capsules were measured in each instar by using a binocular microscope at 36X magnification fitted with an eyepiece micrometer. The measured larvae were preserved and used as a guide in selecting test specimens.

The laboratory testing procedure was as follows: 3rd and 4th stage larvae were treated in groups of 10 while aggregated in feeding position on individual pine needles. The needles were sprayed in a laboratory spray chamber[8] while held upright in 1-cm.-deep holes bored in polystyrene foam. The dosage of insecticide solution deposited in the spray chamber was 0.0339 μl/sq. cm. (equivalent to 2.9 pints/acre). The mass median diameter of the spray droplets was about 20μ.

Dosage was estimated by weighing the spray deposited in the spray chamber on 12-mm. diameter aluminum pans with a Cahn Electrobalance.[9] The deposit measured in μg/sq. cm. was converted to oz./acre by the formula (0.7 μg/sq. cm. = 1 oz./acre):

$$\frac{\mu g/cm^2}{0.7} = \text{oz./acre.}$$

Both expressions of dosage used in this report refer to the active ingredient.

After treatment, larvae were transferred from the treated pine needles to 100- by 20-mm. plastic disposable petri dishes containing fresh pine needles and lined with moist filter paper. The pine needles were randomly crisscrossed to elevate them above the surface of the petri dish and allow the larvae to cling in feeding position. The post-treatment temperatures ranged from 22 to 24°C. Mortality was determined 3 days after treatment. Mortality due to treatment with TPM alone was 7 percent of 457 larvae observed. Mortality data were analyzed by a computer program of probit analysis.[9]

RESULTS

Measurement of head capsules showed five instars *(table 1)*. Cole[10] reported six instars in his laboratory rearings. Our figures for head capsule width, however are consistently four to five times larger than those reported by Cole, e.g., 2.86 mm. vs. 0.577 mm. for the 5th instar. Cole's measurement for the 5th instar (0.577 mm.) is smaller than our measurement for the lst instar (0.68 mm.). As a larva, this insect grows to about 25 mm. long. Cole's estimates of head capsule width seem too low for an insect of this size.

All candidates except trichlorfon were more toxic than DDT *(table 2; fig. 1)*. SBP-1382 was the most toxic compound: 117 times more toxic than DDT at LD_{90}. Next were pyrethrins—62 times more toxic than DDT—and Dowco 214—22 times more so. The remaining nine candidates showed toxicity only moderately higher than DDT, with indexes ranging from 1 to 6.

DDT has been used for pine butterfly control at the rate of 1 lb./acre.[2] In our laboratory tests *(table 2)*, 90 percent mortality was obtained with the equivalent of 6.8 oz./acre. The residual effect of DDT was omitted in these tests and would probably have

Table 1—*Width of head capsules of pine butterfly larvae*

Instar[1]	Head capsule width		Growth ratio[2]
	Average	Range	
	mm.		
1	0.68	0.62 - 0.70	–
2	.90	.80 - .98	1.32
3	1.25	1.18 - 1.52	1.39
4	1.79	1.58 - 2.15	1.43
5	2.86	2.50 - 3.15	1.60

[1] 20 insects measured in each instar.

[2] Average head width of each instar divided by the average head width of the next smaller instar.

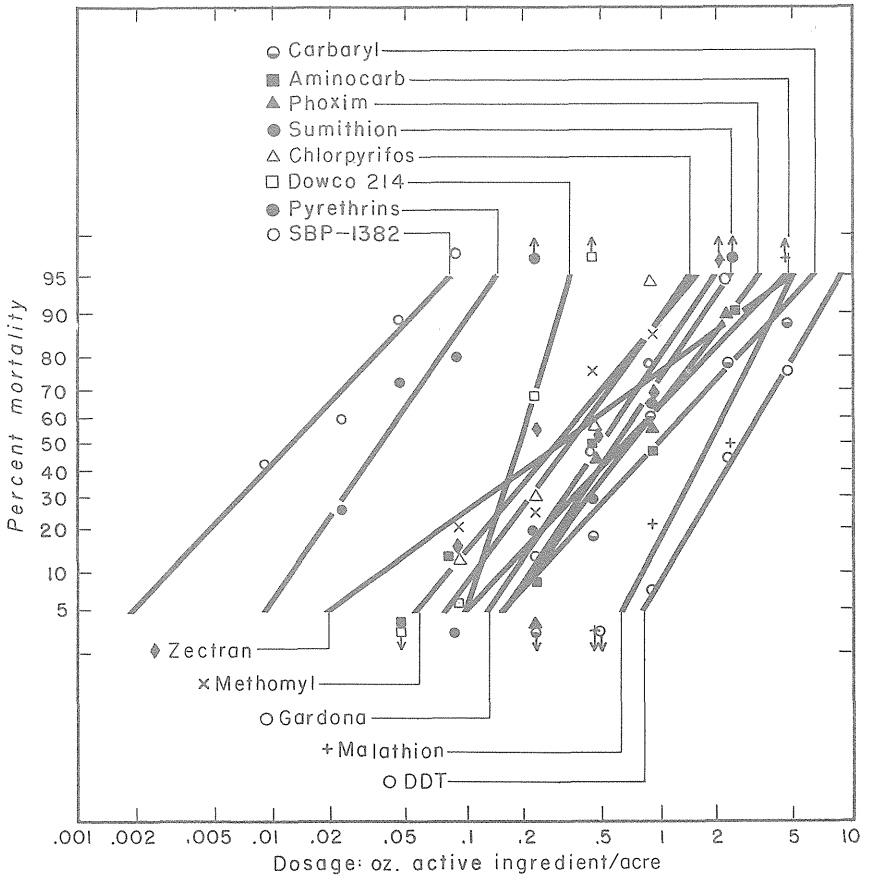

Figure 1—*Dosage-mortality curves for 3rd and 4th stage pine butterfly larvae treated in a laboratory spray chamber.*

Table 2—*Toxicity of 14 insecticides applied in a laboratory spray chamber to 3rd and 4th stage pine butterfly larvae*

Insecticide	Insects treated	LD_{50}	LD_{90}	Toxicity index[1]
	No.	— *Oz./acre* —		
SBP-1382	220	0.013	0.058	117
Pyrethrins	318	.037	.11	62
Dowco 214	179	.19	.31	22
Methomyl	170	.30	1.1	6.2
Chlorpyrifos	140	.35	1.1	6.2
Gardona	140	.52	1.5	4.5
Sumithion	300	.62	1.8	3.8
Phoxim	177	.72	2.4	2.8
Zectran	357	.32	2.8	2.4
Aminocarb	259	.70	3.1	2.2
Malathion	160	1.8	4.1	1.6
Carbaryl	280	1.0	4.3	1.6
DDT	240	2.7	6.8	1.0
Trichlorfon	199	>4.7	–	<1.0

[1] $\frac{LD_{90} \text{ of DDT}}{LD_{90} \text{ of candidate}}$ = toxicity index (times more toxic than DDT).

reduced the dosage needed for 90 percent mortality even further. Although it is not possible to predict the minimum effective field dosage by extrapolation from laboratory data, this study suggests several candidates which would provide adequate field mortality at considerably less than 1 lb./acre. But field tests would be needed to establish the minimum effective dosages.

NOTES

[1]Essig, E. O. *Insects and mites of western North America.* 1050 p. New York: Macmillan Co. Rev. 1958.

[2]Cole, Walter E. *Pine butterfly.* Forest Pest Leafl. 66, 4 p. 1961.

[3]Eggs were supplied by the Division of State and Private Forestry, U.S. Forest Service, Northern Region, Missoula, Montana.

[4]Lyon, Robert L., C. E. Richmond, J. L. Robertson, and B. A. Lucas. *Rearing diapause and diapause-free western spruce budworm (Choristoneura occidentalis) on an artificial diet.* (Accepted for publication in The Canadian Entomologist.)

[5]Addy, Norton D. *Rearing the forest tent caterpillar on an artificial diet.* J. Econ. Entomol. 62(1): 270-271. 1969.

[6]The following companies provided technical-grade samples: Chemagro, Cyanamid, Dow Chemical, DuPont, MGK, S. B. Penick, Shell Chemical, and Union Carbide.

[7]Kenaga, Eugene E., and William E. Allison. *Commercial and experimental organic insecticides.* Bull. Entomol. Soc. Amer. 15(2): 85-148. 1969.

[8]Lyon, Robert L., Marion Page, and Sylvia J. Brown. *Tolerance of spruce budworm to malathion. . .Montana, New Mexico populations show no differences.* USDA Forest Serv. Res. Note PSW-173, 6 p. 1968.

[9]Computer program provided by Gerald S. Walton, U.S. Forest Service, Upper Darby, Pennsylvania.

[10]Cole, Walter E. *Biological observations on the pine butterfly during an outbreak in southern Idaho, 1953-1954.* U.S. Forest Serv. Intermountain Forest & Range Exp. Sta. Res. Note 29, 8 p. 1956.

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