Contact Toxicity of 38 Insecticides to Pales Weevil Adults[1,2]

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The pales weevil, *Hylobius pales* (Herbst), attacks all pine species in Eastern North America and is considered the most destructive pest of pine reproduction in the Eastern United States (Speers and Rauchenberger 1971). Large numbers of seedlings are damaged or killed by the adult weevils, which feed on the inner bark.

Aldrin, BHC, dieldrin, DDT, or heptachlor applied as preplanting dips effectively protect seedlings (Thatcher 1958, Thomas 1971). The use of aldrin as a preplanting seedling dip, although permitted in the past by the U. S. Environmental Protection Agency, has not been registered (pers. commun. James Touhy, EPA, June 14, 1974). Because the continued use of this chlorinated hydrocarbon is ecologically undesirable, alternative chemicals must be found to reduce weevil damage below the level which causes seedling mortality. Therefore, we studied the toxicity of 38 insecticides topically applied to pales weevil adults.

Materials and Methods.—Insects.—Adult weevils were shipped to Berkeley, Calif., from January 1971 to June 1972. Specimens were received from a laboratory colony in Asheville, N.C., a laboratory colony in Athens, Ga., and field collections near Asheville, N.C. Most of the test insects came from the Asheville colony.

The insects were used within 3 wk of their arrival. Most were held before testing in containers made from plastic disposable mouse cages. Two bottom sections, each ca. 29×18×18 cm, were taped together. A layer of sawdust was placed in the lower half and a 5×5-cm air hole covered with 22-mesh plastic screen was made in the upper half. As many as 500 pales weevils could be held in each container without detrimental effects. The insects were initially fed the branchwood which was shipped with them—either loblolly pine, *Pinus taeda* L., or white pine, *P. strobus* L. Later they were fed stems of sugar pine, *P. lambertiana* Dougl. All containers were carefully checked for the presence of an entomogenous fungus, *Beauvaria sp.*, and diseased insects were discarded.

Groups of 50–100 insects also were held successfully in sterile plastic petri dishes 150×25 mm with ca. 15 sugar pine twigs cut to fit the dish. Fifty holes, each ca. 2 mm diam, were made in the top of the dish, which was sealed tightly with rubber bands to prevent the escape of any insects.

Insecticides.—We selected 38 insecticides[3] for testing (Table 1):[4] 9 carbamates, 2 chlorinated hydrocarbons, 24 organophosphates, and 3 pyrethroids. Those without approved common names were: Dasanit® (*O,O*-diethyl-*O*-*p*[(methylsulfinyl) phenyl] phosphorothioate), Dowco 217® ([dimethyl 3,5,6-trichloro-2-pyridyl] phosphorothioate), Landrin® (3,4,5-(93%) and 2,3,5-trimethylphenyl methyl carbamate (7%)), Lauroyl-trichlorfon[5] (dimethyl [2,2,2-trichloro-1-dodecanoyl oxyethyl] phosphonate), Methyl Trithion® (*S*-[*p*-chlorophenylthio) methyl]*O*-*O*-dimethyl phosphorodithioate), Mobam® (4-benzothienyl-*N*-methylcarbamate), Monitor® (*O*-*S*-dimethyl phosphoramidothioate), Orthene® (*O*-*S*-dimethyl *N*-acetyl phosphoramidothioate), and Padan® (*S,S'*[2-(dimethylamino) trimethylene] bis (thiocarbamate), hydrochloride).

Lauroyl-trichlorfon, an acyl derivative of trichlorfon, was included because it has a higher mammalian selectivity ratio than its parent compound[6] but is at least as toxic to lepidopterous larvae.[7]

Padan was formulated in water:ethanol (1:1); the remaining candidates were formulated in reagent grade acetone. Serial dilutions were made from stock solutions prepared fresh daily. Four to 8 concn of each chemical were tested in each of at least 3 replications.

Treatment Procedure.—The insects were segregated into groups of 10, by weight and by sex, in sterile plastic petri dishes (100×20 mm) lined with filter paper. Sex was determined by the characters described by Franklin (1966). An ISCO model M microapplicator with a ¼ tuberculin syringe and a 27-gauge hypodermic needle were used for topical treatment at the dose rate of 1 μl/100 mg body weight. The drop was applied to the thoracic sterna of CO_2-anesthetized insects. Control insects were treated with solvent only; they were included in each replicate of each chemical. After treatment, weevils were held in the same petri dishes and fed small sections of sugar pine twigs.

Mortality was recorded 5 days after treatment. Each insect was prodded on the ventral surface with forceps to ascertain whether it was alive, dead or moribund (unable to walk). Since these weevils characteristically feign death, considerable care was taken in determining dead and moribund individuals. Numbers of dead and moribund insects were combined for probit analysis (Daum 1970). Regression curves were computed from the pooled data for both sexes for all chemicals except 5 carbamates which were not toxic at the highest dose tested (1,670 μg/g body weight). For 28 of the 38 compounds, sufficient data were available to compute separate regression curves for males and females.

Results and Discussion.—The insecticides which exceeded aldrin in toxicity at LD_{50} (Table 1), in decreasing order of toxicity, were Dowco 217, chlormethylfos, bioethanomethrin, chlorpyrifos, chlorphoxim, resmethrin, phoxim, fenitrothion, and fenthion. At LD_{90}, Dowco 217, chlormethylfos, bioethanomethrin, chlorpyrifos, chlorphoxim, and resmethrin exceeded aldrin in toxicity. Organophosphorous insecticides were, in general, highly effective, as were the pyrethroids. Carbamates were, with the exception of methomyl and carbofuran, virtually non-

[1] Coleoptera: Curculionidae.
[2] Received for publication July 19, 1974.
[3] This paper reports research involving insecticides. It does not report recommendations for their use nor does it imply that any uses described here have been registered. All uses of insecticides must be registered by appropriate State or Federal agencies or both before they can be recommended.
[4] Technical grade insecticide samples were provided by American Cyanamid Co., Chemagro Corp., Chevron Chemical Co., City Chemical Corp., Dow Chemical Co., E. I. DuPont de Nemours and Co. Inc., Geigy Agricultural Chemicals, McLaughlin Gormley King Co., Mobil Chemical Co., Niagara Chemical Division of FMC Corp., S. B. Penick and Company, Shell Development Co., Stauffer Chemical Co., and Union Carbide Corp.
[5] Synthesized by Melvin Look and Larry White, U.S. For. Serv., Berkeley, Calif.
[6] T. L. Andrews, U.S. For. Serv., Berkeley, Calif. Unpublished data.
[7] J. Robertson. Unpublished data.

Table 1.—Toxicity of insecticides topically applied to pales weevil adults.

Insecticide and group[a]	Insects treated	Slope±SE	LD_{50}[b]	95% fiducial limits	LD_{90}[b]	95% fiducial limits	Toxicity ratio[f] LD_{50}	Toxicity ratio[f] LD_{90}
Dowco 217 (O)	300[c]	3.87±0.46	3.63	3.13– 4.11	7.77	6.64– 9.72	4.49	3.67
Chlormethylfos (O)	388[c]	3.72±0.49	3.97	3.32– 4.62	8.78	7.32– 11.4	4.10	3.25
Bioethanomethrin (P)	220[e]	3.38±0.42	3.94	3.18– 4.71	9.43	7.67– 12.5	4.14	3.02
Chlorpyrifos (O)	407[c]	4.10±0.31	6.51	5.99– 7.04	13.4	12.0 – 15.2	2.50	2.13
Chlorphoxim (O)	219[c]	4.64±0.46	8.00	7.29– 8.71	15.1	13.4 – 17.7	2.04	1.89
Resmethrin (P)	520[e]	4.10±0.34	11.2	10.2 – 12.1	23.0	20.6 – 26.5	1.46	1.24
Aldrin (CH)	420[c]	5.30±0.62	16.3	14.8 – 17.9	28.5	25.1 – 34.3	1.00	1.00
Phoxim (O)	460[c]	3.78±0.31	13.1	12.0 – 14.3	28.7	25.2 – 34.1	1.24	0.99
Fenitrothion (O)	280[c]	4.46±0.55	15.4	13.7 – 17.2	29.8	25.5 – 37.5	1.06	0.96
Fenthion (O)	309[c]	3.71±0.15	16.2	15.4 – 17.0	35.8	33.3 – 38.9	1.01	0.80
Methyl Trithion (O)	210[c]	4.38±0.48	19.1	17.1 – 21.1	37.5	32.7 – 45.3	0.85	0.76
Monitor (O)	220[c]	4.57±0.22	24.9	23.6 – 26.2	47.5	44.4 – 51.3	0.65	0.60
Phorate (O)	360[c]	3.80±0.43	30.6	26.4 – 34.7	66.6	57.0 – 82.5	0.53	0.43
Malathion (O)	259[c]	2.71±0.30	24.7	20.7 – 29.1	73.4	58.9 – 100	0.66	0.39
Pyrethrins (P)	300[c]	4.46±0.30	69.0	64.5 – 73.7	134	122 – 149	0.24	0.21
Dasanit (O)	350[c]	2.77±0.23	48.7	43.4 – 53.9	141	122 – 170	0.33	0.20
Phosmet (O)	281[c]	1.64±0.15	32.9	26.4 – 40.3	200	149 – 294	0.50	0.14
Methomyl (C)	180[c]	3.05±0.77	77.0	58.6 – 106	203	135 – 602	0.21	0.14
Methomyl (C)	320[c]	2.33±0.38	62.8	51.0 – 76.9	223	158 – 421	0.26	0.13
Trichlorfon (O)	320[c, d]	3.03±0.25	84.8	78.8 – 82.0	225	190 – 284	0.19	0.13
Diazinon (O)	320[c, d]	4.08±0.42	120	110 – 132	248	212 – 309	0.14	0.12
Orthene (O)	559[e]	2.33±0.17	70.0	64.6 – 75.8	248	212 – 308	0.23	0.12
Carbofuran (C)	480[c, d]	1.84±0.32	50.0	35.0 – 73.4	248	140 – 889	0.33	0.12
Padan (C)	340[d, e]	2.20±0.33	74.4	54.7 – 93.0	284	214 – 447	0.22	0.10
Dicrotophos (O)	240[c, e]	3.06±0.38	143	117 – 168	376	309 – 496	0.11	0.08
Dimethoate (O)	260[c]	3.18±0.34	152	134 – 172	386	322 – 497	0.11	0.07
Lauroyl-trichlorfon (O)	381[c, e]	2.36±0.60	126	100 – 210	439	245 – 2400	0.13	0.065
$DDT_{pp'}$ (CH)	279[e]	2.74±0.52	170	112 – 236	499	332 – 1360	0.096	0.057
$DDT_{pp'}$ (CH)	400[c]	3.29±0.20	227	211 – 234	555	501 – 628	0.072	0.051
Disulfoton (O)	290[c, e]	5.95±0.50	547	510 – 583	898	824 – 1000	0.030	0.032
Demeton (O)	279[c, e]	4.68±0.44	506	461 – 551	951	850 – 1100	0.032	0.030
Phosphamidon (O)	260[c, e]	3.57±0.40	433	374 – 488	989	852 – 1220	0.038	0.029
Tetrachlorvinfos (O)	300[c, d]	1.41±0.22	150	99.8 – 202	1220	789 – 2540	0.11	0.023
$DDT_{pp'}$ (CH)	414[d]	2.10±0.36	338	273 – 427	1370	904 – 3050	0.048	0.021
Tetrachlorvinfos (O)	200[c]	1.40±0.26	176	110 – 247	1450	849 – 4100	0.093	0.020
Propoxur (C)	260[c, d]	2.00±0.45	797	612 –1090	3490	2060 –12800	0.020	0.008
Oxydemetonmethyl (O)	270[c, e]	2.19±0.44	1620	1260 –2660	6260	3470 –23500	0.010	0.004
Carbaryl (C)	90[c]	—	>1670	—	—	—	<0.010	—
Dimetilan (C)	100[c]	—	>1670	—	—	—	<0.010	—
Landrin (C)	120[c]	—	>1670	—	—	—	<0.010	—
Mobam (C)	140[c]	—	>1670	—	—	—	<0.010	—
Mexacarbate (C)	240[c]	—	>1670	—	—	—	<0.010	—

[a] C = carbamate, CH= chlorinated hydrocarbon, O = organophosphate, and P = pyrethroid.
[b] $\mu g/g$ body wt.
[c] From a laboratory colony in Asheville, N.C.
[d] Collected from field in Asheville, N.C.
[e] From a laboratory colony in Athens, Ga.
[f] Toxicity relative to aldrin = LD aldrin/LD candidate.

toxic. The responses of males and females to 28 of the candidate insecticides for which adequate data were available did not differ significantly at the LD_{50} level.

Our use of test insects from 3 different sources was not a part of the study plan, but a practical necessity. Some caution must be used, therefore, in interpreting the results. As a check, DDT was tested on adults from all 3 sources. The 2 laboratory colonies were similar in their susceptibility to DDT, but the field-collected insects were significantly more tolerant at LD_{50} (Table 1). We concluded that the order of toxicity of demeton, dicrotophos, disulfoton, Lauroyl-trichlorfon, oxydemetonmethyl, and phosphamidon (Table 1) was not significantly affected by the use of mixed laboratory colonies. The use of mixed laboratory and field insects could have significantly affected the order of carbofuran, dasanit, diazinon, methomyl, Padan, phorate, propoxur, tetrachlorvinfos, and trichlorfon. Because our data for tetrachlorvinfos and methomyl could be analyzed separately, we compared the response of a subsample of laboratory-reared insects with that of the combined laboratory and field insects. In neither instance did the subsample differ significantly in response from the combined sample (Table 1). We do not know to what extent, if any, the order of the other compounds in this group might have been affected by using the mixture of laboratory and field insects since it is not possible to extrapolate from the results with DDT.

The slopes of ld-p lines of DDT suggest a greater heterogeneity in the response of field-collected insects (slope 2.1) compared to the lab insects (slopes 2.7 and 3.3). The higher tolerance of field insects toward DDT may have been a result of their greater genetic diversity or of physiological differences such as age.

Our results indicated that several insecticides might be effective substitutes for aldrin. Nord et al.[8] and Walstad[9] field tested several of these chemicals in various formulations. They found that carbofuran, chlorpyrifos, and phosmet protected pine seedlings from pales weevil damage when applied as foliar dips and sprays. Carbofuran also was effective when applied in granular form around seedlings.[9] In tests of carbofuran as a clay slurry root dip, Walstad et al. (1973) demonstrated that loblolly pine seedlings were protected for the duration of the spring feeding period.

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