Tolerance of the Stages of *Stethorus punctum*[1] to Selected Insecticides and Miticides[2]

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ABSTRACT

The toxicity of 16 pesticides to all life stages of the predatory coccinellid *Stethorus punctum* (LeConte) resulted in a high number of survivors from all treatments except 0.50 lb active ingredient (AI) per 100 gallons of carbaryl WP 50%, and 0.1875 lb AI/100 gal carbofuran WP 75% when tested in an insectary. At the dosages tested, most other materials tested could be used in an integrated control program of apple pests with a high rate of survival of this predaceous arthropod.

The ladybird beetle, *Stethorus punctum* (LeConte), is one of the most important native predators of the European red mite, *Panonychus ulmi* (Koch), in south-central Pennsylvania. A need exists to establish the toxicity of various insecticides and miticides used for control of apple pests to all life stages of *S. punctum* to develop programs of integrated control.

There are only a few reports in the literature on the effectiveness of any specific dosages of insecticides or miticides on any life stage of *S. punctum*. There are still fewer reports of the effectiveness of any material commonly used in orchard spray programs today. A review of the literature pertaining to this subject has been published (Colburn and Asquith 1970). The present paper reports the insectary evaluation of the effect of 16 insecticides and miticides, at dosages used for apple pests, on the adults, eggs, larvae, and pupae of *S. punctum*. This information is essential in deciding if a material can be utilized in future integrated chemical and biological control programs.

We (Colburn and Asquith 1970) found that 0.50 lb AI/100 gal Galecron® (*N'*-(4-chloro-*o*-tolyl)-*N,N*-dimethylformamidine) 4 EC/100 gal; 0.375 lb AI Gardona® (2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate) WP 75%; 0.375 lb AI Imidan® (*O,O*-dimethyl *S*-phthalimidomethyl phosphorodithioate) WP 50%; 0.125 lb AI azinphosmethyl WP 50%; and 0.200 lb AI Lovozal® (phenyl 5,6-dichloro-2-(trifluoromethyl)-1-benzimidazolecarboxylate) WP 40%, when evaluated in the laboratory for toxicity to *S. punctum* adults all resulted in a high number of survivors for all treatments.

MATERIALS AND METHODS.—The insecticides and acaricides tested, their formulations, active ingredients of proprietary compounds, and sources were:

Chlorinated hydrocarbons:

Endosulfan WP 50%, Niagara Chemical Division, FMC Corp.

Carbamates:

Formetanate SP 95%, Morton Chemical Co.
Carbaryl WP 50%, Union Carbide Co.
Carbofuran WP 75%, Niagara Chemical Division, FMC Corp.

Phosphorous compounds:

Azinphosmethyl WP 50%, Chemagro Corp.
Demeton EC 6 lb/gal, Chemagro Corp.
Dialifor EC 6 lb/gal, Hercules Inc.
Dimethoate EC 2.67 lb/gal, American Cyanamid Co.
Dimethoate WP 25%, American Cyanamid Co.
Gardona WP 75%, Shell Chemical Co.
Imidan WP 50%, Stauffer Chemical Co.
Phosalone WP 25%, Chipman Division, Rhodia, Inc.

Miscellaneous compounds:

Fundal SP® 95% (*N'*-(4-chloro-*o*-tolyl)-*N,N*-dimethylformamidine hydrochloride, Morton Chemical Co.
Galecron EC, 4 lb/gal, Ciba Corp.
Lovozal WP 40%, Fisons Corp.
Plictran® WP 50% (tricyclohexylhydroxytin) Dow Chemical Co.

The test materials were weighed and mixed in the appropriate amount of water. The tests on all stages of the beetle were conducted in an insectary.

Evaluation of Tolerance of Adults.—Adults of *S. punctum* were obtained from 3 apple orchards in south-central Pennsylvania on 5 different dates in 1970 from May 14 to Aug. 25. Adult beetles were collected from trees and tested by the methods described previously (Colburn and Asquith 1970). Each formulation was tested on 20 beetles with a check of 10 wetted (water) and 10 nonwetted beetles maintained on each test date.

Relative humidtiy ranged from 20 to 100% (mean 70%). Temperature ranged from 55 to 92°F (mean 73°F). Observations were made at 1, 2, 4, 8, 12, 24, and 48 hr after treatment. An average percent survival was computed.

Evaluation of Tolerance of Eggs.—Eggs of *S. punctum* were collected on 8 different dates in 1970 from 2 Adams County apple orchards, one at Arendtsville and the other at Heacock's orchard near Biglerville. The eggs were collected from the trees first by selecting leaves with adult *S. punctum* present. These leaves were taken to the insectary and the eggs were located under a microscope, and each egg was circled in ink on the leaf and numbered.

When an egg (or eggs) was located on a leaf and the egg's location was marked, the leaf petiole was inserted in moistened (water) cotton and sealed with parafilm. The cotton was moistened each day for the duration of the test. A small amount of each test pesticide was placed in separate styrofoam cups and an entire leaf with the eggs was dipped in each separate solution. The leaves were then taped to a strip of wood in an upright position. Each pesticide was tested on 10 eggs of *S. punctum*. Five check eggs

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were dipped in water and 5 were kept dry throughout each test period.

Relative humidity ranged from 16 to 100% (mean 65%). Temperatures ranged from 50 to 94°F (mean 71°F). Results were recorded each day for 7 days. An average daily percent emergence was computed.

Evaluation of Tolerance of Larvae.—Larvae of *S. punctum* were collected from Heacock's apple orchard on 6 different dates in 1970 and returned to the insectary for the test. Larvae were collected by removing leaves containing the larvae from the apple trees and placing them in plastic bags for transport back to the insectary.

A special cage to confine the larvae during the test was constructed from the following materials: 1 plastic box 2×2×1⅛ in.,[5] white dacron-ninon screening, Acrylite® acyrlic plastic,[6] and Testor's plastic cement no. 3501.[7]

The cage was constructed by drilling 1-in. holes in both the front and back sides of the plastic box with a 1-in. hole saw. These holes were then covered with the screening which was glued in place. The box was glued to a 2½×5¼×⅛-in. plastic strip leaving ⅝ in. overhang in the front to allow the front of the box to be opened. Two ½-in. holes were then drilled through the plastic and the base of the box leaving 1 1/16 in. between holes. These openings supported the stoppers which held the leaves in position. One-half-inch strips of plastic were glued along both outer edges of the base piece of plastic to hold the cage in position over a petri dish which was filled with water to keep the leaves healthy during the test. Two of these cages were placed side by side on each base with ¾-in. separating the boxes (Fig. 1).

The leaf petioles were placed through the holes in the stoppers, allowing the leaves to obtain water from the petri dish. The leaves in the stoppers were placed in the test boxes, and European red mites were brushed onto the leaves as a food source for the *S. punctum* larvae.

A small amount of each pesticide was placed in separate styrofoam cups. The larvae were immersed in the material and placed on a small piece of filter paper in the center of the bottom of the test cage. The front of the box was shut and the test was begun.

Each formulation was tested on 20 *S. punctum* larvae. Ten check larvae were dipped in tower (well) water, and 10 were kept dry throughout each test period.

Relative humidity ranged from 20 to 100% (mean 66%). The temperature range was 55–92°F (mean 74°F). Results were recorded at 1, 2, 4, 8, 12, 24, and 48 hr after treatment. An average percent survival was computed.

Evaluation of Tolerance of Pupae.—*S. punctum* pupae were collected from 2 apple orchards, Arendtsville and Biglerville, on 3 different dates in 1970 and returned to an insectary for the test period.

Entire 'York Imperial' apple leaves with pupae present were removed from the trees and placed in plastic bags and taken to the insectary; here the pupae were checked by use of a microscope to assure that they were alive. When pupae were located on a leaf the location was recorded and the leaf was then selected for the pupal test.

A small amount of each pesticide was placed in separate styrofoam cups. With the pupae marked and numbered, an entire leaf with the pupae present was dipped into each material and allowed to air dry. The petiole of the leaf was placed through

Table 1.—Influence of various insecticides and miticides on all stages of *S. punctum*.

Material	lb AI/ 100 gal	Percent survival			
		Adults[a]	Eggs[b]	Larvae[a]	Pupae[a]
Endosulfan WP 50%	0.500	45	100	70	100
Formetanate SP 95%	.475	85	30	35	100
Carbaryl WP 50%	.500	0	0	0	60
	1.000	0	0	0	60
Carbofuran WP 75%	.075	0			
	.1875	0	0	0	0
Azinphosmethyl	.125	85	70	80	90
WP 50%	.250	70	70	80	100
	.500	50	80	45	100
Demeton 66 EC	.1875	35	80	55	100
Dialifor 6 EC	.375	65	20	0	100
Dimethoate 2.67 EC	.250	55	80	40	100
WP 25%	.250	35	80	70	80
Gardona WP 75%	.1875	70	60	45	90
	.375	70	100	15	90
Imidan WP 50%	.250	95	80	70	100
		80	60	0	100
Phosalone WP 25%	.375	90	90	70	80
Galecron 4 EC	.500	90	50	0	100
Lovozal WP 40%	.200	55	30	50	80
Plictran WP 50%	.125	100	100	20	100
	.250	20	50	40	100
Check (water)		100	90	90	100
(dry)		100	90	90	100

[a] After 48 hours continuous exposure.
[b] After 7 days continuous exposure.

[5] Ward's Natural Science Establishment, Inc., Rochester, N.Y. 14603.
[6] American Cyanamid Co., Plastics and Resins Div., Wallingford, Conn. 06482.
[7] The Testor Corp., Rockford, Ill. 61100.

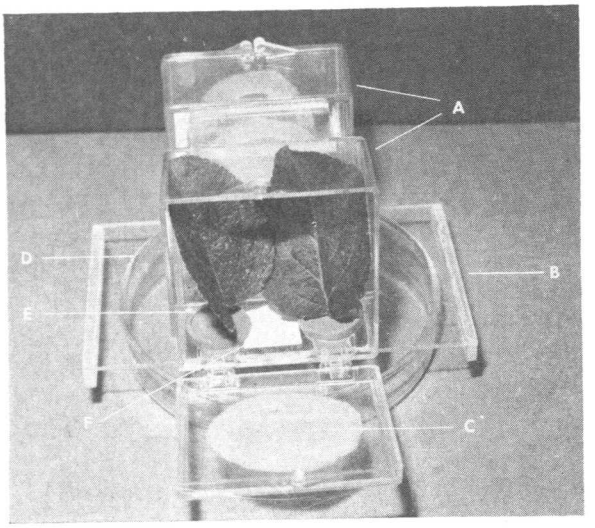

FIG. 1.—Plastic box cage used to confine *S. punctum* larvae during insecticide and miticide evaluations. A, Plastic boxes; B, acrylite base; C, dacron-ninon screening; D, petri dish; E, stopper; F, filter paper.

a hole in a stopper and into a vial of water to keep the leaf fresh. Ten pupae were tested in each pesticide. Ten checks were dipped in water and 10 were kept dry throughout each test period.

Relative humidity ranged from 16 to 100% (mean 67%). The temperature range was 52–88°F (mean 72°F). Results were recorded each day for 7 days. An average daily percent emergence was computed.

RESULTS AND DISCUSSION.—Table 1 presents the results. Those materials that were highly toxic to the adults were carbaryl and carbofuran. Those materials that had only minimal effect on *S. punctum* adults included formetanate, Imidan, phosalone, azinphosmethyl, Galecron, and Plictran. The checks were averaged for each test date with no mortality occurring with either the wetted or the nonwetted adults.

Materials that were highly toxic to *S. punctum* eggs were carbaryl and carbofuran. Materials that had only a minimal effect on *S. punctum* eggs were endosulfan, Gardona, phosalone, and Plictran. The check mortalities were averaged for each test date with 90% emergence occurring in 7 days with both wet and dry treatments.

Those materials that were highly toxic to *S. punctum* larvae were carbaryl, carbofuran, Gardona, 0.375 lb AI Imidan, dialifor, and Galecron. The only material that was tolerated to a high degree by *S. punctum* larvae was azinphosmethyl at dosages of 0.125 and 0.250 lb AI. There was no difference in the mortality of the checks between the wet (water) and dry larvae with 10% occurring by 48 hr.

The only material that was highly toxic to *S. punctum* pupae was carbofuran. All other materials tested were tolerated to a high degree by the pupae with carbaryl showing a slight toxic effect to the pupae. By the end of 7 days there was 100% emergence of both the wet (water) and dry check pupae.

Since the various stages of *S. punctum* were all immersed directly in the pesticides it is probable that these tests yielded higher mortalities than are likely to occur in the orchard. For this reason these mortalities are only an indication of the relative toxicity of the various chemicals but they do yield valuable information in deciding if a material can be used in an integrated chemical and biological program of apple pests.

REFERENCE CITED

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Sterilization of the Beet Leafhopper[1]: Induction of Sterility and Evaluation of Biotic Effects with a Model Sterilant (OM-53139) and ^{60}Co Irradiation[1,2]

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ABSTRACT

Fourteen chemicals comprising alkylating agents, organotin compounds, an antimetabolite (aminopterin), and an antibiotic (porfiromycin) were evaluated as chemosterilants of *Circulifer tenellus* (Baker). Topical application and contact exposure were found unsatisfactory, but oral administration in sucrose solution through parafilm membranes was satisfactory and was employed throughout the study. Apholate and tepa were toxic at sterilizing dosages. Metepa, tepa, and Compound I (*N,N'*-hexamethelene bis-1-aziridinyl carboxamide) were the most effective sterilants; hempa was the least effective. Because of high sterilant activity and low toxicity, Compound I was selected as a model compound for detailed study. Male leafhoppers were somewhat more susceptible than females to the toxic as well as to sterilant action of Compound I. Susceptibility was highest in late-stage nymphs and it decreased in both sexes with advancing age. High degree of sterility was evident when matings were performed immediately after a 24-hour acquisition period, and it increased to a plateau at 48 hours, remaining constant for the entire 1-month period of observation. Females which mated to sterile males remained monogamous provided the 1st copulation was long enough (approximately 1.6 minutes) to insure passage of seminal fluid. Chemosterilized males, when confined at various ratios with normal males and females, were found to be sexually as competitive as nonsterile individuals, both under optimum environmental conditions and under temperature stress.

Sterilization of the insect by ^{60}Co irradiation was also demonstrated, 95% sterility having been obtained with doses of 16–20 krad for males and 4–6 krad for females.

The beet leafhopper, *Circulifer tenellus* (Baker), is the only known vector of the curly top virus in western North America. The disease affects 35 economically important crops, causing especially heavy losses in sugarbeets, beans, squash, watermelon, cantaloup, and tomatoes (Cook 1967). The State of California incurs an annual expenditure of $200,000 to $300,000 in suppressing the population of this insect, mainly by application of insecticides to overwintering grounds.[5] The objective of this study was to investigate the amenability of the insect to sterilization as an alternative to use of insecticides.

Information on chemical sterilization of Hemiptera is limited to *Oncopeltus fasciatus* (Dallas) (Simkover 1964), *Acyrthosiphon pisum* (Harris) (Bhalla and Robinson 1968), and *Psylla pyricola* Foerster (Kaloostian 1968). Radiation sterilization of Hemip-

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[5] Annual Reports, Calif. Department of Agriculture, 1963–67.