Stethorus punctum[1] and Pest-Population Responses to Pesticide Treatments on Apple Trees[2]

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ABSTRACT

In 1970, 1971, and 1972, 32 pesticide treatments were tested for their effect on the predatory coccinellid *Stethorus punctum* (LeConte) and apple pests. Outstanding treatments with commercially satisfactory effectiveness on lepidopterous pests and only slight effect on *S. punctum* were: 0.0625 lb AI dinocap + 0.125 lb AI azinphosmethyl + 1.341 lb AI lead arsenate/100 gal; the same amounts of dinocap and azinphosmethyl + 0.125 AI Imidan® (*O,O*-dimethyl S-phthalimidomethyl phosphorodithioate)/100 gal; and the same amounts of dinocap and azinphosmethyl + 0.125 lb AI phosalone/100 gal. The last-mentioned treatment was more effective than the former 2 treatments on the white apple leafhopper, *Typhlocyba pomaria* McAtee. These 3 treatments demonstrate the dinocap + *S. punctum* interaction with the European red mite, *Panonychus ulmi* (Koch). Phosvel® (*O*-(4-bromo-2,5-dichloropheynl) *O*-methyl phenylphosphonothioate) at 1 lb AI/100 gal was effective on the lepidopterous pests, and at 0.5 lb AI/acre it is effective on the white apple leafhopper. At these rates, Phosvel is only slightly toxic to *S. punctum*. Phosvel was not effective on the apple aphid, *Aphis pomi* De Geer. Hercules 16801 (Phenyl N-dimethoxyphosphinodithioacethyl N-methylcarbamate) was more effective on the lepidopterous pests at 1 lb AI/100 gal than at 0.5 lb AI. It was not effective on the apple aphid or the white apple leafhopper, and it had low toxicity to *S. punctum*.

In the Pennsylvania integrated pest-management system for apple orchards, it is important to retain the interaction of the predator *Stethorus punctum* (LeConte) with the European red mite, *Panonychus ulmi* (Koch). To accomplish this purpose, it is essential to know how to use pesticides to hold populations of components of the apple-pest complex below economic injury levels without excessive deleterious effects on populations of *S. punctum*. The 3 experiments reported here were designed to accumulate this information.

MATERIALS AND METHODS.—To increase the chances of having fairly high populations of pests and *S. punctum*, experiments were arranged in a 20-year-old apple orchard so that more than half the trees were not treated with either insecticides or acaricides. In all 3 years, each experimental spray treatment was applied to 4 replicated single-tree plots. In 1970, one replicate was the cultivar 'York Imperial' and 3 were 'Golden Delicious'; in 1971, 2 replicates were York Imperial and 2 Golden Delicious; and in 1972, all 4 replicates were Golden Delicious. The experimental sprays, all dilute (1×) mixtures, were applied by the method of Asquith (1968). Tables 1, 2, 3, 4 list the treatments and the dates of application. General sprays involving the fungicides Captan and Zineb were applied as 6× conc to all trees at appropriate times during the 3 seasons.

The pesticides tested, their formulations, AI, and sources were:

Azinphosmethyl; WP; 50%; Chemagro Corp.

Phosalone; WP; 25%; Chipman Div., Rhodia, Inc.

Lead arsenate; WP; 94%; Niagara Chemical Div., FMC Corp.

Phosvel®; WP; 50%; *O*-(2,5-Dichloro-4-bromophenyl) *O*-methyl phenylthiophosphonate; Velsicol Chemical Corp.

Plictran®; WP; 50% tricyclohexyltin hydroxide; Dow Chemical Co.

Carbofuran; WP; 75%; and EC; 4 lb/gal; Niagara Chemical Div. FMC Corp.

SD-17250; WP; 50% acetic acid, thio, -S-(2-cyanoethyl) ester, methyl = carbamoyloxime; Shell Development Co.

Imidan®; WP; 50% *O,O*-dimethyl S-phthalimidomethyl phosphorodithioate; Stauffer Chemical Co.

Dialifor; WP; 50%; Hercules, Inc.

Galecron®; SP; 95% N′-(4-chloro-*o*-tolyl)-N,N-dimethylformamidine; Ciba Agrochemical Co.

Fundal®; SP; 97% N′-(4-chloro-*o*-tolyl)-N,N-dimethylformamidine, hydrochloride; Nor-Am Agricultural Products, Inc.

SN-334; SP; 60% Fundal + 30% formetanate hydrochloride; Nor-Am Agricultural Products, Inc.

Bio-Film®; alkylarylpolyethoxy ethanol, free and combined fatty acids, glycol ethers, di-alkyl benzenedicarboxylate, isopropanol; Colloidal Products Corp.

15223; SP; 60% *O*,S-Dimethyl Methoxyacetylphosphoramido thioate; Chevron Chemical Co.

CGA 13608; WP; 50% *o*-(Methyl-2-propynylamino) phenyl methylcarbamate; Ciba Agrochemical Co.

Dipel®; WP; *Bacillus thuringiensis* Berliner; Abbott Laboratories.

Cela S-2957; EC; *O,O*-Diethyl-*O*-(2,4,5-dichloromethylthiophenyl)-thionophosphate; 4 lb/gal; EM Laboratories, Inc.

16801; WP; 50% Phenyl N-dimethoxyphosphinodithioacetyl N-methylcarbamate; Hercules, Inc.

Dinocap; EC; 48%; Rohm and Haas Co.

Bay Hox 2709; WP; 50% *O*-(3-Chloro-7-methylpyrazolo [1,5-*a*] pyrimidin-2 yl) *O,O*-diethyl phosphorothioate; Chemagro Corp.

Dursban®; EC; *O,O*-diethyl *O*-(3,5,6-trichloro 2-pyridyl) phosphorothioate; 2 lb/gal; Dow Chemical Co.

Fruit-injury records were taken on all apple drops after July 1 each year and on fruit samples picked in the period 12–20 days after the last spray. In 1970, dropped and picked fruit averaged 190/replicate, 760/treatment; in 1971, 325/replicate, 1300/treatment; and in 1972, 320/replicate, 1280/treatment. Counts of the apple aphid, *Aphis pomi* De Geer, in 1970 and 1972 were made according to the method of Asquith (1967). European red mites and the predatory mites were

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Table 1.—Effect of pesticide treatments on apple pests and the predator *Stethorus punctum*. 1970.

Treatments	Lb Al/[a] 100 gal	Injuries/100 apples[b]		Pest numbers/leaf[b]		*S. punctum*/tree/3-min count[b]					
						Aug. 3		Aug. 17		Aug. 26	
		CM[c]	RBL[c]	Aphids[cd]	ERM[c] 8/3	Adults	Larvae	Adults	Larvae	Ahults	Larvae
Phosalone +	0.375	0.00 a	17.36 cd	11.97 a	11.98 cd	8.00 a	4.00 a	5.75 bc	4.25 cd	17.75 bc	12.00 bc
Lead arsenate +	1.341										
Plictran[e]	.0625										
Phosvel +	1.0	.23 a	1.30 a	120.92 d	23.30 d	8.50 a	2.00 a	10.25 ab	31.00 b	33.25 b	6.75 bcd
Plictran[e]	.0625										
Carbofuran WP +	.25	.23 a	10.67 bcd	6.70 a	10.77 cd	4.00 b	0.00 b	1.50 c	0.00 d	5.50 cd	1.00 cd
Plictran[e]	.0625										
Carbofuran EC +	.25	.00 a	20.24 d	8.13 a	0.14 a	0.25 bc	0.00 b	0.00 d	.00 d	0.00d	0.00 d
Plictran	.0625										
SD-17250	.75	.67 a	11.32 bcd	10.91 a	1.04 ab	.00 c	.00 b	.00 d	.00 d	.00 d	.00 d
Azinphosmethyl +	.125	.46 a	6.03 ab	80.70 bcd	17.68 cd	13.25 a	.75 a	5.50 bc	26.25 b	32.75 b	21.25 b
Plictran[e]	.0625										
Imidan +	0.25	1.59 a	13.91 bcd	52.68 b	16.24 cd	13.00 a	2.75 a	19.75 a	128.50 a	110.00 a	55.25 a
Plictran[e]	.0625										
Azinphosmethyl +	.125	.30 a	9.71 bc	67.81 bc	.51 ab	.00 c	.00 b	.00 d	.00 d	.50 d	.00 d
Lead arsenate +	1.341										
Plictran	.0625										
Check (No	Insecticide)	34.35 b	38.65 e	108.52 cd	5.41 bc	7.25 a	5.00 a	5.50 bc	1.25 cd	4.75 cd	1.00 cd

[a] Spray dates: May 29 (except the azinphosmethyl, lead arsenate, and Plictran treatment), June 10, 24; July 8, 23; Aug. 5.
[b] Means followed by the same are not significantly different at the 5% level.
[c] CM = codling moth, RBL = redbanded leafroller, Aphids = apple aphid, ERM = European red mite.
[d] Each no. is the average of counts taken June 22 and July 1.
[e] Plictran was omitted from these treatments after the June 10 spray.

Table 2.—Effect of pesticide treatments on apple pests and *S. punctum*. 1971.

Treatments	Lb AI/[a] 100 gal	Injuries/100 apples[b]			Mites/leaf 8/11[b]			*S. punctum*/tree/3-min count[b]				
								July 27		Aug. 12		
		CM[c]	RBL[c]	TABM[c]	ERM[c]	AF[c]	ZM[c]	Adults	Larvae	Adults	Larvae	Pupae
Dialifor	0.50	0.13 a	0.79 a	0.10 a	36.10 bc	0.01 ab	0.66 cde	1.25 abc	0.50 ab	6.75 bcd	2.50 cd	1.00 b
Dialifor +	.50	.30 a	.63 a	.46 a	33.20 bc	.05 ab	.14 ef	0.50 bc	0.25 b	5.50 cd	2.75 cd	0.75 b
Lead arsenate	1.341											
Galecron	.356	1.55 a	3.32 b	1.23 a	0.18 a	.00 b	.01 f	.00 c	.00 c	0.00 e	0.00 e	.00 c
Azinphosmethyl +	.125	.24 a	.33 a	.00 a	2.90 a	.01 ab	.16 ef	.00 c	.00 c	.25 e	.00 e	.00 c
Fundal	.122											
SN-334	.226	.29 a	3.41 b	1.58 a	.40 a	.00 b	.05 ef	.00 c	.00 c	.00 e	.00 e	.00 c
Azinphosmethyl +	.125	.30 a	.96 a	.31 a	19.34 b	.08 a	1.12 bc	9.00 a	3.25 ab	27.25 ab	45.50 ab	51.25 a
BioFilm	.25											
Azinphosmethyl +	.125	.13 a	.27 a	.00 a	21.16 b	.01 ab	2.50 a	6.00 ab	5.25 a	42.00 a	29.50 abc	32.25 ab
Imidan	.125											
Azinphosmethyl +	.125	.29 a	.45 a	.00 a	23.53 b	.08 a	.88 bcd	3.00 abc	.75 ab	23.25 abc	63.00 a	32.25 ab
Lead arsenate	1.341											
Phosvel +	.50	.59 a	1.44 a	.12 a	.50 a	.00 b	.03 f	0.00 c	.00 c	.00 e	.00 e	.00 c
Plictran	.0625											
Azinphosmethyl +	.125	.07 a	.23 a	.12 a	46.81 c	.01 ab	.48 def	1.75 abc	2.75 ab	13.25 bc	24.50 abc	11.00 ab
Phosalone	.375											
Check	(No insecticide)	57.69 b	13.84 c	10.57 b	4.65 a	.08 a	1.73 ab	8.25 a	2.75 ab	10.50 bcd	11.00 bcd	32.00 ab

[a] Spray dates: May 27; June 11, 24, July 7, 22; Aug. 4, 17.
[b] Means followed by the same letter are not significantly different at the 5% level.
[c] CM = codling moth, RBL = redbanded leafroller, TABM = tufted apple budmoth, ERM = European red mite, AF = *Amblyseius fallacis*, and ZM = *Zetzellia mali*.

Table 3.—Effect of pesticide treatments on apple pests and *S. punctum*. 1972.

Treatments	Lb AI/[a] 100 gal	Injuries/100 apples[b]				Mites/leaf[b]		*S. punctum*/tree/3-min count[b]			
								Aug. 21	Aug. 28		Sept. 7
		CM[c,d]	RBL[c]	TABM[c]	OBL[c]	ERM[c]	ZM[c]	Adults & larvae	Adults	Larvae	Adults & larvae
15223	0.60	1.34 a	0.41 a	0.20 a	2.06 ab	0.10 a	0.66 ab	0.00 e	0.50 c	0.25 d	0.00 f
CGA-13608	.75	1.53 a	1.86 abc	.69 ab	4.91 ab	31.20 e	.11 b	5.75 cd	3.50 bc	2.75 cd	36.00 bc
Galecron	.356	0.82 a	1.49 abc	.66 ab	3.43 ab	.11 a	.01 b	.00 e	1.25 c	.00 e	1.25 e
Dipel	.50	24.14 b	2.91 cd	1.79 d	2.58 ab	2.25 abc	.11 b	9.50 bcd	7.75 bc	2.50 cd	5.50 de
Dipel	1.00	34.82 bc	4.64 e	1.70 cd	2.59 ab	.80 a	1.36 ab	4.25 cd	4.75 bc	2.50 cd	4.00 de
Cela S-2957	.25	1.27 a	.68 ab	.25 a	1.51 ab	2.53 abc	1.09 ab	5.00 cd	1.75 bc	.75 d	27.50 bcd
16801	.50	2.55 a	2.11 bc	.89 abc	14.35 c	10.30 d	2.49 a	36.75 a	21.25 a	26.75 a	28.50 bc
16801	1.00	1.47 a	.88 ab	.44 a	5.91 b	27.60 e	.40 b	30.25 ab	21.50 a	25.75 a	92.75 a
Dinocap[e] +	.0625	0.73 a	.80 ab	.20 a	0.30 a	9.28 cd	.09 b	18.25 ab	9.25 ab	12.50 ab	66.50 ab
Azinphosmethyl +	.125										
Lead arsenate	1.341										
Dinocap[e] +	.0625	.82 a	.62 ab	.08 a	2.61 ab	6.36 bcd	0.05 b	6.00 cd	7.50 bc	8.50 bc	37.25 b
Azinphosmethyl +	.125										
Imidan	.125										
Dinocap[e] +	.0625	.46 a	.13 a	.20 a	.62 a	3.09 abcd	0.09 b	13.25 bcd	4.00 bc	3.75 bcd	52.50 ab
Azinphosmethyl +	.125										
Phosalone	.125										
Bay Hox 2709	.50	.29 a	.31 a	.15 a	.89 ab	.13 a	0.05 b	3.00 d	1.50 bc	.50 d	.25 e
Dursban	.25	.95 a	.40 a	.10 a	.88 ab	2.73 abc	.20 b	9.75 bcd	4.75 bc	8.25 bcd	9.00 cde
Dinocap[e]	.0625	39.12 c	4.50 de	1.71 cd	26.39 d	1.18 ab	.01 b	2.25 e	3.25 bc	2.25 cd	11.25 cde
Check	(No insecticide)	62.92 d	7.17 f	3.30 e	26.73 d	2.03 abc	.36 b	18.50 abc	4.25 bc	3.75 bcd	2.50 e

[a] Spray dates: May 22, Plots 1, 2, 3 on June 5; other plots June 6, 19; July 3, 24; Aug. 9 and 24.
[b] Means followed by the same letter are not significantly different at the 5% level.
[c] CM = codling moth, RBL = redbanded leafroller, TABM = tufted apple budmoth, OBL = obliquebanded leafroller, ERM = European red mite, and ZM = *Zetzellia mali*.
[d] A mixed population of the codling moth and the oriental fruit moth.
[e] No dinocap in the spray of Aug. 24.

Table 4.—Effect of pesticide treatments on apple aphid and white-apple leafhopper populations. 1972.

Treatment	LbAl/[a] 100 gal	Aphids/leaf[b] 6/8	White apple leafhoppers[b]/25 leaves	
			6/1	8/15
15223	0.60	0.03 a	0.25 a	0.00 a
CGA-13608	.75	.03 a	.00 a	.38 a
Galecron	.356	52.65 de	8.50 ab	.38 a
Dipel	.50	73.20 e	37.25 c	34.50 ef
Dipel	1.00	46.78 de	38.50 c	30.37 e
Cela S-2957	.25	9.73 c	.75 a	.00 a
16801	.50	40.30 de	27.25 bc	11.12 d
16801	1.00	49.45 de	23.25 abc	2.50 abc
Dinocap[c] +	.0625	7.53 bc	37.25 c	6.50 cd
Azinphosmethyl +	.125			
Lead arsenate	1.341			
Dinocap[c] +	.0625	4.45 ab	24.00 abc	6.75 cd
Azinphosmethyl +	.125			
Imidan	.125			
Dinocap[c] +	.0625	4.53 abc	6.25 ab	.50 ab
Azinphosmethyl +	.125			
Phosalone	.125			
Bay Hox 2709	.50	5.68 bc	.00 a	.00 a
Dursban	.25	.40 ab	5.50 ab	2.12 abc
Dinocap[c]	.0625	35.60 d	38.50 c	21.12 de
Check	No Insecticide	32.58 d	74.25 d	38.62 f

[a] Spray dates: May 22, Plots 1, 2, and 3 on June 5; other plots June 6, 19, July 3, 24; Aug. 9, 24.
[b] Means followed by the same letter are not significantly different at the 5% level.
[c] No dinocap applied Aug. 24.

counted directly on the leaves. Sample size for each count was 80 leaves/treatment, 20/tree. Counts of the white apple leafhopper, *Typhlocyba pomaria* McAtree, in 1972 were made by examining the undersides of 100 leaves/treatment, 25/tree. Three-min examinations of individual trees were made by trained observers in taking the *S. punctum* records.

DISCUSSION.—Because of the extensive nature of the results of these experiments, various pests and predators are discussed separately. The 1970 results are in Table 1, those of 1971 in Table 2, those of 1972 in Tables 3 and 4.

Codling moth.—In 1970 (Table 1) and 1971 (Table 2), all pesticide treatments were highly effective in controlling *Laspeyresia pomonella* (L.).

In 1972 (Table 3), only Dipel and dinocap were commercially ineffective in reducing injury by the codling moth. Whereas dinocap is used in the Pennsylvania program to suppress mite populations and to control powdery mildew, it held codling moth injury 38% below that on the fruit from the 1972 check trees. The 1972 injuries were caused by a mixed population of the codling moth and the oriental fruit moth, *Grapholitha molesta* (Busck).

Redbanded leafroller.—In 1970 (Table 1), only Phosvel at 1 lb Al/100 gal was highly effective in preventing injury by *Argyrotaenia velutinana* (Walker). Azinphosmethyl at 0.125 lb Al + Plictran at 0.0625 lb Al/100 gal was not significantly less effective at the 5% level, but 6.03% fruit injury is not commercially satisfactory. Next in order of effectiveness was the azinphosmethyl + Plictran treatment with the addition of lead arsenate at 1.34 lb Al/100 gal. In connection with the 1970 redbanded leafroller injury data, it should be pointed out that 38.65% of the fruit from the check trees were injured, or ca. 4 times more fruit than is usually injured in a poorly sprayed commercial orchard.

In 1971 (Table 2), only 13.84% of the check fruit were injured by this pest. In the presence of this lower degree of pressure from the pest, all 1971 treatments except Galecron at 0.356 lb Al/100 gal and SN-334 at 0.226 lb Al/100 gal were highly effective in preventing injury; both were moderately effective.

In 1972 (Table 3), only 7.17% of the fruit from the check trees were injured by this pest in 1972 (Table 3). Dipel at 0.5 and 1.0 lb Al/100 gal and dinocap at 0.0625 lb Al/100 gal gave borderline results.

Platynota idaeusalis (Walker).—In 1971, when 10.57% of the check fruit was injured (Table 2), all treatments were highly effective in preventing injury by this pest, sometimes referred to as the tufted apple budmoth. In 1972 (Table 3) when 3.30% of the check fruit was injured, all treatments except the 2 rates of Dipel and dinocap significantly reduced injury below the amount on the checks.

Obliquebanded leafroller.—Only in the 1972 (Table 3) experiment were records taken of injury by *Choristoneura rosaceana* (Harris). In the presence of a population that injured 26.73% of the check fruit, 16801 at 0.5 lb Al/100 gal and the dinocap treatment were comparatively ineffective. The other treatments were effective enough for use in most commercial orchards where populations of this pest are usually only 25% as high as in this experimental orchard. The outstanding treatments were dinocap + azinphosmethyl + lead arsenate, dinocap + azinphosmethyl + phosalone, Bay Hox 2709, and Dursban.

Apple aphid.—Data from 1970 (Table 1) and 1972 (Table 4) are presented, because it is useful to know the degree of effectiveness of various insecticides on this pest when one is considering pest management procedures for the season. In our opinion, only the experimental treatments 15223, CGA-13608, and Dursban, all used in 1972, would not require the addition of an aphicide during most seasons. Other treatments that might not require the addition of an aphicide during seasons unfavorable for aphid development and in orchards on a minimal fertilizer program are: phosalone + lead arsenate + Plictran; carbofuran WP or EC + Plictran; SD-17250 (Table 1); Cela S-2957; dinocap + azinphosmethyl + lead arsenate; dinocap + azinphosmethyl + Imidan; dinocap + azinphosmethyl + phosalone; and Bay Hox 2709 (Table 4). Especially in the case of the apple aphid, significantly better control by a pesticide in a given test is not proof that the pesticide is effective enough for commercial use.

Although aphid data are reported here on the basis of leaf counts, observational evidence indicates that the economic-injury threshold of this pest is reached when 30% of the outside terminals on the trees are infested. At this population level, the volume of honeydew secreted onto fruit is an excellent growth medium for several black sooty molds which mar the fruit.

White apple leafhopper.—The data (Table 4) indicate that 15223, CGA-13608, Cela S-2957 and Bay Hox 2709 are highly effective, because the June 1 count, taken 8 days after the 1st spray, was very low on trees that received these treatments. More moderately effective in one application, but almost as effective as the last-mentioned treatments in several sprays according to the count of Aug. 15, were: Galecron, dinocap + azinphosmethyl + phosalone, and Dursban. Only slightly effective in one spray, but moderately effective in several sprays were 16801 at 1 lb AI/100 gal, dinocap + azinphosmethyl + lead arsenate, and dinocap + azinphosmethyl + Imidan. Phosvel at 0.5 lb AI/acre is effective (Asquith, unpublished data). According to the amount of leaf injury, the economic threshold is close to 6 leafhoppers/25 leaves at any date up to Aug. 15. Also, at this population density fecal deposits on fruit become a special washing problem.

Amblyseius fallacis (Garman) and *Zetzellia mali* (Ewing).—Counts of these predatory mites were made in 1971 and 1972. In 1971, the population of *Z. mali* was greater than that of *A. fallacis* (Table 2). This was true also in 1972, hence no count of *A. fallacis* is listed in Table 3. In both years, pesticide treatments varied in their effect on *Z. mali*. Some treatments that were least toxic to this predator were dialifor, azinphosmethyl + Bio Film, azinphosmethyl + Imidan, azinphosmethyl + lead arsenate, and azinphosmethyl + phosalone in Table 2; and 15223; Dipel at 1 lb AI/100 gal, Cela S-2957, and 16801 at 0.5 lb AI/100 gal (Table 3). There is some indication that lead arsenate may be toxic to *Z. mali* because the count (Table 2) was lower on the dialifor + lead arsenate and the azinphosmethyl + lead arsenate-treated trees than on those trees sprayed with dialifor and azinphosmethyl + Bio Film, respectively. It is not known why fewer *Z. mali* occurred on trees sprayed with 0.5 lb AI/100 gal of Dipel than on trees sprayed with 1 lb/100 gal. A comparison of treatments without dinocap (Table 2) with those in which dinocap was included (Table 3) indicates dinocap is toxic to *Z. mali*.

European red mite and *S. punctum*.—Colburn and Asquith (1971) demonstrated attraction of adult *S. punctum* by the European red mite. Counts of the European red mite and *S. punctum* (Tables 1, 2, 3) indicate also that the predator is attracted by the mite in an orchard environment.

These experiments were not designed to demonstrate mite control. Mite populations on check trees were suppressed by such predators as *Hyaliodes vitripennis* (Say) and *H. harti* Knight, which could not survive on trees sprayed with insecticides. Among the chemicals that exhibited significant acaricidal activity were: Plictran (Tables 1 and 2) especially on those trees where the low rate of 0.0625 lb AI/100 gal was used in all the cover sprays; SD-17250 (Table 1); Galecron, Fundal, and SN-334 (Table 2); and 15223, Galecron, Cela S-2957, Bay Hox 2709, and Dursban (Table 3). Also, Dipel and dinocap (Table 3) showed some acaricidal activity, but the mite populations on trees treated with them also reflect the repressive effects of predation.

Only the following 3 treatments (Table 3) were designed to demonstrate the dinocap and *S. punctum* interaction with the European red mite: dinocap + azinphosmethyl + lead arsenate; dinocap + azinphosmethyl + Imidan; and dinocap + azinphosmethyl + phosalone. Other treatments were tested primarily to determine their effects on *S. punctum* and whatever pests were present.

Some of the insecticides were tested also for direct toxicity to *S. punctum* by a laboratory dip method (Colburn and Asquith 1971, 1973). Carbofuran WP, 0.25 lb AI/100 gal (Table 1), was highly toxic to *S. punctum* adults and larvae in the orchard. In the 1971 dip test, carbofuran WP, 0.1875 lb AI/100 gal, killed 100% of exposed eggs, larvae, pupae, and adults. Dialifor WP, 0.5 lb AI/100 gal (Table 2), was too toxic to *S. punctum* adults and larvae for them to reach high numbers in the presence of a large population of mites. The EC formulation, 0.375 lb AI/100 gal, in the 1971 dip test killed 35% of the exposed adults, 80% of the eggs, 100% of the larvae, but none of the pupae. Galecron SP, 0.356 lb AI/100 gal (Table 2), held mites at too low a level to attract *S. punctum* to the trees. In the 1971 dip test, the EC formulation, 0.5 lb AI/100 gal, killed 10% of exposed adults, 50% of the eggs, 100% of the larvae, but none of the pupae. In the treatment with azinphosmethyl + Fundal, which is basically the same chemical as Galecron (Table 2), the combination of toxicity to both mites and *S. punctum* was too great for *S. punctum* to become established in the trees. At 0.125 lb AI/100 gal, double the rate used in the 1970 and 1971 orchard tests, Plictran WP as a dip treatment in 1971 killed 100% of exposed larvae, but no adults, eggs, or pupae. SN-334 at 0.226 lb AI/100 gal (Table 2) is a known mite toxicant (Asquith 1973), and it prevented the mite population from reaching numbers attractive to *S. punctum*.

At 0.6 lb AI/100 gal 15223 SP (Table 3) held mites to numbers not attractive to *S. punctum*. At the same rate 90% of exposed adults were killed in the 1973 dip test. In this same dip test, Bay Hox 2709 WP, 0.5 lb AI/100 gal, and Dursban EC, 0.25 lb AI/100 gal killed 70% of the adults, and CGA-13608 WP, 0.5 AI/100 gal killed 100%. According to the combined count of *S. punctum* adults and larvae on Sept. 7 (Table 3), residues of CGA-13608 and Dursban do not retain toxicity to this insect as long as residues of Bay Hox 2709. In the orchard, Cela-S-2957 EC, 0.25 lb AI/100 gal held populations of the European red mite to a low level and was moderately toxic to *S. punctum*. In the laboratory, the same rate killed only 20% of the adults.

At concentrations tested in the orchard, pesticides which showed low enough toxicity to *S. punctum* for use in the Pennsylvania integrated pest-management system for apples were: azinphosmethyl, phosalone, Imidan, and lead arsenate. Also used in alternate side sprays described by Lewis and Hickey (1967) are Plictran WP at 0.0625 lb AI/acre, Galecron SP at 0.119 lb AI/acre, and Fundal at 0.122 lb AI/acre. Additional insecticides not tested here, but used in the Pennsylvania integrated pest-management system after bloom, are listed in a Pennsylvania Agricultural Extension Service publication, 1973 Agricultural Chemicals for Tree Fruit Production.

A comparison of the counts of the European red mite and *S. punctum* for the treatments azinphosmethyl + lead arsenate, Imidan, or phosalone (Table 2) with counts on plots treated with the same insecticides + dinocap (Table 3) illustrates the importance of adding the acaricidal effects of dinocap to predation by *S. punctum* on the repressive side of the interaction with the European red mite. Removing dinocap from this interaction requires a substitute if populations of the European red mite are to be held in check.

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