Project 77-C1B IMPACT OF INSECTICIDES ON MITES 6 Dec. 1977

Marjorie A. Hoy, U.C. Berkeley

The objectives of the project were to determine the impact of NOW insecticide use on plant feeding mite populations in almond orchards in the northern growing areas, and to survey almond orchards for mite predators and their potential alternate prey.

Five almond orchards were monitored every two weeks from April to October: one each near Yuba City, Wheatland and Stockton, and two near Modesto. Guthion and Sevin were applied once to the Stockton and Modesto orchards, Guthion only was applied to the Yuba City orchard, and no pesticides were applied to the Wheatland orchard.

Pest mite and predator species varied from orchard to orchard and this complex influenced the impact of the pesticides. For example, early in the season the brown almond mite, Bryobia, was common in the Yuba City and Wheatland orchards, but never common in the three more southern orchards. In contrast, one orchard near Stockton had no detectable mites until June, when 2-spotted and Pacific spider mites began appearing. However, the most common spider mites were the European red mite, Panonychus ulmi and large P. ulmi populations occurred early in 4 of the 5 orchards. Therefore, numbers of P. ulmi mites on treated trees was significantly higher at the next sample interval (June 7) after Guthion was applied and remained higher until the August 30 sample date. For example, in one orchard, there were 2-10 X as many P. ulmi on treated trees as on control trees, with an average of 320 mites per leaf on one date. No impact of Guthion was seen in the Stockton orchard that lacked mites early in the season.

Applications of Sevin were made in two Modesto orchards and in the Stockton orchard. In the Modesto orchards, significant increases in mite levels were observed on the second sample period after application. The Stockton orchard yielded inconclusive results, probably due to the drift of acaricides applied aerially in adjacent trees.

The results of these tests show that Guthion and Sevin can result in higher pest mite populations, although in one orchard, Guthion had no significant impact because pest mites were not detectable in any samples taken until late June. Causes of the increases of European red mites after treatment with Sevin and Guthion were not determined. However, a complex of predators was found in the five orchards. The most numerous predators, in both species composition and density, were found in the untreated Wheatland orchard where the following predators were found: green lacewings (Chrysopa); 4 species of lady bird beetles, including Stethorus; spiders and thrips. In addition, a predatory mite was present. In one Modesto orchard the predatory mite, Metaseiulus occidentalis, was found to be well-established naturally. Releases of M. occidentalis were made into individual trees in all five orchards, but no significant impact of the releases was observed. However, additional tests need to be conducted.

Preliminary tests with an exotic lady beetle (Stethorus loxtoni) from Australia indicate that it can feed on the pest mites attacking almonds, and efforts to evaluate its potential for establishment and control of almond mites is underway.

A laboratory analysis of the impact of a synthetic pyrethroid insecticide (permethrin) for potential use as a NOW pesticide indicates that levels recommended for NOW control would probably not kill pest spider mites, but would kill the predatory mite, M. occidentalis. Thus, this pesticide may have the potential to elicit mite outbreaks; particularly if other predator species are affected similarly.

Assistance was kindly given by Farm Advisors Norm Ross and Don Rough, and by George Post of Ag. Advisors, Inc.

RECEIVED
DEC 29 1977

Project Report: 77-C1B Impact of Insecticides on Mites

From: Dr. Marjorie A. Hoy, Dept. of Entomological Sciences
U.C. Berkeley 94720 (415) 642-3989

Date: 31 December 1977

CONTENTS

INTERPRETATIVE SUMMARY

The objectives of the project were to determine the impact of NOW insecticide use on plant-feeding mite populations in almond orchards in the northern growing areas and to survey almond orchards for mite predators and their potential alternate prey.

Five almond orchards were monitored every two weeks from April to October - one each near Yuba City, Wheatland and Stockton, and two near Modesto. Guthion and Sevin were applied once to the Stockton and Modesto orchards. Guthion only was applied to the Yuba City orchard, and no pesticides were applied to the Wheatland orchard.

Pest mite and predator species varied dramatically from orchard to orchard and this complex influenced the impact of the pesticides.

The test results show that Guthion and Sevin can result in significantly higher pest mite populations, although in one orchard, Guthion had no significant impact because pest mites were not detectable in any samples taken until late June.

The most effective and numerous mite predators in these orchards were the lady beetles, *Stethorus picipes*, and brown and green lacewings. These predators were associated with high mite populations, however. One orchard had the predatory mite, *Metaseiulus occidentalis*, naturally present. This predator is potentially able to regulate mite populations at lower densities, although I can not document that they did so in this orchard.

Predator releases (*M. occidentalis*) were less effective than hoped for in trees where the prey was the European red mite - a food less favored than the two-spotted spider mite. Additional releases should be done in almond orchards with good populations of the two-spotted spider mite.

Laboratory evaluation of permethrin (Ambush) showed that recommended field application rates are nontoxic to the two-spotted spider mite, and very toxic to the predator, M. occidentalis. This means that permethrin for N.O.W. control may allow mite outbreaks since insect predators are likely to be more sensitive to permethrin also.

INTRODUCTION and OBJECTIVES

The objectives of the project were to determine the impact of N.O.W. pesticides on plant-feeding mites in the northern almond growing areas since these orchards were reputed to be quite different from the orchards studied by Drs. Martin Barnes and Dick Rice and their associates in the southern San Joaquin Valley. Natural control agents were to be sampled to determine if these agents could be controlling pest mites.

Secondary objectives of the project were to:

a) evaluate the impact of releases of a guthion-resistant strain of the predator, *Metaseiulus occidentalis*, into almond trees,

b) to develop preliminary information on the suitability of an exotic lady beetle from Southern Australia as a predator of almond mites, and

c) develop an estimate of the reliability of samples for estimating mite densities in various areas of almond trees for the various pest mite species.

Impact of Guthion and Sevin on Spider Mites

Guthion was applied once to individual Non Pareil almond trees in 4 orchards on May 26, 1977 using egg traps as timing indicators. The applications were made at a rate of 2 lbs 50% WP Guthion/100 gallons, using about 8 gallons per tree. Pre-treatment counts were taken 2 days before. Post-treatment counts were made after 12 days, and every 2 weeks thereafter. Thirty leaves were sampled from around the lower periphery of the tree, including inner and outer areas. These leaves were put in plastic bags, placed in a cool ice chest and stored in a refrigerator until they were scored under a dissecting microscope within 1 - 4 days. Counts included all stages of pest and predators on both the top and bottom of the leaf and totals were recorded for individual leaves.

Sevin applications to individual trees were made in 3 orchards (near Modesto and Stockton) on July 27. Pre- and Post-treatment counts were made, as above.

Results of the pesticide treatments can best be discussed on an individual orchard basis.

<u>Whitmore Avenue Orchard:</u>

The most dramatic impact was seen in the Whitmore Avenue orchard near Modesto belonging to Mr. Sid Long, Superior Fruit Ranch, Inc. This orchard was flood irrigated. Trees in this block had a "history of mites". On Jan. 21 Kleenup oil, upper 53, Delmo 2 and Imidan were applied and on April 6, Delmo 2 and potassium nitrate were applied. Four blocks of trees were set up with treatments randomly assigned within the block (i.e. control, Sevin or Guthion). Within each block there were 2 control trees, 2 Sevin trees and 2 Guthion trees side by side, with 2 blank trees between.

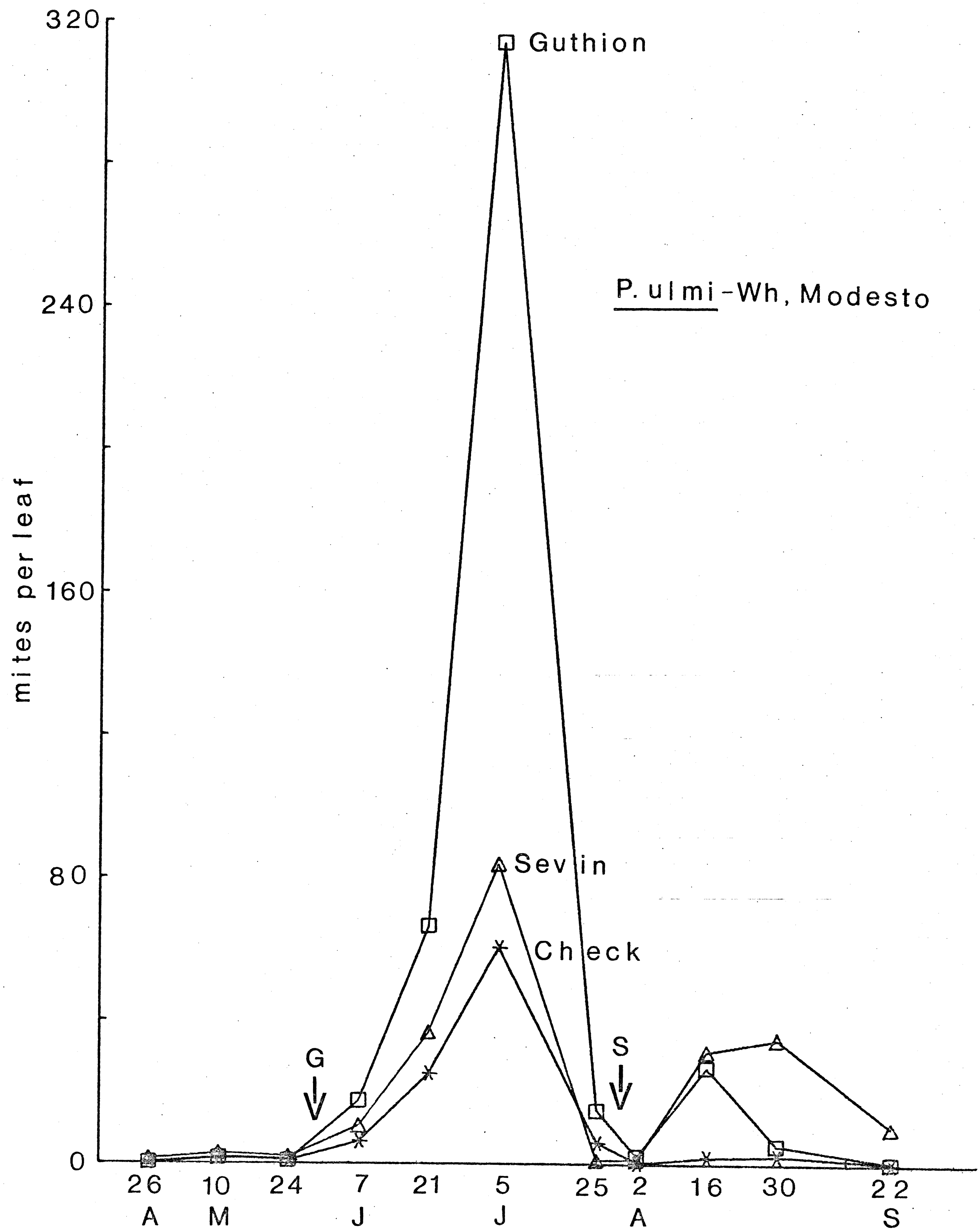
Two or three guard rows shielded the blocks on each side. Sampling began April 26 and continued until September 23. The overwhelmingly prevalent pest mite in this orchard was European red mite, with only a few T. urticae and T. pacificus recorded. A very few Bryobia and peach silver mites were sampled. Fig. I-1 shows the population trends or ERM in the 8 control, 8 guthion and 8 sevin trees.

ANOVA (analysis of variance) for each sample date showed significantly more ERM in the 8 guthion trees compared to the 8 control trees for the June 7, 21, July 5, 25, August 2 and 16 sample periods. (Guthion was applied May 26.) ANOVA showed that ERM counts were higher in the 8 sevin trees compared to the controls on August 16, 30 and September 22. Sevin was applied on July 27. (See Fig. I-1)

Peak mite populations were found on the July 5 sample date in all treatments in this orchard. I believe that the dramatic drop on the July 25 sample date may be attributed to the action of insect predators, particularly Stethorus picipes and brown lacewings (Hemerobius), as both were numerous at this time. Unfortunately leaf samples are an inadequate way to assess these insect predators' numbers and impact upon the spider mites. To date, adequate sampling methods are unavailable.

Highway 99 Orchard: The other Modesto orchard is located along Hwy. 99 and is ownedby Mr. Steve Vilas. This orchard had parathion, copper and oil applied on January 12, 1977. One July 14, Plictran was applied to adjacent trees and the presence of dead mites on the July 19 sample leaves led me to conclude that drift affected the ERM population in this section as well. As in the Whitmore Ave. orchard, guthion was applied May 26 and sevin was applied July 27.

Figure I-1. ERM populations in trees treated with guthion and in untreated trees. Guthion was applied May 26, and Sevin was applied on July 27, 1977.



Guthion
P. ulmi-Wh, Modesto
Sevin
Check
mites per leaf
320
240
160
80
0
G
S
26
A
10
M
24
7
J
21
5
J
25
2
A
16
30
22
S

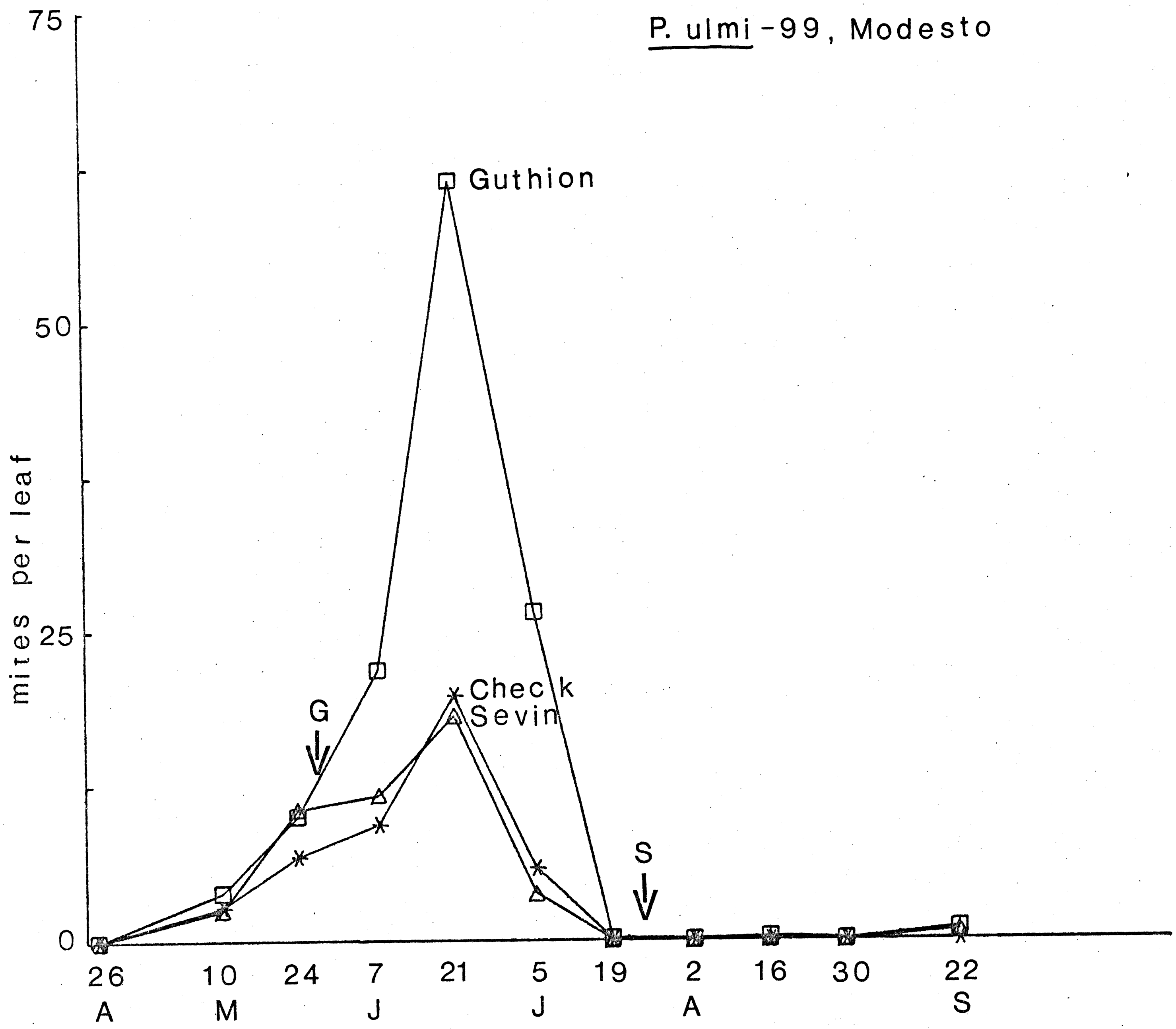
Only sevin or guthion was applied to each of 8 trees and there were 8 check trees. Samples were taken as above, and Figure I - 2 shows the population trend of ERM in these trees. Peak populations occurred on June 21 in this orchard. Significant statistical differences in mite numbers occurred on the June 7, June 21, July 5 and July 19 sample dates when comparisons were made between control and guthion trees using ANOVA for each of these sample dates.

No differences were seen in the sevin and control trees due to the drift of Plictran. Only a few two-spotted spider mites or Pacific mites were found in this orchard. A few peach silver mites were found in May and June, and 4 individual *Bryobia* were collected in May. This orchard had significant numbers of the predatory mite, *Metaseiulus occidentalis*, present on the May 10 sample date--which was before the releases of guthion-resistant predators were made. I conclude that *M, occidentalis* is established in this orchard naturally.

Hwy. 132 Orchard: The orchard west of Stockton near Hwy 132 and Hwy 5 had both guthion and sevin applications made to individual trees (Nonpareils) under premanently-set sprinkler irrigation. This orchard had a "history of spider mites". Samples were taken beginning on April 14, 1977 and at intervals thereafter until Sept. 22. No mites were found in the trees on the April 14, 24, or May 10 sample dates. Only a few two-spotted spider mites were found on May 24, but the numbers climbed until the July 19 sample date and gradually declined until the August 16 sample date. After that no live mites were found in the samples. Drift of acaridides from adjacent trees killed the *T. urticae* population. (See Fig. I - 3.)

Other than *T. urticae*, a few *T. pacificus* were found in this orchard. One *Bryobia* only was found on June 7 and a total of only

Fig. I - 2. ERM populations in untreated trees, in trees treated with guthion on May 26 and in trees treated with sevin on July 27, 1977. Drift of Plictran from adjacent plots probably affected mites after July 14.


P. ulmi -99, Modesto
75
50
25
0
mites per leaf
Guthion
Check
Sevin
G
S
26
A
10
M
24
7
J
21
5
J
19
2
A
16
30
22
S

53 ERM were collected in this orchard throughout the season.

Since the guthion application was made on May 26, when almost no mites could be found, no impact of guthion was evident. The two-spotted spider mites in the sevin trees were not significantly greater than in the check trees either, according to ANOVA, but Fig. I-3 shows that the numbers of mites increased dramatically on the 8 sevin trees on the August 16 sample date. The mean number of mites per leaf on August 16 for the control trees were 3.39 ± 3.72; for the guthion-treated trees the mean number of mites/leaf were 4.60 ± 5.85 and for the sevin-treated trees, the mean was 32.81 ± 47.70. This very high variability within the blocks prevents the F value from being significant, although it is close to the critical region. With an increased sample size, and/or if acaricides had not destroyed the plots, the results might have achieved statistical significance in the next sample period.

Yuba City Orchard: One guthion application was made by the grower in this orchard. Eight guthion-treated trees and 8 untreated trees were sampled. These trees had an early population of ERM and of brown almond mite (*Bryobia*). These trees lost some leaves in the crotch area of the tree dut to feeding damage from *Bryobia*. However, by late June refoliation had occurred and numbers of *Bryobia* were negligible.

Guthion applications affected the peach silver mite dramatically by lowering their numbers from a high of 27-44 mites/leaf to nearly zero. Recovery did orcur, but the numbers of peach silver mite dropped again in August (Fig. I - 4). No impact of guthion was detected on the ERM population.

Figure I - 3. Two-spotted spider mites in the Hwy. 132 orchard near Stockton treated with guthion and sevin on May 26 and July 27, respectively. So few mites were in the trees in April, May and early June that they were not plotted. Applications of acaricides between the Aug. 16 and Aug. 30 sample dates in adjacent trees affected the spider mite populations.

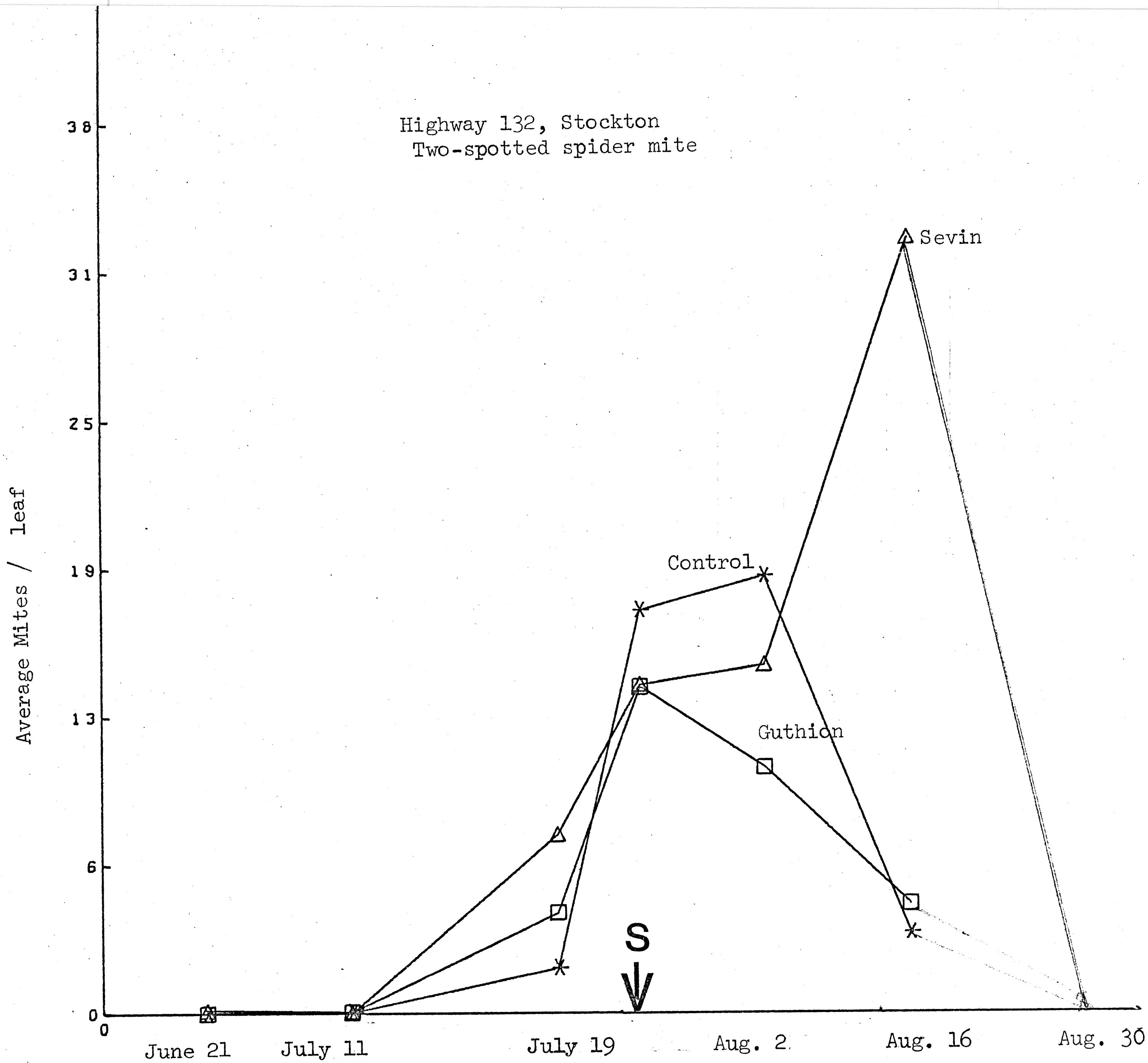
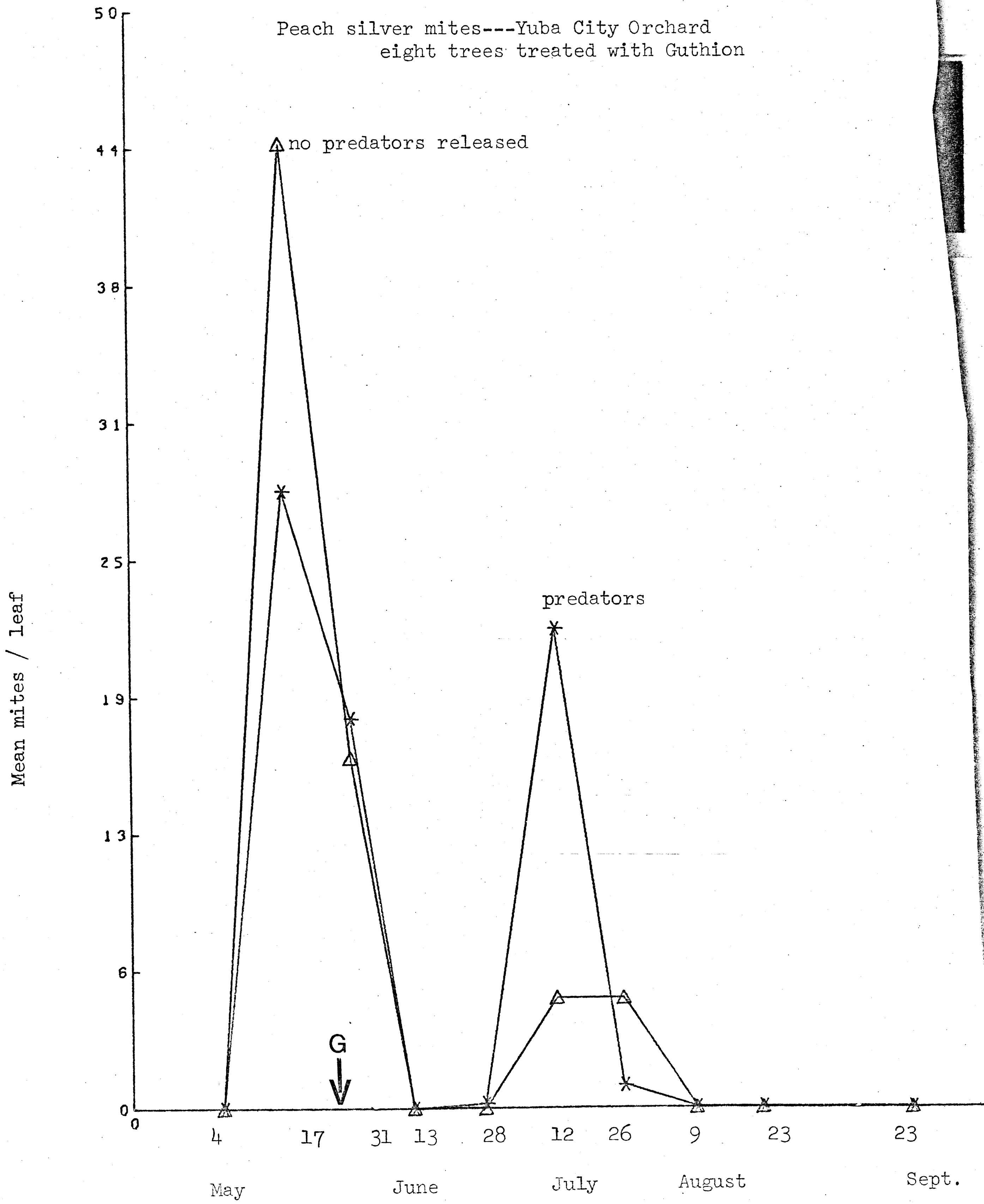

Highway 132, Stockton
Two-spotted spider mite
Average Mites / leaf
38
31
25
19
13
6
0
0
June 21
July 11
July 19
Aug. 2
Aug. 16
Aug. 30
S
Control
Guthion
Sevin

Fig. I - 4. Mean numbers of peach silver mite (Aculus cornutus) in 4 trees treated with guthion and in 4 trees treated with guthion in which Metaseiulus occidentalis had been released as well.



Peach silver mites---Yuba City Orchard
eight trees treated with Guthion
no predators released
predators
Mean mites / leaf
50
44
38
31
25
19
13
6
0
0
G
4
17
31
13
28
12
26
9
23
23
May
June
July
August
Sept.

Pest Mites Found in Northern Almond Orchards

Five orchards were sampled during 1977 from late March until late September, one each near Yuba City, Wheatland and Stockton and two orchards near Modesto. The table below lists the species observed and their relative abundance.

Table 1. The Complex and Relative Abundance of Mites Found in 5 Northern California Almond Orchards During 1977

Location	Mite Species				
	European red mite	Brown almond mite	Two-spotted spider	Pacific spider mite	Peach silver mite
Whitmore Ave, Modesto	++++	+	++	+	++
Hwy.99, Modesto	++++	+	+	+	+
Hwy.132,Stockton	+	+	+++	+	0
Wheatland	++++	++	+	0	++
Yuba City	++	+++	++	+	+++

++++ = abundant
+= present, but low
0 = absent

Orchard ______________ TEN MINUTE SURVEY DATE ______________

	not seen	observed: rare	observed: common	observed: heavy	damage: evident	damage: not evident	Notes
PESTS							
Panonychus ulmi							
Tetranychus urticae							
Tetranychus pacificus							
Bryobia							
peach silver mite							
other ______							
______							
PREDATORS							
spiders on leaves							
spiders on twigs							
spiders on bark							
Coccinellidae							
Stethorus larvae							
Stethorus adults							
Others (color) adults							
______							
______							
Chrysopa adults							
Chrysopa larvae							
Chrysopa eggs							
Metaseiulus occidentalis (?)							
Other Phytoseiids							
Six spotted thrips							
OTHERS ______							

Predators Found In Northern Almond Orchards

Predators of spider mites were found and identified on leaves during sampling of pesticide treatment plots, during counts in predator release trees and during counts of the "intensive" sampling of leaves. Predators were also evaluated using a 10-minute survey method. This survey allowed us to get an estimate of relative abundance of predators not easily sampled on leaves, especially those that fly readily. The attached data sheet demonstrates the types of observations made.

The results of leaf samples and 10-minute surveys allow me to conclude that insect predators are dramatic in their numbers and impact in these northern orchards. The most common and active predators included especially the lady beetle, *Stethorus picipes*, which feeds on mites exclusively,and various lacewings, including two green lacewing species (*Chrysopa carnea* and *C. nigrocornus*) and a brown lacewing, *Hemerobius*. The brown lacewings were so numerous in late June and July in the Modesto orchards that they became a pest to the leaf samplers by landing on, and attempting to bite, them.

It is likely that the very high ERM populations in these orchards were decimated by the combined action of the *Stethorus picipes* and the brown lacewings along with the increase in temperatures.

Other predators found, but never common, included the ashy grey lady beetle (*Olla*) and various species of spiders.

Predators of Spider Mites Commonly Found in Almond Orchards Near Yuba City, Wheatland, Stockton and Modesto During 1977.

Coccinellidae spider mite destroyer	*Stethorus picipes*
Chrysopidae green lacewings	*Chrysopa carnea* *Crhysopa nigrocornus*
Hemerobiidae brown lacewing	*Hemerobius* sp.
Phytoseiidae predaceous mites	*Metaseiulus occidentalis* *Metaseiulus mcgregori*
Thripidae 6-spotted thrips	*Scolothrips sexmaculatus*

Releases of the Predatory Mite, *Metaseiulus occidentalis*, into Almond Trees

The predatory phytoseiid mite, *M. occidentalis*, is considered to be able to regulate spider mites in a number of crops in California. Crops in which it *may* be effective include: apples, pears, grapes, walnuts, peaches, strawberries, plums, etc. In Washington state, a mite pest management program for apples has been built around pesticide-resistant *M. occidentalis*. Organophosphate-resistant predators allow chemical control of the codling moth without secondary mite outbreaks.

Surveys of pear orchards near Sacramento showed that *M. occidentalis* is resistant to Guthion and diazinon (and probably cross-resistant to most organophosphates). Therefore, I wanted to learn if Guthion-resistant *M. occidentalis* could be released into almond trees, established, and effect control of spider mites even though Guthion applications might be made.

Releases of *M. occidentalis* were made in all 5 orchards sampled in 1977. Releases were made as early as possible and release dates were determined by the availability of prey. As soon as samples showed there were at least 1 - 2 prey mites/leaf, releases were made.

Releases were made twice in each orchard, using 5 release sites/tree each time. Adult gravid, guthion-resistant female *M. occidentalis* were aspirated from colonies into plastic drinking straws and plugged with cotton. The straws were pinned to the tree trunk, open end up and the plug was removed. Observations made at the time of releases showed that the predators quickly left the straws. Altogether, 300 females were released/tree.

Wheatland - No pesticide applications were made in this orchard. The predators were released into 4 trees on May 17 and June 13. The August 23 sample showed significantly more European red mites in the non-release trees than in the release trees. This difference supports the hypothesis that the predator had an impact on the pest population, but does not prove it.

Whitmore Avenue, Hwy 99 and Hwy 132

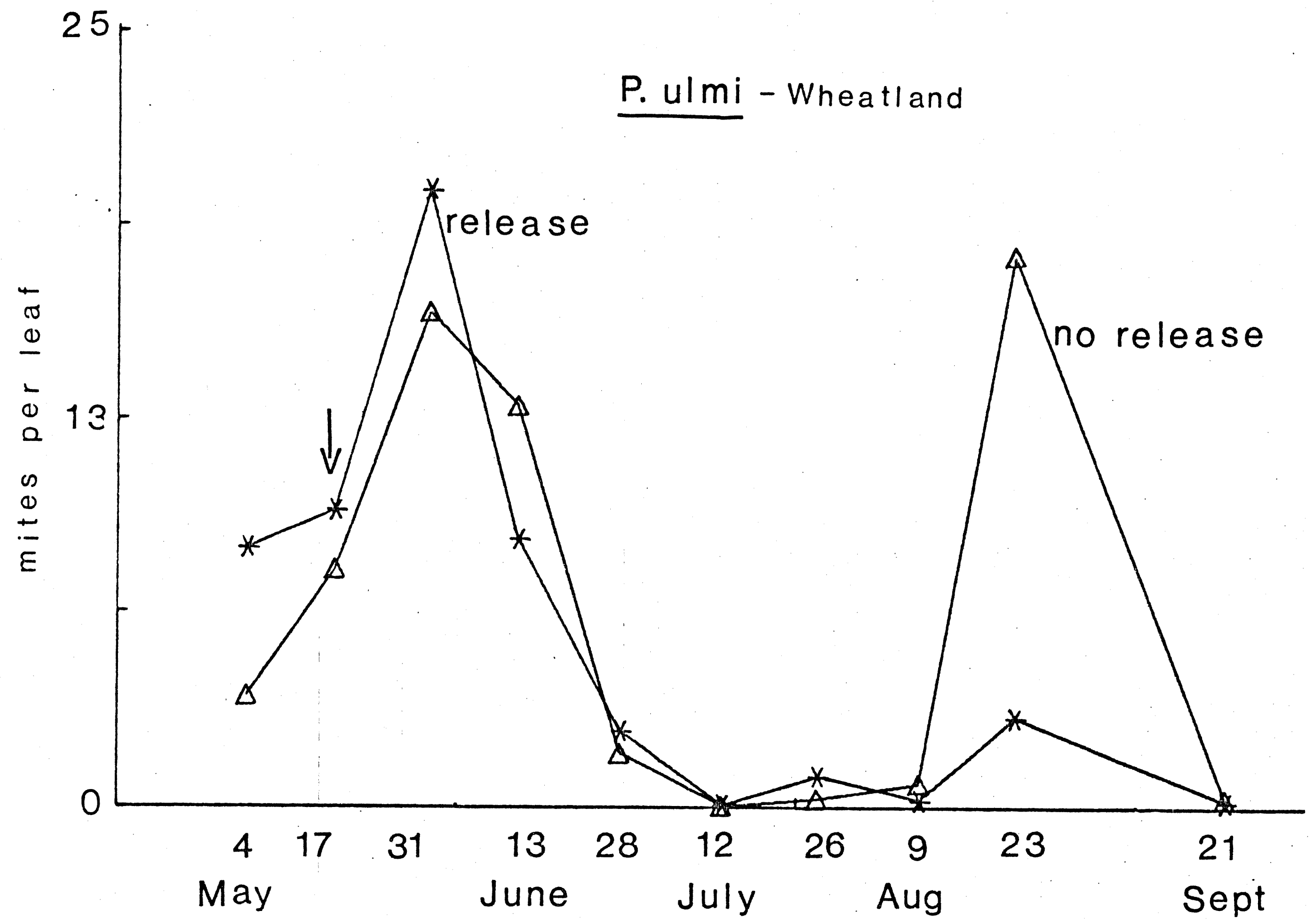
In the Whitmore Avenue and Hwy. 99 orchards near Modesto and in the Hwy 132 orchard near Stockton no impact of the predator releases could be determined when ANOVA was conducted comparing ERM numbers in release and non-release trees for each sample date in either the control, Sevin or Guthion trees (a total of 24 trees per orchard).

In the Yuba City orchard, significantly fewer peach silver mites (A. cornutus) were present in the predator-release trees than in the non-release trees on leaves sampled from the lower half of the trees only in the trees being sampled "intensively" in quadrants. This suggests that M. occidentalis was feeding upon the peach silver mite but did not disperse far from the release sites in the lower part of the tree. Although the peach silver mite is rarely (or never?) considered a pest in almonds, the impact on these prey is promising as it means that the peach silver mite may serve as an alternate prey for this predator, and allow f the permanent establishment of M. occidentalis in at least some almond orchards.

In the Hwy 132 orchard, near Stockton, predator releases were made very late in the season (in June), because adequate prey was not present earlier to sustain the predators (see Fig. I-4 in Section I). No measurable impact of predators was found.

Figure IV - 1

Population trends of European red mite in trees with and without *Metaseiulus occidentalis* releases in an almond orchard near Wheatland, CA during 1977.


P. ulmi - Wheatland
release
no release
mites per leaf
25
13
0
4
17
31
13
28
12
26
9
23
21
May
June
July
Aug
Sept

Preliminary Evaluations of the Lady Beetle, *Stethorus loxtoni*, for Spider Mite Control

Lady beetles of the genus *Stethorus* are known for their mite feeding habits. Our native California species, *S. picipes*, was very numerous in two almond orchards that had high densities of European red mite. These beetles require large numbers of prey mites to develop, to maintain themselves and to reproduce. Hence they are often found after the "damage" has occurred.

In contrast, *S. loxtoni*, from Australia, is about half the size of *S. picipes*. As a result, it can survive on much lower densities of prey mites, and is reported to be a very effective predator of mites in apples. Since this predator has the added advantage over predatory mites of being able to fly - and hence distribute itself - I felt it should be tested as a predator of mite species found on almonds.

A thesis by Noel Richardson (U.C. Berkeley 1977) on *Stethorus loxtoni* had established that it is extremely effective as a predator of the two-spotted spider mite. (An abstract of Dr. Richardson's thesis is attached.)

In addition, we attempted to feed *S. loxtoni* with peach silver mite (*Aculus cornutus*), brown almond mite (*Bryobia rubioculus*), and European red mite (*Panonychus ulmi*).

We saw no evidence that *S. loxtoni* would attack any stage of peach silver mite or brown almond mite. *S. loxtoni* did feed readily on the mobile stages of European red mite, but appeared to have difficulty with the eggs.

A colony of citrus red mite (Panonychus citri) near the laboratory in Berkeley allowed an additional test. S. loxtoni fed on all stages in these preliminary trials. Since citrus red mite is found in almonds in the southern San Joaquin Valley this is of considerable interest. Additional feeding preferences need to be determined to allow judgment as to whether S. loxtoni will do well in almonds.

Other evaluations that need to be done include trying to learn if S. loxtoni has a reproductive diapause that would allow it to overwinter successfully in the San Joaquin Valley. Field cage methods are being developed now to help answer whether this species can be successfully established in California almond orchards.

THE BIOLOGY OF *Stethorus loxtoni* Britton and Lee (Coleoptera : Coccinellidae) AND ITS POTENTIAL AS A PREDATOR OF *Tetranychus urticae* Koch (Acarina : Tetranychidae) IN CALIFORNIA.

By NOEL LOUIS RICHARDSON.

ABSTRACT

Stethorus loxtoni is a small exotic predaceous coccinellid, that preys upon the twospotted mite, *Tetranychus urticae*. At 25°C the life cycle of *S. loxtoni*, from egg to adult, is completed in 16.0 days, followed by a 2.1 day pre-oviposition period. Females lay an average of 281 eggs during an average reproductive period of 43 days. *S. loxtoni* has a mean generation time of 29.6 days during which the net reproductive rate is 89.6 times. The intrinsic rate of increase at 25°C is 0.152 per female per day and the time required for the population to double its size is 4.6 days. The eggs hatch in 3.5 days. There are four larval stages lasting 2.6, 1.4, 1.4 and 3.0 days, respectively. The duration of the pupal stage is 3.4 days. The threshold and optimum temperatures for development are 11°C and 35°C, respectively. An obligatory diapause does not occur in the life cycle. *S. loxtoni* appears to detect its host only by contact, and wanders randomly until a prey is encountered. All stages are voracious feeders. Mite eggs are preferred as prey. First, second, third and fourth instar larvae consume 21, 48, 67 and 147 mite eggs per day, respectively. Adult males, pre-ovipositional females, gravid females and non-fecund females consume 62, 87, 130 and 51 mite eggs per day,

respectively. All stages show a strongly developed functional response to prey density. The number of prey consumed per predator increases linearly at low prey densities but levels off to a plateau at high prey densities. All stages show a significant numerical response to prey density. In the immature stages this is exhibited in a changing survival rate. The adult females respond by producing more eggs. All active stages of S. loxtoni are cannibalistic. Cannibalism is greatest at low prey densities. Arithmetic models describing the theoretical interaction between T. urticae and S. loxtoni are presented, assuming that the predator has no trouble finding the prey. The prey populations are theoretically annihilated on the second day of the interaction when the original female predator to female prey ratio is 1 : 10; on the third day when the original ratio is 1 : 20; on the fifth day when the original ratio is 1 : 30; on the sixth day when the original ratio is 1 : 50; and on the ninth day when the original ratio is 1 : 100. The interaction between populations of S. loxtoni and T. urticae on living host plants was studied in growth chambers. The experiments indicate that S. loxtoni could suppress a field population of mites below the economic threshold in less than two generations of the prey when the initial predator-prey ratio is 1 : 100.

S. loxtoni exhibits many of the attributes expected in an effective natural enemy. It is able to maintain itself at low prey densities; its power of increase is more than adequate to offset that part of the intrinsic power of increase of the prey that is not negated by predation; it is behaviorally and reproductively synchronized with its prey and its habitat; and finally it possesses strongly developed functional and numerical responses to prey density.

It is concluded that Stethorus loxtoni would be a valuable natural enemy for the control of T. urticae in California. Once established, it should remain effective unless disrupted by the use of persistent broad spectrum insecticides.

.... Thesis Committee

Chairman

THE Relative Toxicity of Permethrin to a Predator, *Metaseiulus occidentalis*, and to Its Prey, *Tetranychus urticae*.

The attached manusc ript has been accepted by Environmental Entomology for publication. These laboratory data show that the toxicity of this pyrethroid is significantly greater (20-40 times) to the predator than to the prey, the two-spotted spider mite.

Insect predators of mites were not tested, but based on relative toxicities of other pesticides to insect predators, permethrin is likely to be relatively more toxic to insect predators of mites as well. Outbreaks of spider mites have been commonly reported in field trials involving this group of pesticides, and the outbreaks could be due to mortality of the predators and/or to physiological stimulation of the spider mites. (There is no data to date that shows this chemical causes physiological stimulation of spider mite reproduction, however.)

Because the pyrethroid chemicals are effective at very low doses, have very low mammalian toxicity and high levels of activity against lepidopteran pests, integrated pest management programs may be developed with this group of pesticide as part of the program. Therefore, I have begun a genetic selection program to obtain resistance to permethrin in the spider mite predator, *M. occidentalis*. Should this selection program be successful, I hope to release it into crop systems to obtain permanent establishment. High levels of organophosphate resistance already can be found in this predator in grapes and pears (Hoy, unpublished). Ideally, we can combine OP resistance with carbamate and pyrethroid resistance in one strain of *M. occidentalis*.

Desirable future work to be done would involve condinuing this selection program involving M. occidentalis and the evaluation of the lady beetle predators of spider mites, Stethorus picipes (our native California species) and S. loxtoni, the tiny Australian lady beetle, for sensitivity to permethrin.

Table. No 3 (Contd.) -

Stack identity	Fumigant location in stack	Insect location in stack	Fumigated in early egg stage: Unhatched	Fumigated in early egg stage: hatched	Fumigated in pupae stage – Pupae: Alive	Pupae: dead	Adults: Alive	Adults: dead	Total: Alive	Total: dead
number	Location	number	number	number	number	Number	Number	Number	Number	Number
12	not fumigated	2 (2)	133	236	0	0	27	3		
"		3 (3)	48	351	0	0	30	0		
"		4 (4)	34	301	0	0	27	3		
"		5 (5)	29	323	0	0	29	1		
Total =			244	1211	0	0	113	7		
Avg. =			61	303			28	1.75		
% =			16.8	83.2			94.1	5.9		
Placed in holding room at laboratory			23	275	0	0	30	0		
			26	205	0	0	29	1		
"			13	268	0	0	28	2		
"			17	158	0	0	23	7		
"			13	183	0	0	29	1		
"			19	212	0	0	30	0		
Total =			111	1301	0	0	169	11		
Avg. =			18.5	216.58			28	1.8		
% =			7.9	92.1			93.9	6.1		

Table. No 3 (Contd.) -

Stack identity	Fumigant location in stack	Insect location in stack	Fumigated in early egg stage		Fumigated in pupae stage					
					Pupae		Adults		Total	
			Unhatched	hatched	Alive	dead	Alive	dead	Alive	dead
Number	Location	number	number	number	number	Number	Number	Number	Number	Number
12	not fumigated	2 2]	133	236	0	0	27	3		
"		3 3]	48	351	0	0	30	0		
"		4 4]	34	301	0	0	27	3		
"		5 5]	29	323	0	0	29	1		
	Total =		244	1211	0	0	113	7		
	Avg =		61	303			28	1.75		
	% =		16.8	83.2			94.1	5.9		
Placed in holding room at laboratory			23	275	0	0	30	0		
			26	205	0	0	29	1		
"			13	268	0	0	28	2		
"			17	158	0	0	23	7		
"			13	183	0	0	29	1		
"			19	212	0	0	30	0		
	Total =		111	1301	0	0	169	11		
	Avg =		18.5	216.8			28	1.8		
	% =		7.9	92.1			93.9	6.1		

... Summary of the effect of hydrogen phosphide, under conditions described in tables No. 1 + No. 2, on the early egg stage (less than 24 hrs. old) + the pupa stage of the NOW. In all four stacks the dosage + exposure period was the same. In stacks 8+9 the tablets were placed at one location by each stack + in stacks 10+11 tablets were placed at 2 locations by each stack. Stack No. 12 remained untreated.

Stack identity	Fumigant location in stack	Insect location in stack	Fumigated in early egg stage		Fumigated in pupae stage					
					Pupae		Adults		Total	
			Unhatched	Hatched	Alive	Dead	Alive	Dead	Alive	Dead
number	location	number	number	number	number	number	Number	number	Number	number
8	1 side	2 [2]	367	0	0	30				
"	"	3 [3]	239	0	0	30				
"	"	4 [4]	370	1	0	30				
"	"	5 [5]	332	133	0	30				
	Total	=	1675	134	0	120				
	Avg	=	419	34						
	%	=	92.6	7.4						
9	1 side	2 [2]	415	0	0	30				
"	"	3 [3]	395	3	0	30				
"	"	4 [4]	327	0	0	30				
"	"	5 [5]	134	177	0	30				
	Total	=	1271	180	0	120				
	Avg	=	318	45						
	%	=	87.6	12.4						
10	2 sides	2 [2]	326	0	0	30				
"	"	3 [3]	361	0	0	30				
"	"	4 [4]	478	0	0	30				
"	"	5 [5]	385	0	0	30				
	Total	=	1550	0	0	120				
	Avg	=	388							
	%	=	100							
11	2 sides	2 [2]	352	0	0	30				
"	"	3 [3]	379	0	0	30				
"	"	4 [4]	370	0	0	30				
"	"	5 [5]	194	28	0	30				
	Total	=	1295	28	0	120				
	Avg	=	324	7		12.0				

ible No. 2.- Summary of concentrations of hydrogen phosphide + temperatures found a five locations within 2 stacks of inhull almonds fumigated with Aluminum phosphid Phostoxin®) in tablet form during a 72 hour exposure period. The dosage was 20 tablets/M ca [illegible]t. + half of the tablets were placed at 1 location on one side of each stack + the remaining ½ on the other side of each stack.

ample	Concentration of fumigant					Temperature				
	Location in stack					Location in stack				
terval	number 1 [1]	number 2 [2]	Number 3 [3]	Number 4 [4]	Number 5 [5]	Number 1 [1]	Number 2 [2]	Number 3 [3]	Number 4 [4]	Number [5]
ours	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.	P.P.M.
					Stack Number 10					
egan :10 P.M										
1	40	5	10	15	5	112	82.5	86	88	93.5
2	45	15	15	40	25	81	81	85	86	83
4	50	10	20	90	30	70	87	85	86	74
8	60	10	40	120	40	62	84	84	85	67
12	110	50	100	100	110	59	81	89	83	61
24	100	145	115	100	190	111	101	84	84	78
36	140	120	125	140	120	69	85	85	85	68
48	120	110	100	110	100	102	120 +	83	85	82
[illegible]	90	110	90	90	90	60	86	87	88	56
72	80	85	70	75	70	120	85	81	84	68
Total =	835	660	685	880	780	846	892.5	849	854	730.5
Avg =	83.5	66.0	68.5	88.0	78.0	84.6	89.2	84.9	85.4	73.0
N =	10									
					Stack Number 11					
egan at 3:20 P.M.										
1	25	0	10	5	5	114	83	88	85	71
2	25	5	15	15	25	90	82	86	83	70
4	20	5	15	50	20	70	86	88	83	73
8	60	15	90	120	20	62	77	87	83	73
12	120	60	120	125	30	58	77	86	80	67
24	100	100	150	190	105	149	100	86	77	71
26	120	100	140	150	95	70	87	87	82	72
48	100	100	110	110	100	120	100	84	79	71
[illegible]	90	80	90	90	90	58	86	88	89	71
72	60	60	50	65	60	128	82	83	74	65
Total =	720	525	790	920	620	919	860	863	815	704
Avg. =	72.0	52.5	79.0	92.0	62.0	91.9	86.0	86.3	81.5	70.4
N = 10										
Total =	1555	1185	1475	1800	1400	1765	1752.5	1712	1669	1434.5
Avg =	77.8	59.2	73.8	90.0	70.0	88.25	87.6	85.6	83.4	71.7
N = 20										

Table No. 1 - Summary of Concentrations of hydrogen phosphide + temperatures found a[illegible] four locations within 2 stacks of inhull almonds fumigated with aluminum phosphid[e] (Phostoxin®) in tablet form during a 72 hour exposure. The dosage was 20 tabl[ets] [illegible] M cu. ft. + were placed at one location along one side of each stack.

Sample interval hours	Concentration of Fumigant — Location in Stack: Number 1[1] P.P.M.	Number 2[2] P.P.M.	Number 3[3] P.P.M.	Number 4[4] P.P.M.	Number 5[5] P.P.M.	Temperature — Location in Stack: Number 1[1] °F	Number 2[2] °F	Number 3[3] °F	Number 4[4] °F	Number [5][5] °F
Stack Number 8 (Began at 4:35 P.M.)										
1	20	5	20	5	2	105	90	70.5	70	66.5
2	40	15	45	15	15	81	90	71	71	69
4	20	20	40	20	20	82	89	74	72	66
8	50	40	90	40	20	67	82	78	73	72
12	120	90	100	85	50	62	77	73	72	69
24	175	125	150	190	60	155	101	77	74	69
36	150	150	140	150	90	72	76	78	77	72
48	100	100	100	150	120	120+	105	80	79	70
[illegible]	110	115	115	115	95	64	58	80	77	74
72	90	95	105	95	95	120+	95	77	76	62
Total =	875	755	905	865	567	928	863	758.5	741	689.5
Avg = N = 10	87.5	75.5	90.5	86.5	56.7	92.8	86.3	75.8	74.1	69.0
Stack Number 9 (Began at 3:50 P.M.)										
1	10	15	20	15	1	114	60	70	72	64
2	20	20	25	10	3	85	90	70	72	65
4	20	20	30	20	10	80	88	72	74	66
8	30	30	56	90	15	70	76	73	75	68
12	90	80	110	110	50	63	81	72	75	63
24	150	125	100	200	120	116	102	74	76	67
36	150	125	125	150	120	74	91	75	77	69
48	100	110	100	100	100	120+	106	76	76	70
60	105	110	100	90	90	91	93	78	78	68
72	75	85	95	80	80	130	99	77	77	60
T[illegible]l =	750	720	755	865	589	943	880	737	752	660
Avg = N = 10	75.0	72.0	75.5	86.5	58.9	94.3	88.0	73.7	75.2	66.0
G Total =	1625	1475	1660	1730	1156	1871	1743	1495.5	1493	1349.5
avg = n = 20	81.25	73.8	83.0	86.5	57.8	93.6	87.2	74.8	74.6	67.5