CONTROL OF MITES ON ALMONDS

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Project Number: 83-B7

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Project No. 83-B7-Navel Orangeworm Mite and Insect Research
Control of Mites on Almonds

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Objectives: To develop methods which will aid control of mites in almond orchards.

Interpretive Summary: During 1983, we evaluated the orchards where pesticide-resistant predatory mites (Metaseiulus occidentalis) were established during 1979-1982. We determined their efficacy, their ability to overwinter, and their carbaryl (Sevin) resistance levels. Very low rates of the selective acaricides Omite and Plictran were assessed as spider mite management tools for these orchards.

To determine the rates and timing of these selective acaricides, seven orchards from Livingston to Bakersfield were monitored each week beginning May 1. Leaf samples were brushed and counted and the mean number of mites, the predator:spider mite ratio and the number of spider mite days (feeding damage) that had accrued since the previous sample were determined. These predators were present and well distributed in all the orchards. However, when the ratio of predators:spider mites was inadequate to give rapid control early in the season, a single application of 1 lb. 30 WP Omite/acre allowed the predators to gain complete control. No additional acaricide applications were necessary in the orchards where our recommendations were followed.

Samples of predators were obtained from each orchard and tested for their Sevin resistance levels. Sevin resistance levels are high in the majority of the release sites, despite the fact that only one, or occasionally two, applications of Sevin have been made since the releases. Thus, the Sevin-OP-sulfur and Sevin-OP resistant strains are persisting well in the release orchards.

Dispersal studies were conducted to answer two questions: 1) Do the resistant predators move out of the orchard and colonize surrounding orchards/vineyards? If so, how far and how rapidly? 2) How many susceptible native M.occidentalis disperse into the orchards that have received resistant predators? Can they reduce the resistance levels? We conclude that resistant predators are dispersing from the release orchards, but they are not doing so in sufficiently high numbers that they dramatically increase the resistance levels of the native predators in the recipient orchards. Conversely, sufficiently few susceptible predators move into the release sites that resistance levels are not decreasing in the predators established there. Thus, growers who want to use Sevin-OP-sulfur resistant predators in their mite management program should release them into their orchards; once established, the resistance levels should remain high for several years.

A carbaryl-OP resistant strain of the predator Typhlodromus pyri, obtained from New Zealand, was released; no recoveries have been made so far.

II Introduction

The objectives for 1983-84 were: 1) Document efficacy of resistant _M.occidentalis_ released into almonds during 1981 and 1982. 2) Develop guidelines for mite management with reduced rates of acaricides. 3) Continue collaborative work on a simplified sampling program for spider mites in almonds. 4) Improve the predator mass rearing system. 5) Determine distances aerially dispersing mites travel. 6) Provide seed cultures of resistant predators and training on how to rear, release, and monitor. 7) Release a pesticide resistant strain of _Typhlodromus pyri_ from New Zealand into almond orchards with abundant European red mites. 8) Maintain pure cultures of resistant predator strains for future releases.

The above objectives were all met during the past year, and are discussed in detail in separate sections.

III. Mass Production of Resistant *M. occidentalis*

During the 1983 field season, carbaryl-OP-sulfur and carbaryl-OP-permethrin resistant *M. occidentalis* were reared in the greenhouse on pinto bean plants with *Tetranychus urticae* as prey, following the method described by Hoy *et al*. (1982). Flats of predators were shipped beginning in May and continued throughout August (Table III-1). While predators can be made available even later in the season, releases are not made in September since the released predators must go through at least one generation in the field before diapause induction occurs in early September. Multiplication and diapause induction are difficult to obtain in almond orchards if prey are scarce, which is often the case at this time of the year.

Most of the predators reared were carbaryl-OP-sulfur resistant (Table III-1) and these were provided to Lonnie Hendricks for releases into three almond orchards (Table III-2 and see maps). Cliff Kitayama released the predators into a 285-acre almond orchard near Chico (Tables II-2 and 3). Walt Bentley provided half a flat of carbaryl-OP-sulfur resistant *M. occidentalis* to Mr. Weins for release into a 20 acre almond orchard near Shafter, in Kern County, with preliminary indications that establishment has occurred.

Nearly 4 million adult female predators were produced over the season, with about 3.4 million of them the carbaryl-OP-sulfur resistant strain (Table II-1). Fewer (ca. 0.355 million) of the permethrin-OP-carbaryl resistant strain were reared due to fewer requests for this predator.

The densities of this strain on the bean foliage were always lower than those of the carbaryl-OP-sulfur strain, for unknown reasons.

Greenhouse rearing required about 5 hours labor/week. This included planting, watering, infesting, monitoring, spraying, and sampling prior to shipment. Each strain was reared on 2 benches (4 total). These 2 benches covered ca. 102 square feet. The lower labor input reported during 1983 as compared to 1981 is attributed to the fact that the technicians doing this are expert in the procedure and can do it more efficiently. Savings in time can be attributed to the following changes in procedure as reported in Hoy *et al*. (1982): 1) sampling has been streamlined and is done only to obtain estimates of the numbers present on the flats before field releases. Daily observations are sufficient to ascertain that predator: prey ratios are in good adjustment. 2) The densities of predators on flats has been increased dramatically for both the predators and *T. urticae*. Newly planted bean flats were inoculated with high densities of *T. urticae* in order to provide adequate prey for the predators transferred from old flats. Even then, prey often had to be added at least once because the predators were able to consume the spider mites. 3) This meant that Omite was never sprayed during the 1983 season, another savings in time and effort. 4) Each newly infested bean flat was sprayed with either carbaryl, sulfur or diazinon. This effort insured that no foreign predators contaminated the flats. 5) Finally, diseases of the bean plants were absent during the 1983 summer months, so that use of fungicides was unnecessary.

We provided starter cultures of both predator strains to several people for rearing in greenhouses (or soybean plots) and the results were substantially less successful. It appears that predator rearing must be conducted over a period of 6 months to a year so that the individuals doing the rearing can become sufficiently expert so that problems from contamination, disease and inappropriate predator:prey ratios are minimized.

We planted no soybean plots during the summer in 1983 since previous summer soybean plots planted in April or May were successful during both 1981 and 1982. It was anticipated that greenhouse production during 1983 would be adequate for our needs.

The soybean plot could not be planted in January or February 1983 in Berkeley due to the extremely wet winter we had. The soil could not be worked until May and by that time, we were heavily involved in field work and did not have time. Furthermore, the point of this project had been to determine if it were possible to plant soybeans VERY early in January or February so that mass releases could occur in late June rather than August as they do with the April or May plantings. Because of our difficulties, we conclude that early season rearing would depend upon winter weather conditions and thus could not be done every winter.

Conclusions

At the moment, the greenhouse production method appears to be best overall. Large numbers of predators can be produced at any time of the year and are dependent only upon the size of greenhouse space available.

The predator yields achieved during this summer were not maximized and even this small space (102 sq ft/strain) could have produced many more predators if efforts had been made to achieve maximum production, primarily by distributing the predators at peak densities prior to reductions in prey densities on the bean flats in the greenhouse.

Reference

Hoy, M. A., D. Castro and D. Cahn. 1982. Two methods for large scale production of pesticide-resistant strains of the spider mite predator *Metaseiulus occidentalis* (Nesbitt) (Acarina: Phytoseiidae). Zeitsch. angew. Entomol. 94:1-9.

Table III-1. Total greenhouse production of resistant M. occidentalis during May - August 1983, Berkeley, Calif. in ca. 100 sq. feet of bench space using pinto beans and T. urticae as prey[1/].

Predator strain[2/]	Date shipped	No. flats	No. ♀♀ per flat	Total	Sent to:
Carb-OP-S	20 May	24	15,100	363,000	Dick Bethell
Carb-OP-S	23 May	16	25,100	401,000	Lonnie Hendricks
Carb-OP-S	27 May	34	5,300	179,000	Dick Bethell
Perm	27 May	10	3,100	31,000	Dick Bethell
Carb-OP-S	14 June	32	15,300	490,000	Dick Bethell
Carb-OP-S	23 June	25	3,800	95,000	Cliff Kitayama
Perm	17 June	6	3,100	19,000	P.H. Westigard
Carb-OP-S	8 July	30	15,400	463,000	Cliff Kitayama
Perm	8 July	30	4,500	136,000	Dick Bethell
Carb-OP-S	22 July	10	34,600	346,000	Carolyn Pickel
Carb-OP-S	29 July	16	32,400	713,000	Dick Bethell
Perm	29 July	16	6,500	104,000	Dick Bethell
Carb-OP-S	8 Aug.	16	7,900	127,000	Dick Bethell
Perm.	8 Aug.	24	2,700	65,000	Dick Bethell
Carb-OP-S	19 Aug.	13	8,900	116,000	Jack Feltman
Carb -OP-S	24 Aug.	19	6,900	131,000	Dick Bethell

Total all strains: 3.779 million females Total Carb-OP-S strain: 3.424 million females

Total perm. strain: 0.355 million females

1/ A total of ca. 5 hours per week were devoted to planting, infesting, monitoring, watering, sampling, and shipping.

2/ Carb-OP-S = carbaryl - organophosphate and sulfur resistant

Perm = carbaryl - organophosphate and permethrin resistant

Table III-2. Shipments of carbaryl-OP-sulfur resistant *M. occidentalis* during 1983 field season from the U.C.-Berkeley greenhouse.

Date	No. flats	Estimated # *M.o.* ♀♀ per flat	Total ♀♀ shipped	Sent to
23 May	16	25,100	401,000	Lonnie Hendricks
23 June	25	3,800	95,000	Cliff Kitayama
8 July	30	15,400	463,000	Cliff Kitayama
		Total	959,000	

Additional small numbers of predators (1-2 flats) were provided to Bill Barnett, Lonnie Hendricks and Walt Bentley as starter cultures for large-scale rearing elsewhere

Table III-3. Releases in Chico of the carbaryl-OP-sulfur resistant strain of _M_. _occidentalis_[1/].

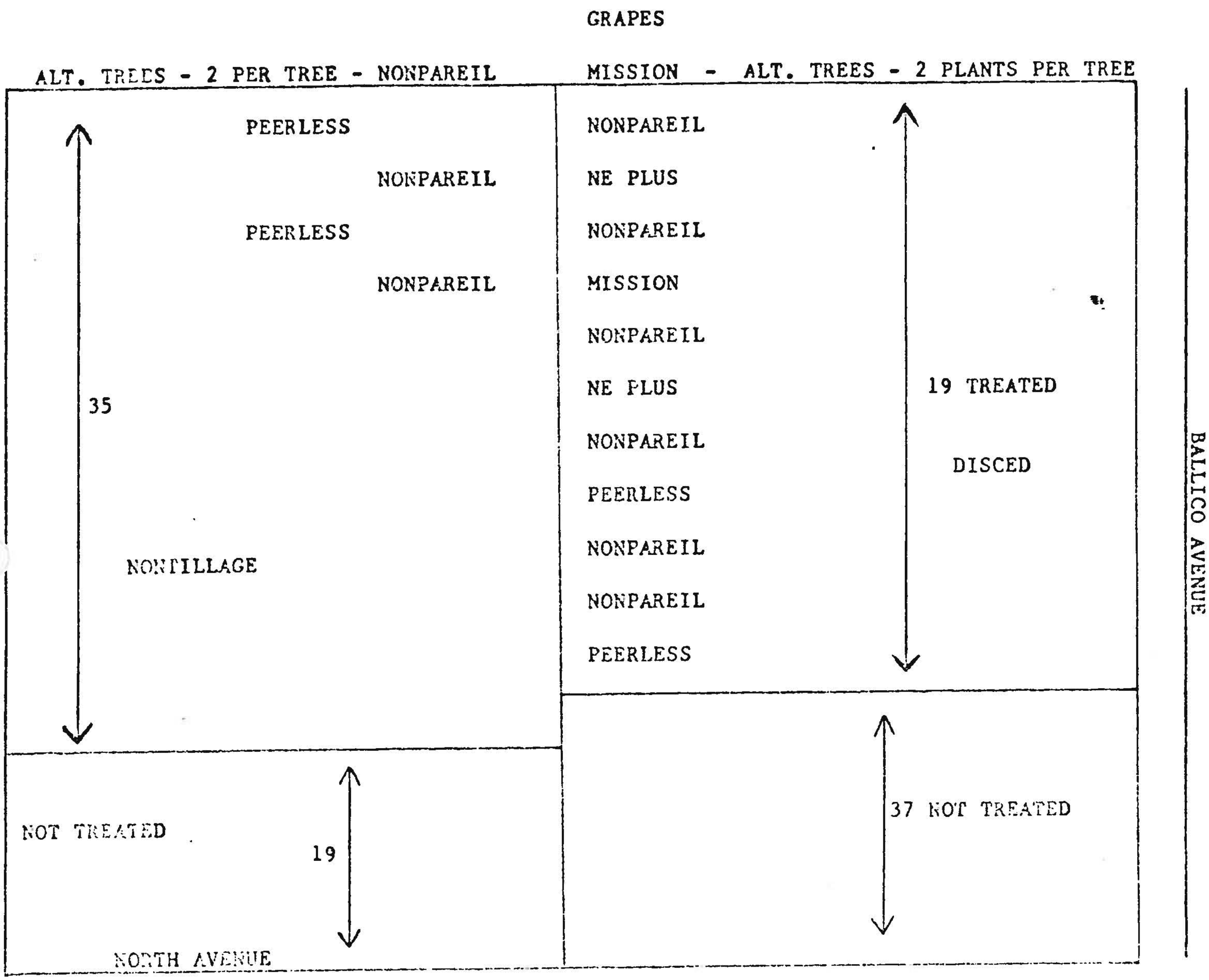
Date	Block size	Release pattern	Total number ♀♀ released
June 23, 1983	80 acres	1 plant/tree	95,000
July 8, 1983	205 acres	1 plant every other tree	463,000

_1_/ The almond orchard is on Hwy 99 and Anita Road 6 mi. N. of Chico (Butte Co.) and is owned by Mr. Hennigan. Guthion was applied at hull split and carbaryl was applied in August before harvest for NOW. In September, abundant _M_. _occidentalis_ were observed in the orchard.

DON HARCKSEN

May 25, 1983

M. occidentalis Release - carb-OP-S

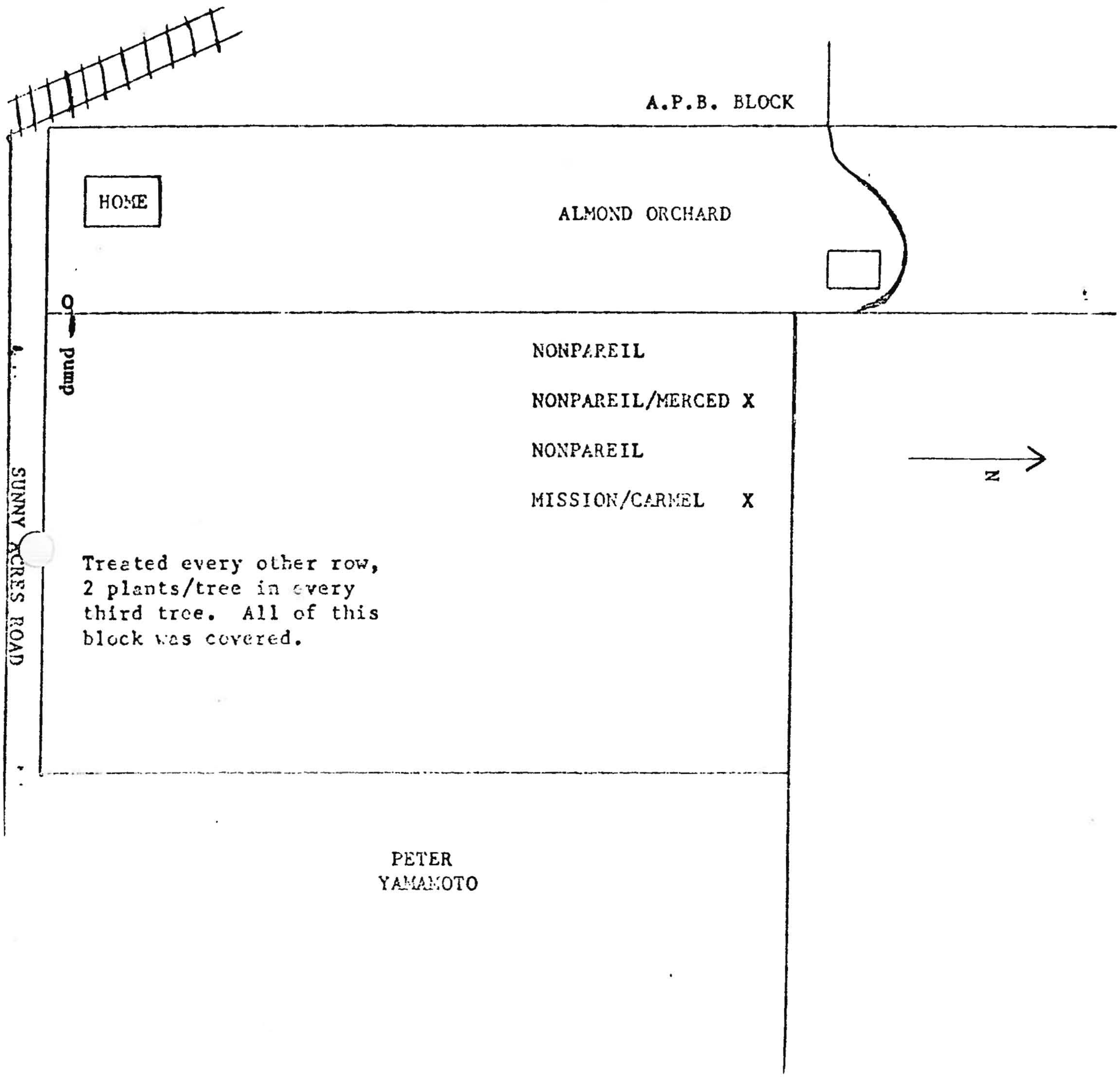


Released in every other tree in every 3rd row. Started with Row 1 at the north end. Used two plants per tree.

YEICHI SAKAGUCHI

May 25, 1983

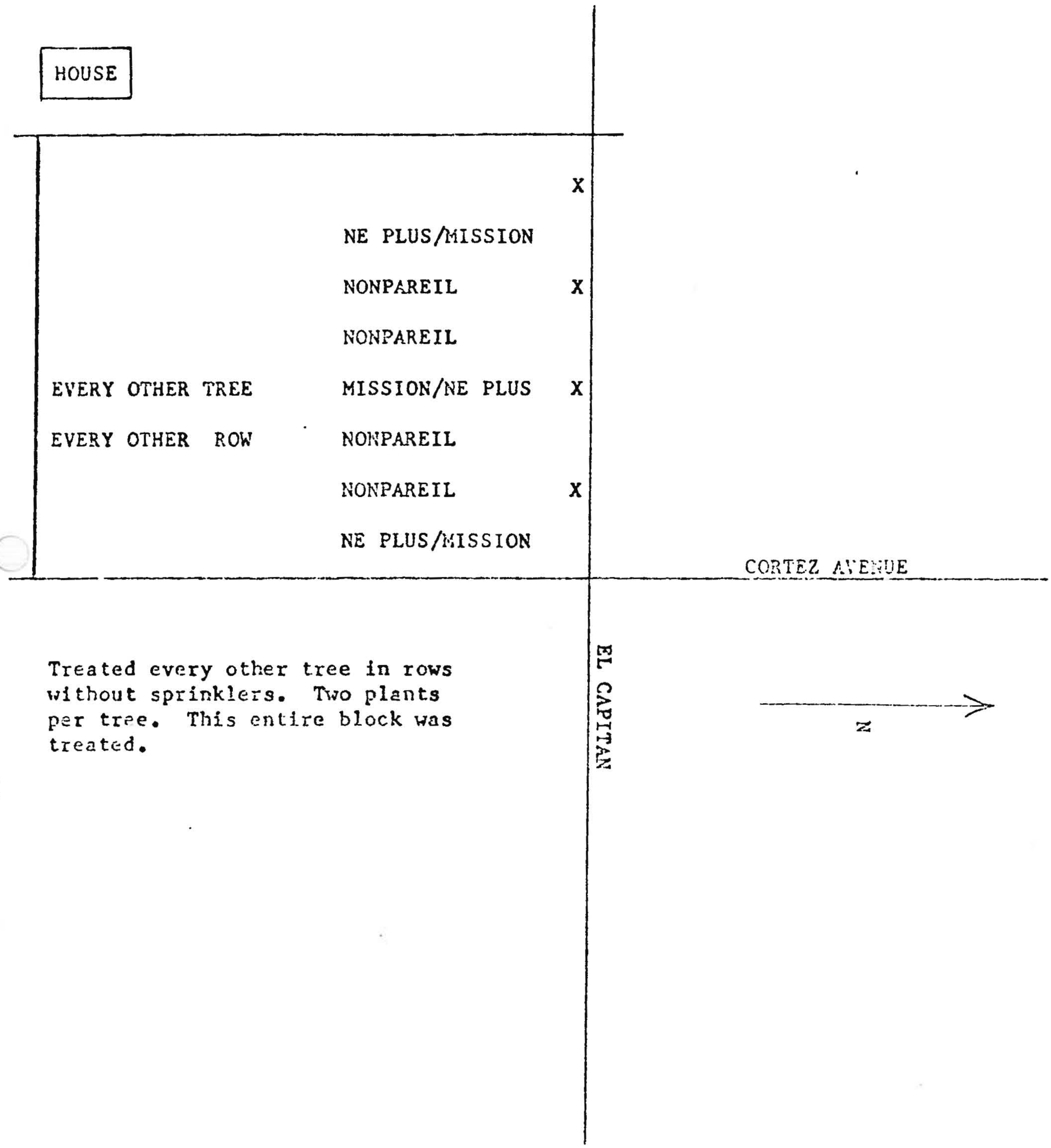
M. occidentalis Release



MADELYN BELL

May 25, 1983

M. occidentalis Release



IV. Evaluations of Previous Releases of Pesticide-Resistant *M. occidentalis* in Almond Orchards

General Methods

During 1983, spider mites and predators were monitored in the following almond orchards: Livingston-I, Livingston-II and II combined, Livingston-IV, Livingston-V, Wasco (Weddle orchard), Bakersfield (Bidart orchard), and Three Rocks (Sumner-Peck Ranch).

The orchards were monitored beginning the first week of May up to the second week of September. Ten leaves were taken from each marked tree and brushed and counted. Foliage samples were taken from "clusters," which consisted of one tree and the four surrounding trees. A cluster was usually located 10 rows and 10 trees from each corner of the orchard; in most orchards four clusters were sampled. Maps of each orchard are included in the discussion of each site. Mean spider mites and predators (active stages only)/leaf were estimated for each tree, each cluster, and the total orchard. Spider mite days (SMD) were estimated using the following formula: (last total SMD) + ½ (days between counts) x (last mean/leaf + new mean/leaf). Predator: prey ratios were estimated for each cluster and for the orchard. A discussion of the Mite Management Guidelines is in Section XI.

Livingston-I

This orchard was inoculated with carbaryl-OP resistant *M. occidentalis* in May 1981. Fig. IV-1 illustrates mean spider mites and *M. occidentalis* (active stages only) per leaf for 1981, 1982 and 1983. These graphs show the combined effects of establishing of M. occidentalis in this orchard and a program of mite management by use of low rates of acaricides. Over the three years, a decline in spider mite damage has been achieved as measured by the number of SMD accumulating over the season (illustrated at the top of each graph, Figs. IV-1). Data presented by Dr. Barnes' research group suggests that less than 120 SMD has little impact on almond trees.

During 1983, no insecticides were applied to this block and only one application of 0.5 lb. 30 WP Omite/acre was applied by ground in early June because counts in 2 of the 4 clusters sampled had predator-densities that were very low (Figs. IV-2 and 4). The spider mite:predator ratio was over the level proposed in the Management Guidelines (See Section Xi) in clusters 1 and 3. This very low rate of Omite apparently was sufficient to maintain the spider mite population at a plateau until the predators could multiply and maintain a 10:1 or better ratio the rest of the season. This is the first time we have tried 0.5 lb 30 WP Omite/acre; it is evident that it gave some assistance to the predators in this situation, but it might not be adequate if used later in the season when webbing or densities are higher, and we recommend that at least 1 lb be used in managing mites in orchards with pesticide-resistant M. occidentalis.

A small spray trial was conducted in this block during July that evaluated the effect of carbaryl, permethrin or water on spider mite control (See Section VII). The results showed that permethrin did disrupt spider mite control, leading to substantial defoliation in late August/early

September in these 6 trees. Carbaryl also disrupted spider mite control briefly; this is due to the fact that about half the predators in this orchard were *Amblyseius hibisci* during 1983 and these phytoseiids are susceptible to carbaryl. Thus about half the total predators on the carbaryl-treated trees were lost. The *M. occidentalis* in the block were also disrupted because the carbaryl resistance level in this population in June was only moderate (34% survival at 2.4 g.a.i. carbaryl/liter water). *M. occidentalis* recovered from the 6 trees treated with carbaryl had an 84% survival rate after selection with carbaryl. Despite this, *M. occidentalis* was able to control spider mites in the carbaryl-treated trees, but not before additional feeding damage had accrued. Thus, if carbaryl is used in this block in the future, a low rate of Omite should be included (1 or 2 lbs 30 WP/acre) to assist the predators after the spray.

It is noteworthy that during 1983 the dominant spider mite species in this orchard was the European red mite (ERM) and that *M. occidentalis* and *Amblyseius hibisci* did a good job of controlling this mite despite the fact that ERM is not a preferred prey for *M. occidentalis*. About half the phytoseiids in this block during 1983 were *A. hibisci*, which we have rarely observed in almonds. Perhaps the *A. hibisci* numbers were greater in 1983 than in previous years because no insecticides were applied during 1983.

The Mite Management Guidelines were designed to keep the number of *Tetranychus* species SMD under 120. In this orchard, the number of SMD at the end of the season totalled 98, and these were primarily induced by ERM, which has less impact on defoliation than feeding by *Tetranychus* spp.

There was no defoliation in this block during 1983 (except the 6 permethrin-treated trees) and M. occidentalis were present at the end of the season in good numbers. We expect good control by phytoseiids during 1984 unless disruptive pesticides are applied. If insecticides are applied, we expect M. occidentalis to become the dominant predator species again; if no insecticides are used, A. hibisci could continue to be abundant (see also Section VII).

In comparing the spider mite-predator interactions during 1981, 1982, and 1983, it is clear that predator-prey interactions have stabilized (Fig. IV-1). Whether the predators can maintain spider mite damage below 120 SMD without any acaricide is unknown; however, the extremely low rate used in 1983 is a fraction of the commonly-applied rate of 5-10 lb/acre. Such a reduction in acaricide usage will provide substantial savings to the grower, and will delay the onset of acaricide resistance in spider mites.

PLOT MAP

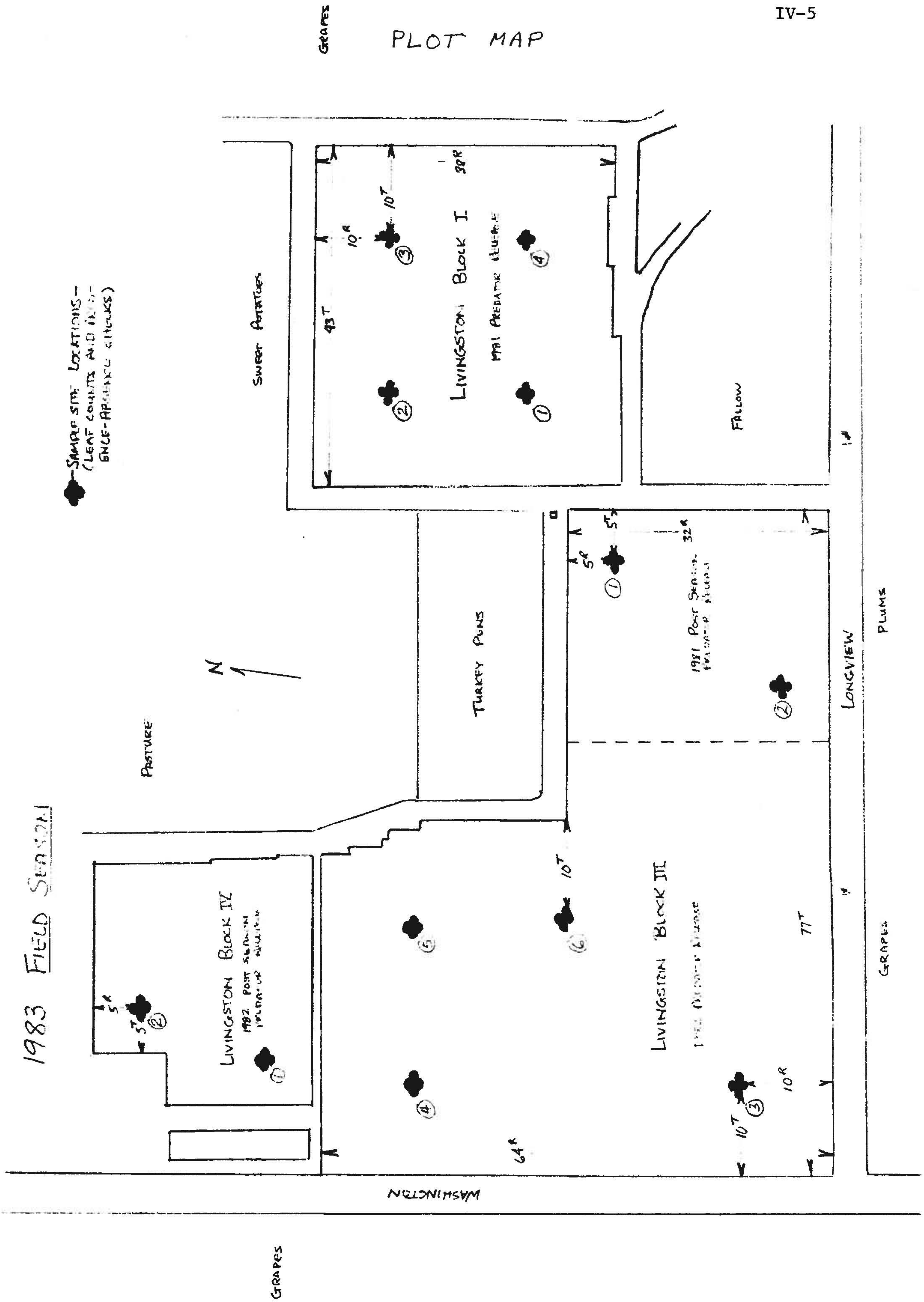
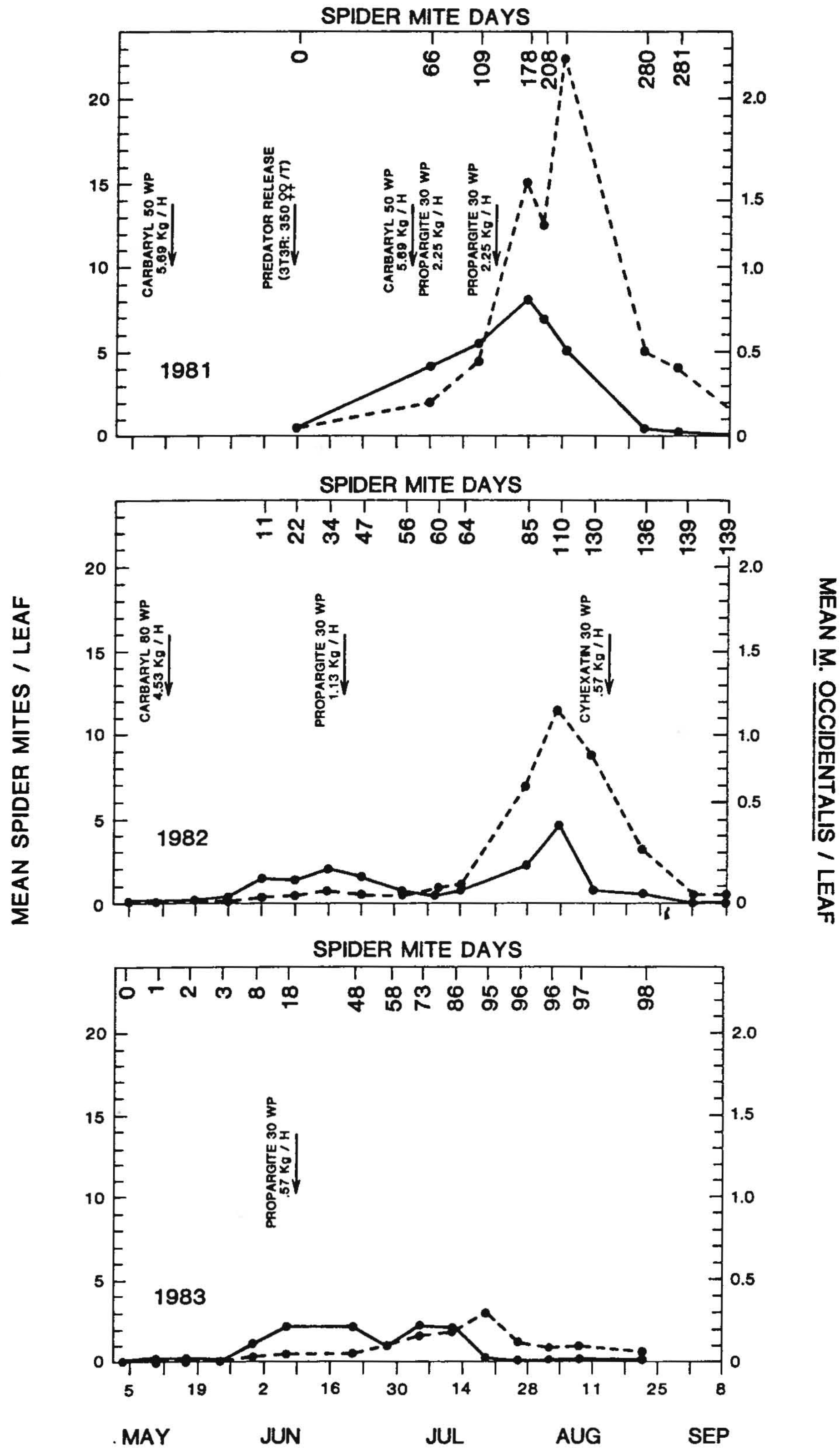
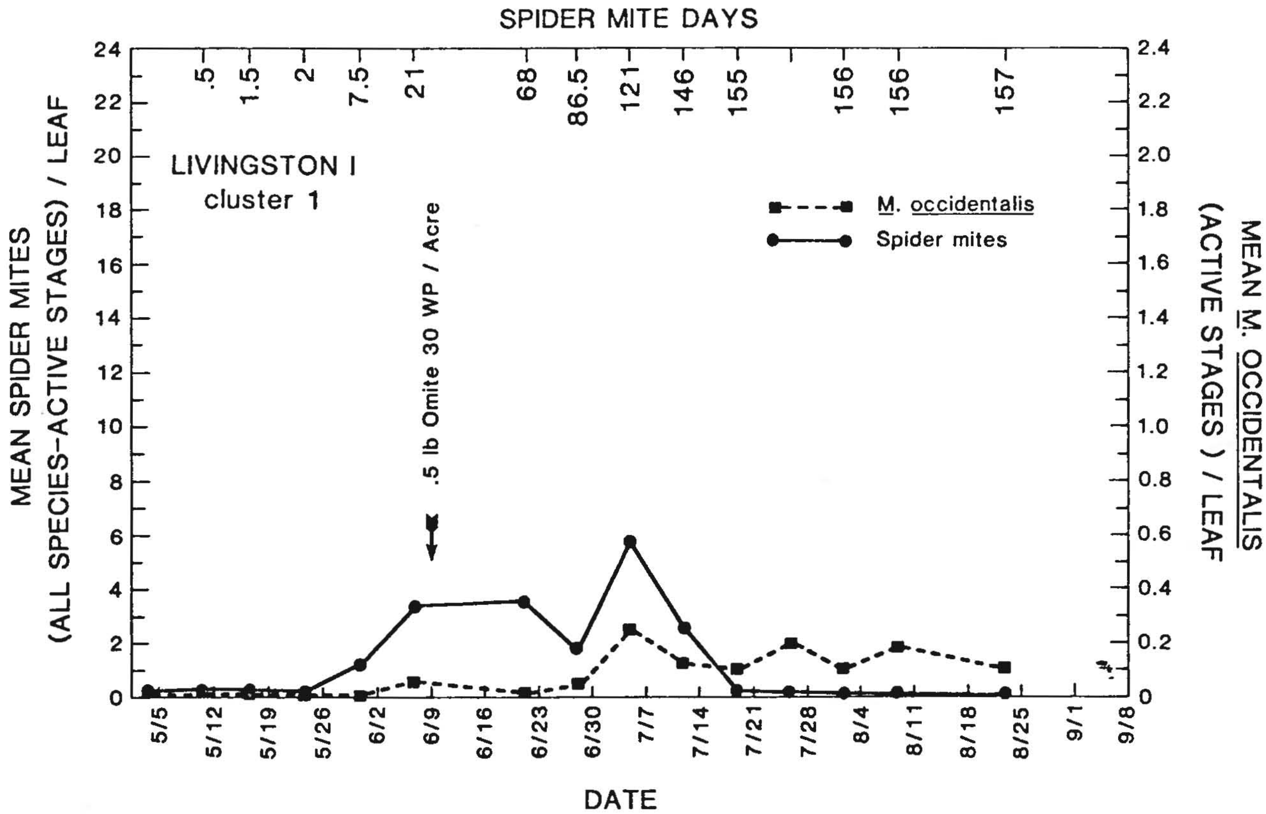
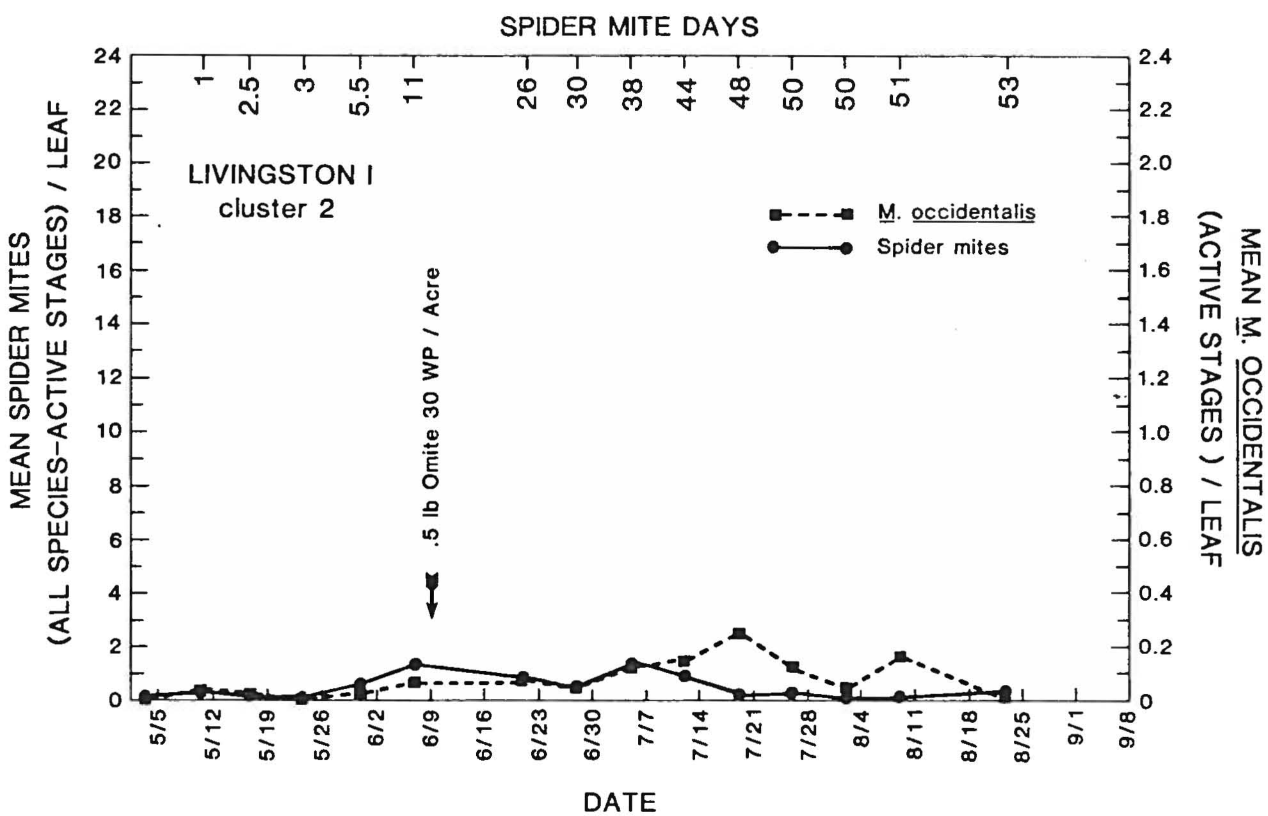

GRAPES
1983 FIELD SEASON
SAMPLE SITE LOCATIONS—(LEAF COUNTS AND INTERFERENCE-APHIDS CHECKS)
SWEET POTATOES
LIVINGSTON BLOCK I
1981 PREDATOR RELEASE
FALLOW
TURKEY PENS
1981 POST SEASON PREDATOR RELEASE
LONGVIEW
PLUMS
PASTURE
N
LIVINGSTON BLOCK IV
1982 POST SEASON PREDATOR RELEASE
LIVINGSTON BLOCK III
GRAPES
WASHINGTON
GRAPES
43T
38R
10R
10T
5R
5T
32R
77T
64R
10R
10T

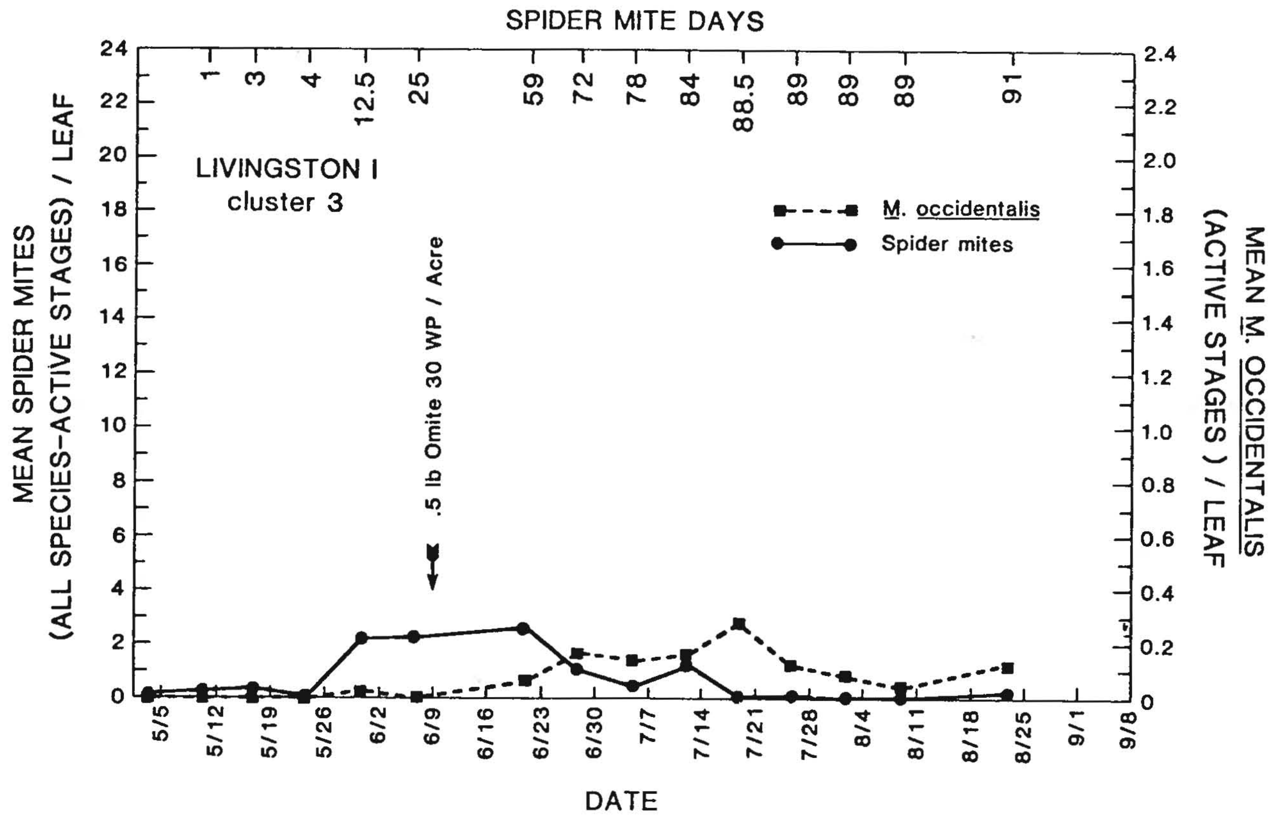
Fig.IV-1. Control of spider mites by carbaryl-OP resistant M.occidentalis in the Livingston-I almond orchard during 1981, 1982 and 1983. Solid lines represent spider mites and dashed lines represent predators. During 1981 and 1982, M.occidentalis was the dominant phytoseiid, but in 1983 Amblyseius hibisci composed ca. 50% of the phytoseiids.

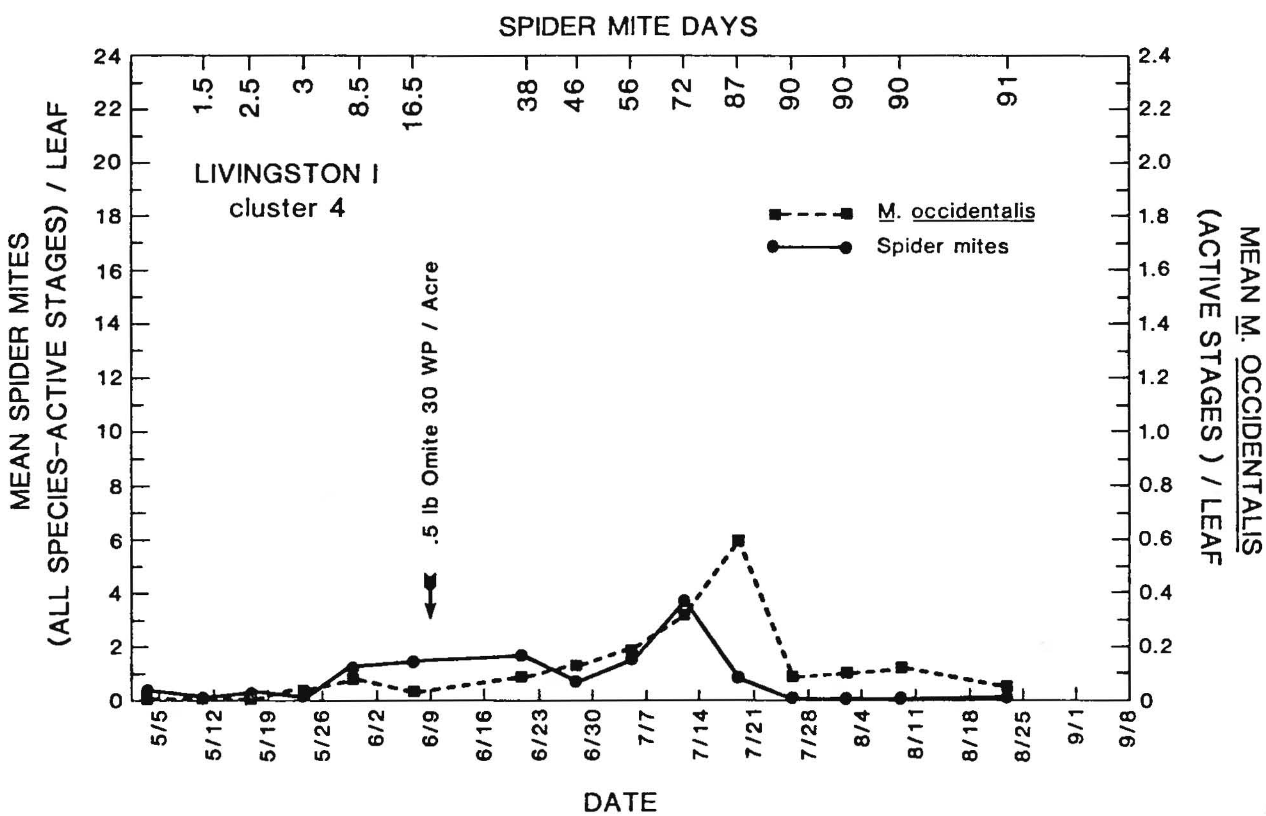






Figures IV-2-3. Spider mites and predators in the four sample sites (clusters) in Livingston-I during 1983. Cumulative spider mite days are also presented at the tops of each graph. European red mite dominated during 1983. *M. occidentalis* and *Amblyseius hibisci* were the phytoseiids during 1983.





Figures IV-4-5. Spider mites and predators in the four sample sites (clusters) in Livingston-I during 1983. Cumulative spider mite days are also presented at the tops of each graph. European red mite dominated during 1983. *M. occidentalis* and *Amblyseius hibisci* were the phytoseiids during 1983.

Livingston-II and III combined

During 1982 these two blocks were evaluated separately because predators were released at different times: carbaryl-OP resistant M. occidentalis were released (350 into every third tree in every third row) into Livingston-II on September 15, 1981; carbaryl-OP-sulfur resistant predators were released either in every third tree in every third row or into every tree on May 15, 1982 in Livingston-III. During 1983 we combined the two sites since they are contiguous (see plot map) and the predator-prey interactions that were occurring by the end of the 1982 season suggested that this area was moderately uniform.

During 1983, six sites were sampled (clusters containing 5 trees each), and the predator-prey interactions for the entire block are presented in Fig. IV-6.

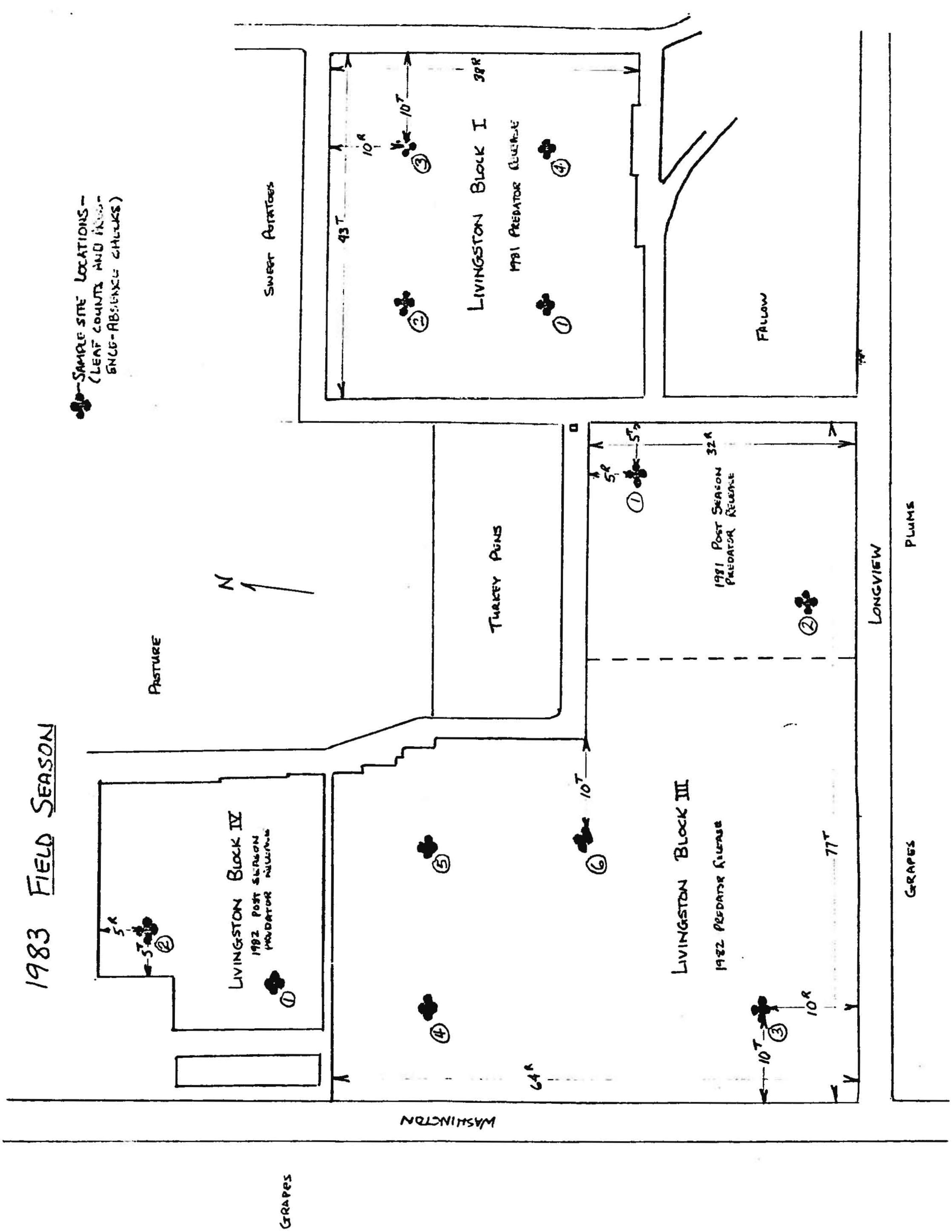
The block was not uniform, however, and clusters 1, 3, and 3 (Figs. IV-7, 8,9) had early season peaks of ERM. The accumulated SMD in these clusters indicated that an acaricide application was necessary in early June, particularly since M. occidentalis densities were still quite low. After the application by ground of 1 lb. 30 WP Omite/acre, no additional acaricides were required in the orchard, as the predators were able to maintain control the rest of the season (Fig. IV-6). ERM densities were not uniform throughout the block, however, and ERM rose slightly in early July in clusters 4, 5, and 6 (Figs. IV-10, 11, 12). M. occidentalis appeared to follow those populations as well. The center of the spider mite problems was the area around cluster 2, where ERM exploded in late May and early June. This section had received Guthion in 1982, whereas the rest of the orchard had received carbaryl. We don't know if there is a relationship or not as ERM was unusually abundant in all almond orchards we sampled during 1983, for unknown reasons. Later in the season, Pacific mite densities rose slightly in clusters 4 and 5 during July, but M. occidentalis was able to control them rapidly.

No insecticides were applied to this block during 1983. The predator-prey interaction was stabilized by the early season application of 1 lb of Omite/acre and the number of SMD accumulated subsequent to the acaricide application was ca. 50 over the orchard as a whole (Fig. IV-6). Ca. 153 SMD were accumulated over the season, with most of these being due to Duropean red mite feeding. Foliage in this orchard experienced some stippling, but mite-induced defoliation did not occur. M. occidentalis constituted the majority of the predators in this block, although there were a few Amblyseius hibisci present as well.

The predator-prey ratio in this orchard is good, and the predators should continue to control spider mites unless disrupted through the use of an insecticide such as permethrin or by use of high rates of acaricides. It appears from these results that the distribution and ratio of spider mites and predators early in the season is critical. By applying the 1 lb of Omite early in June to adjust these, the predators were able to maintain control the rest of the season (July). Later in the season Pacific mite populations rose slightly in the areas around clusters 5 and 6, but

M. occidentalis was able to control them quickly. If carbaryl is applied to this block in the future, a low rate of Omite (1 lb/acre) should probably be included to assist the predators. Application of low rates of Omite (one or two lbs 30 WP/acre) may be necessary to assist the predators in subsequent years. The 1983 results are the best mite control the grower has achieved in this block, which is located next to dusty turkey pens, and he is pleased with the Mite Management Program.

PLOT MAP


GRAPES
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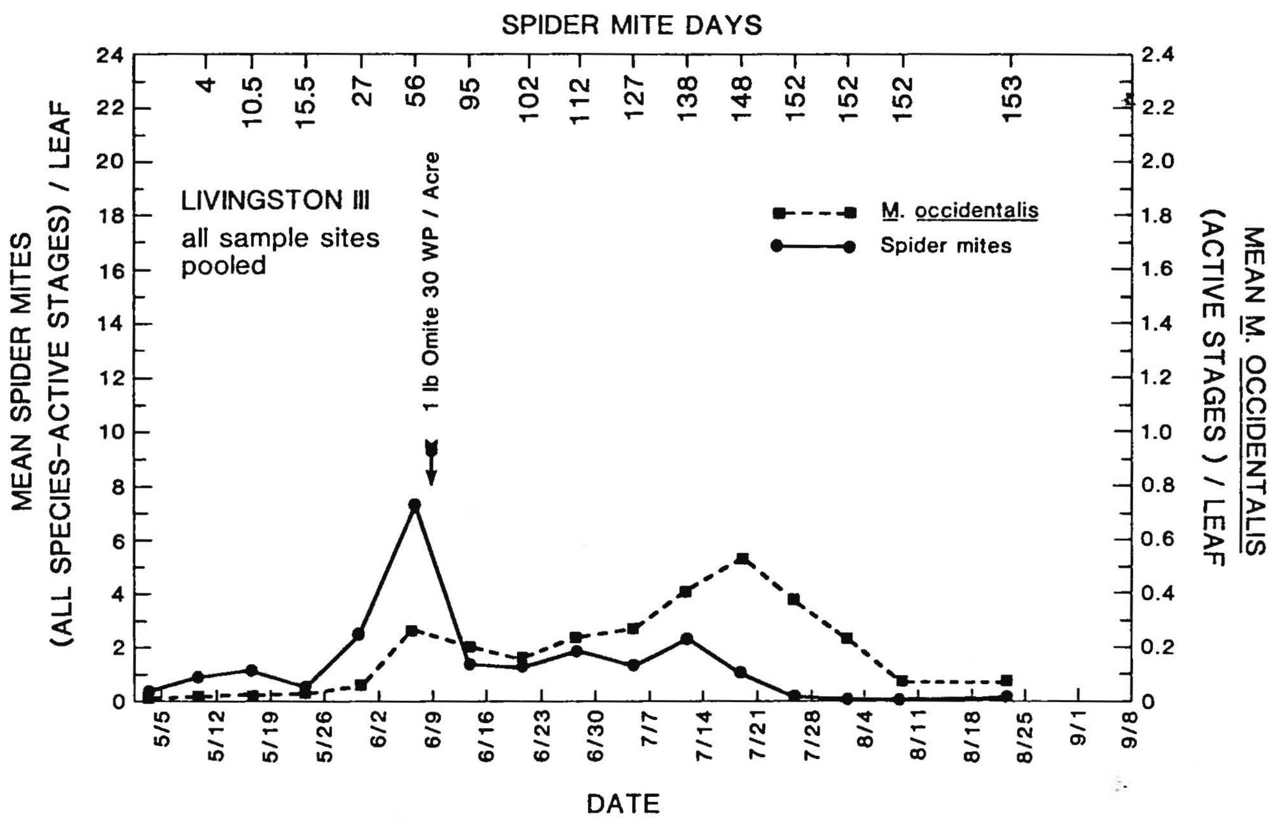
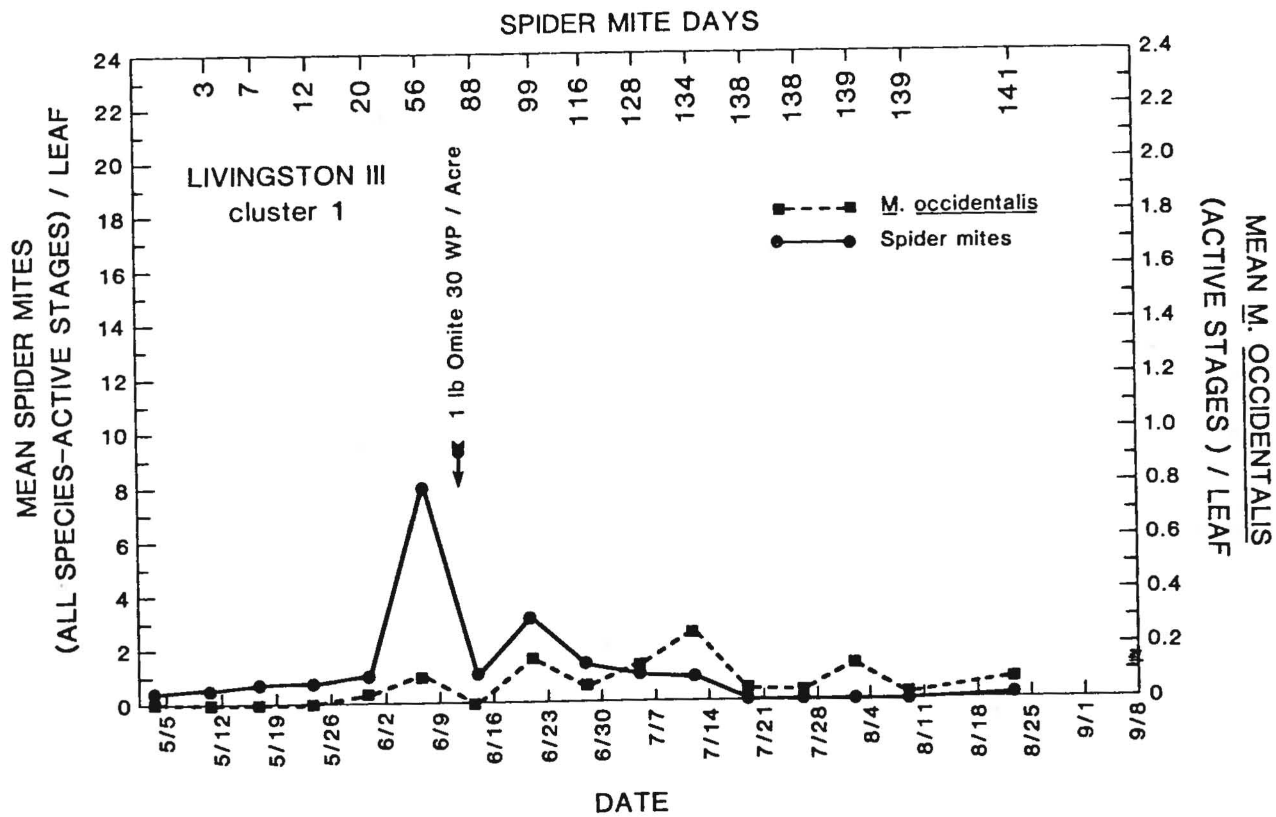
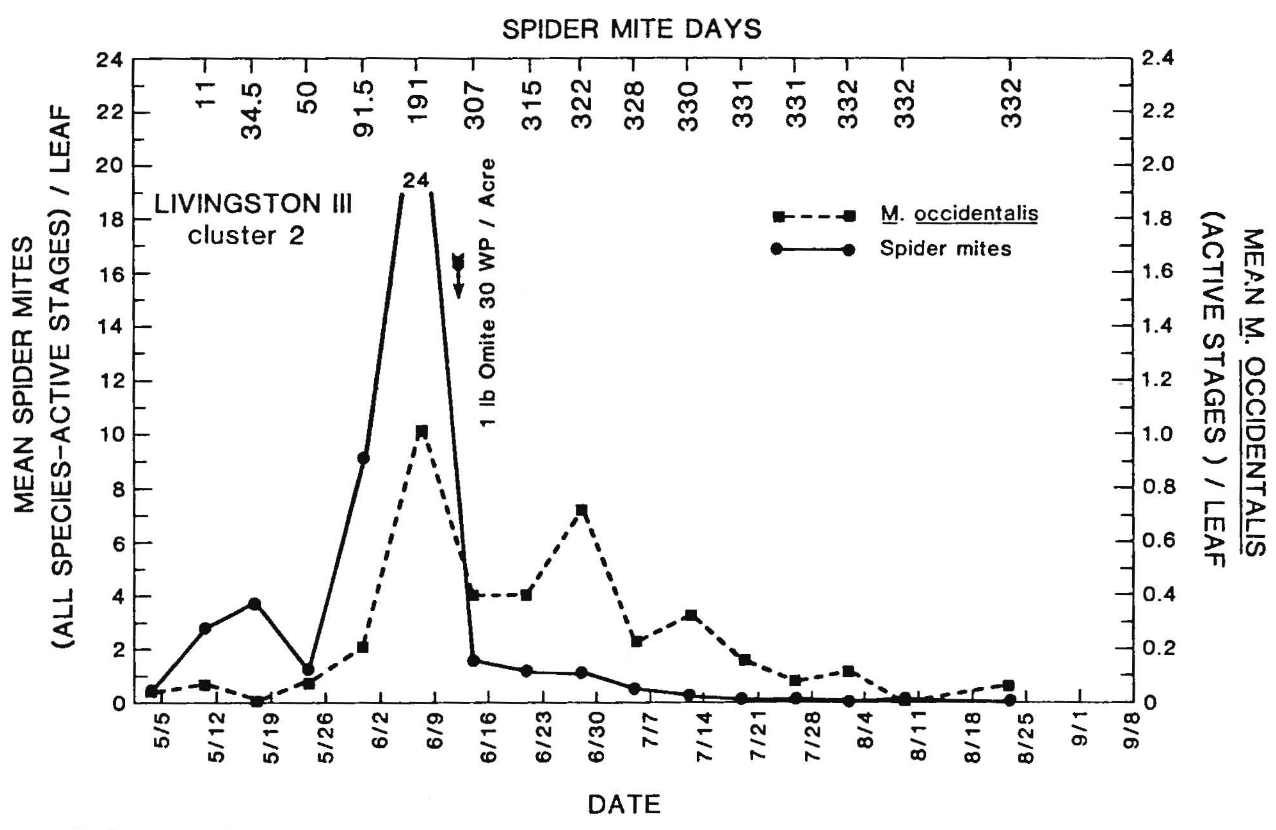
10T
77T
10R
64R
LIVINGSTON BLOCK IV
1982 POST SEASON PREDATOR RELEASE
5R
5T
GRAPES
WASHINGTON
GRAPES

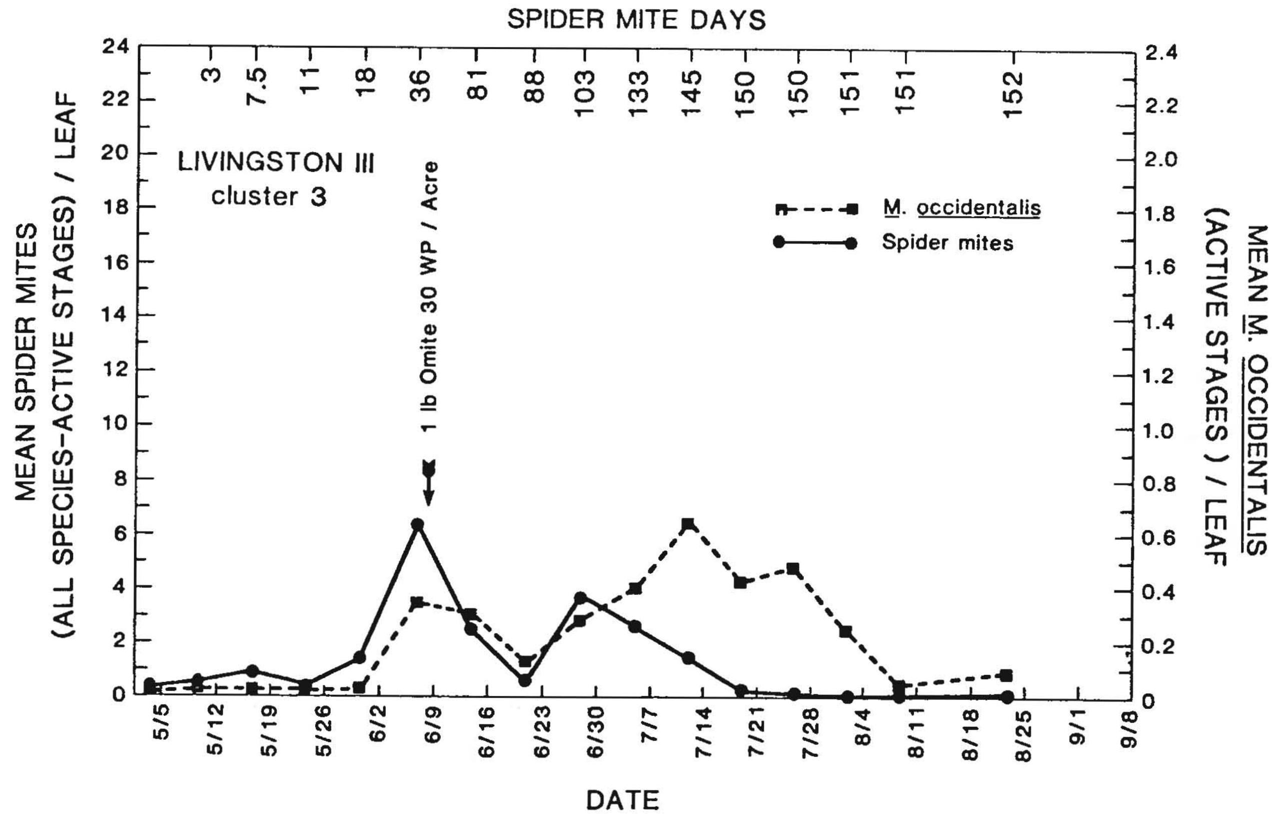
Figure IV-6. Spider mite and phytoseiid interactions in the combined Livingston II and III blocks during 1983.

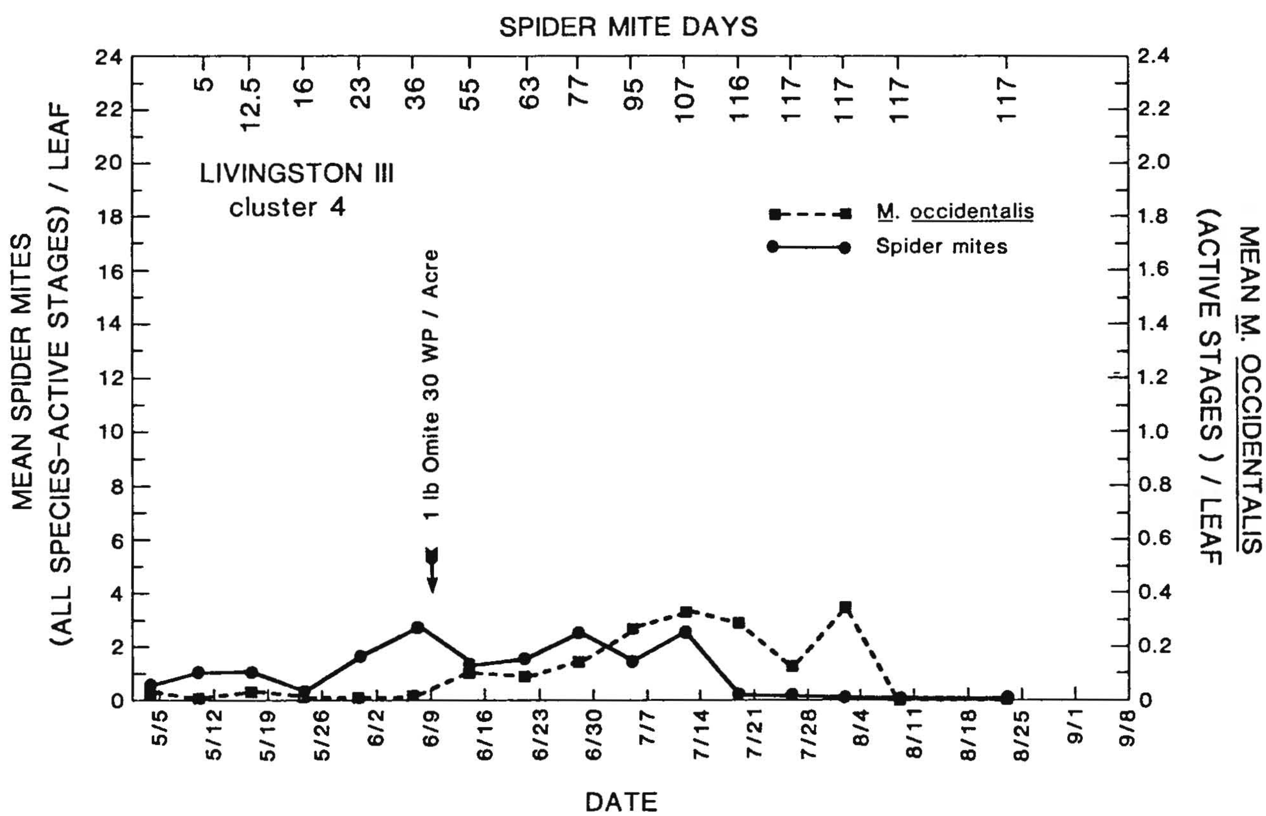




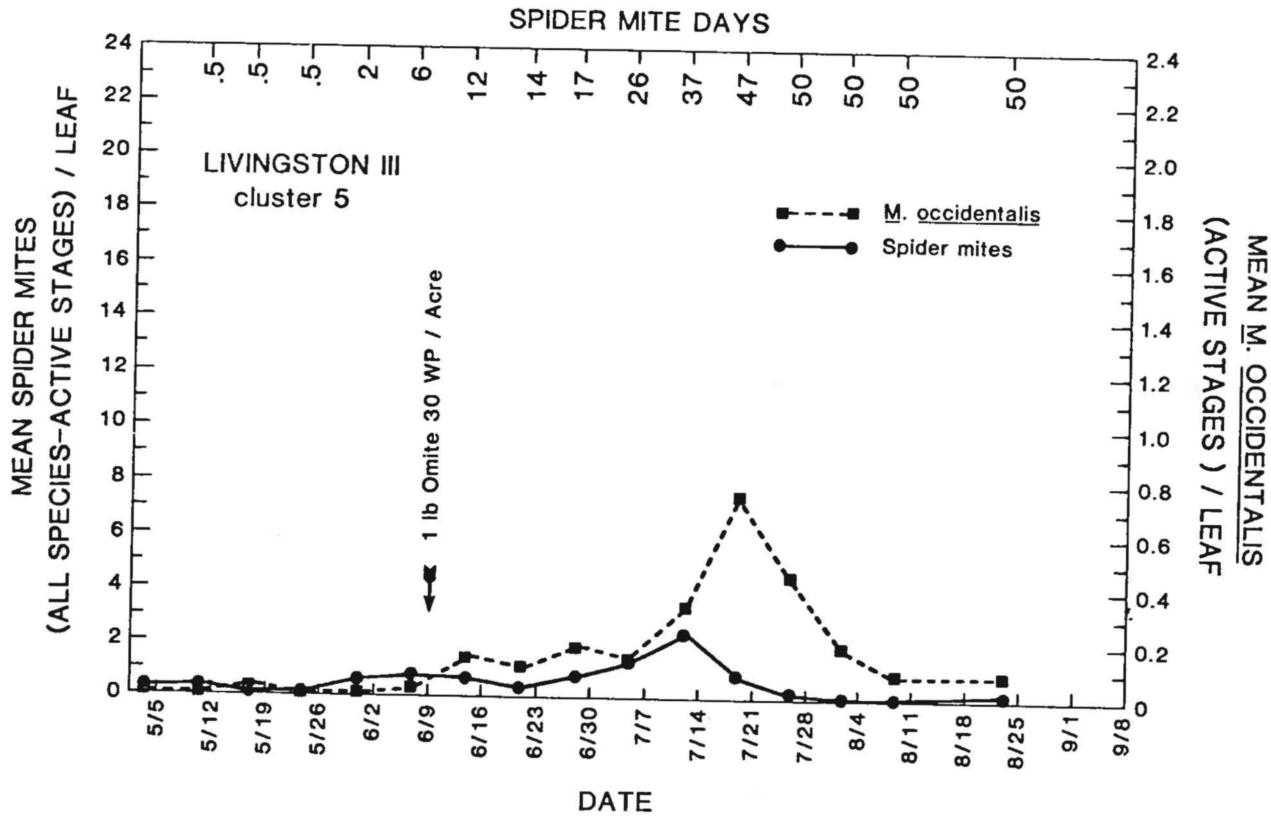


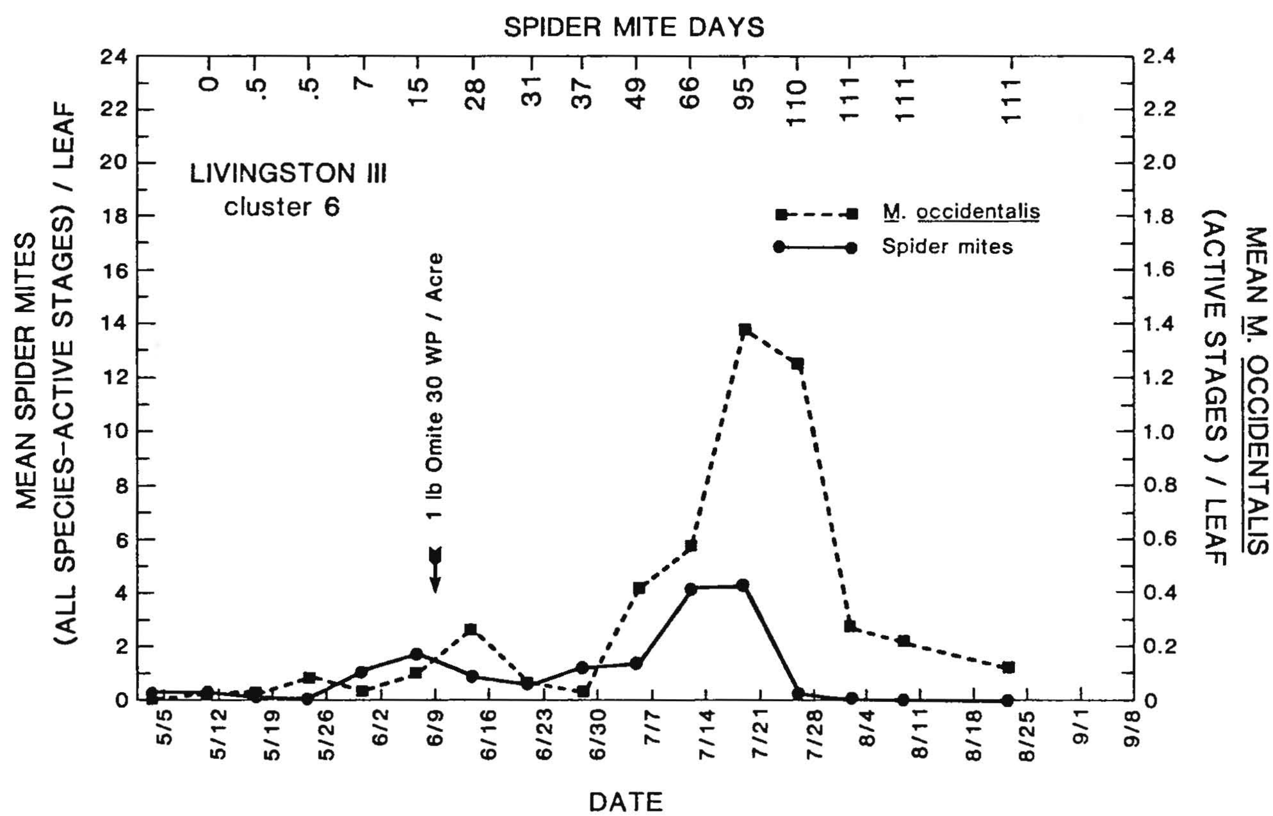
Figures IV-7-8. Predator-prey interactions in the six sample sites of the combined Livingston II & III almond orchards during 1983.





Figures IV-9-10. Predator-prey interactions in the six sample sites of the combined Livingston II & III almond orchards during 1983.





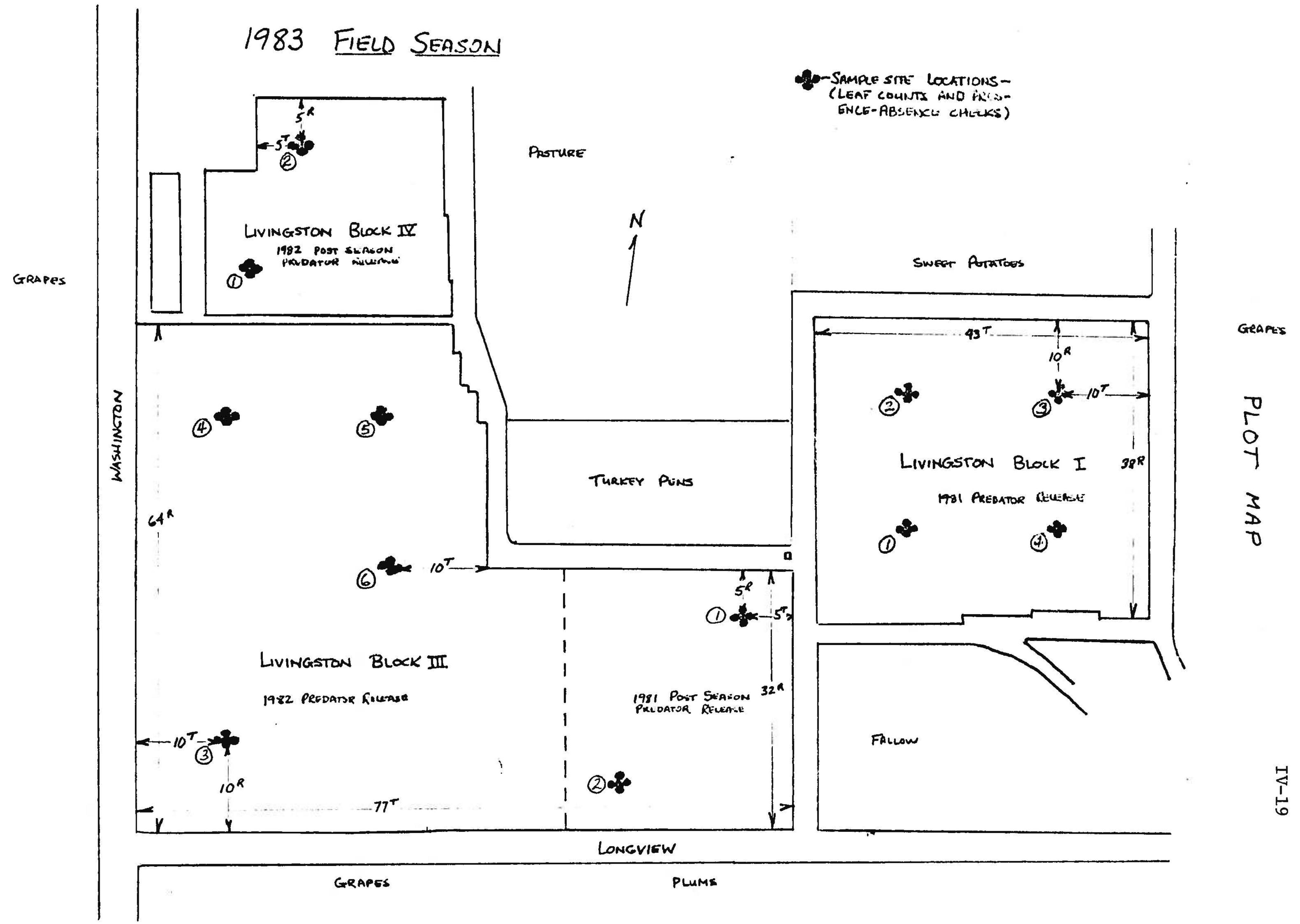
Figures IV-11-12. Predator-prey interactions in the six sample sites of the combined Livingston II & III almond orchards during 1983.

LIVINGSTON-IV ORCHARD

Bill Barnett released one soybean plant in every tree containing ca. 360 carbaryl-OP-sulfur resistant M. occidentalis on August 18, 1982. This 8 acre block is located near Mr. Horton's home and is near Livingston-I, II & III blocks. During 1983, this block was evaluated using 2 clusters of 5 trees (see plot map).

During 1983, no acaricides or insecticides were applied to this block. Predator-prey interactions were good and the foliage accumulated only about 70 SMD of damage (Figs. IV 13-15). Most of spider mites in this block were Pacific mite. The reason this block had Pacific mite predominating rather than European red mite (which predominated in nearby blocks I, II & III) is not understood. Predators collected from this block in June 1983 had a high level of carbaryl resistance (72% survival at the 2.4 g.a.i. carbaryl/liter water rate, see Section IX), indicating either that the late release resulted in establishment or that the resistant strain had moved in from the surrounding blocks, or both. Unfortunately, predators were not tested for their resistance levels prior to the releases in August 1982, so this can't be resolved.

It is remarkable that this block required no acaricides this season. This is the first orchard that has received resistant predators that didn't require any acaricide treatments during the first year after release. This may be due in part to the fact that no insecticides were applied, so the predators required no assistance to control the spider mites. Most of the phytoseiids in this block were M. occidentalis and the block appears to be in good condition for the 1984 field season.



1983 FIELD SEASON
SAMPLE SITE LOCATIONS — (LEAF COUNTS AND PRESENCE-ABSENCE CHECKS)
PASTURE
N
LIVINGSTON BLOCK IV
1982 POST SEASON PREDATOR RELEASE
5R
5T
GRAPES
WASHINGTON
SWEET POTATOES
GRAPES
43T
10R
10T
LIVINGSTON BLOCK I
38R
1981 PREDATOR RELEASE
PLOT MAP
TURKEY PENS
64R
10T
5R
5T
LIVINGSTON BLOCK III
1982 PREDATOR RELEASE
1981 POST SEASON PREDATOR RELEASE
32R
FALLOW
10T
10R
77T
LONGVIEW
GRAPES
PLUMS

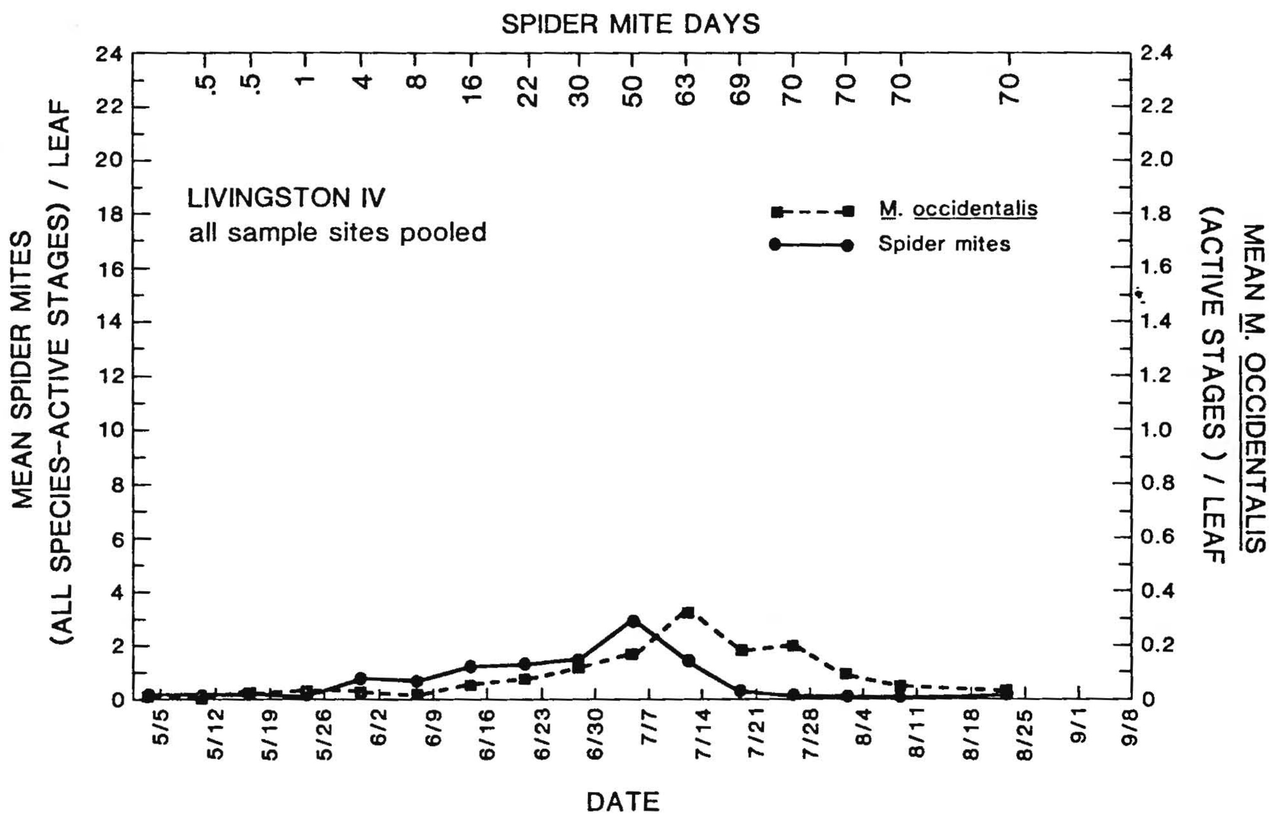
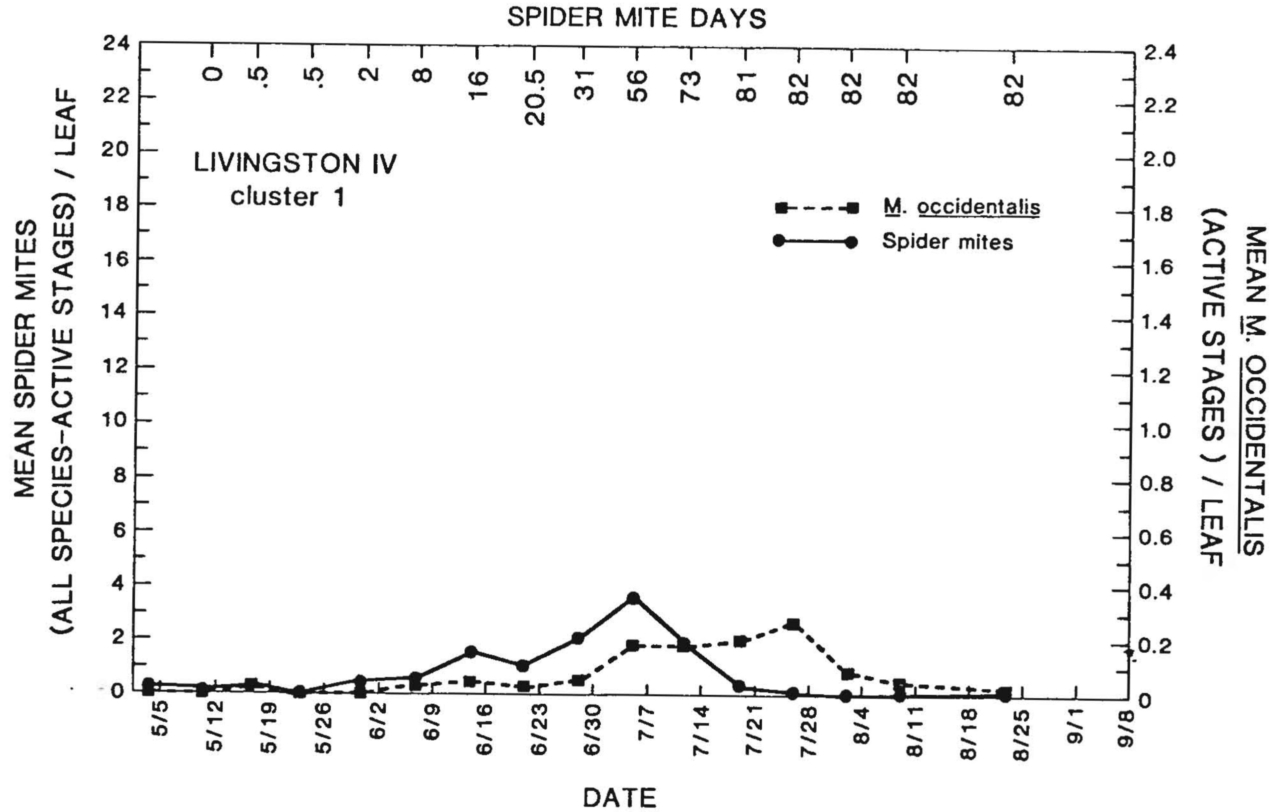


Figure IV-13. Predator-prey interactions in the Livingston IV almond orchard during 1983.



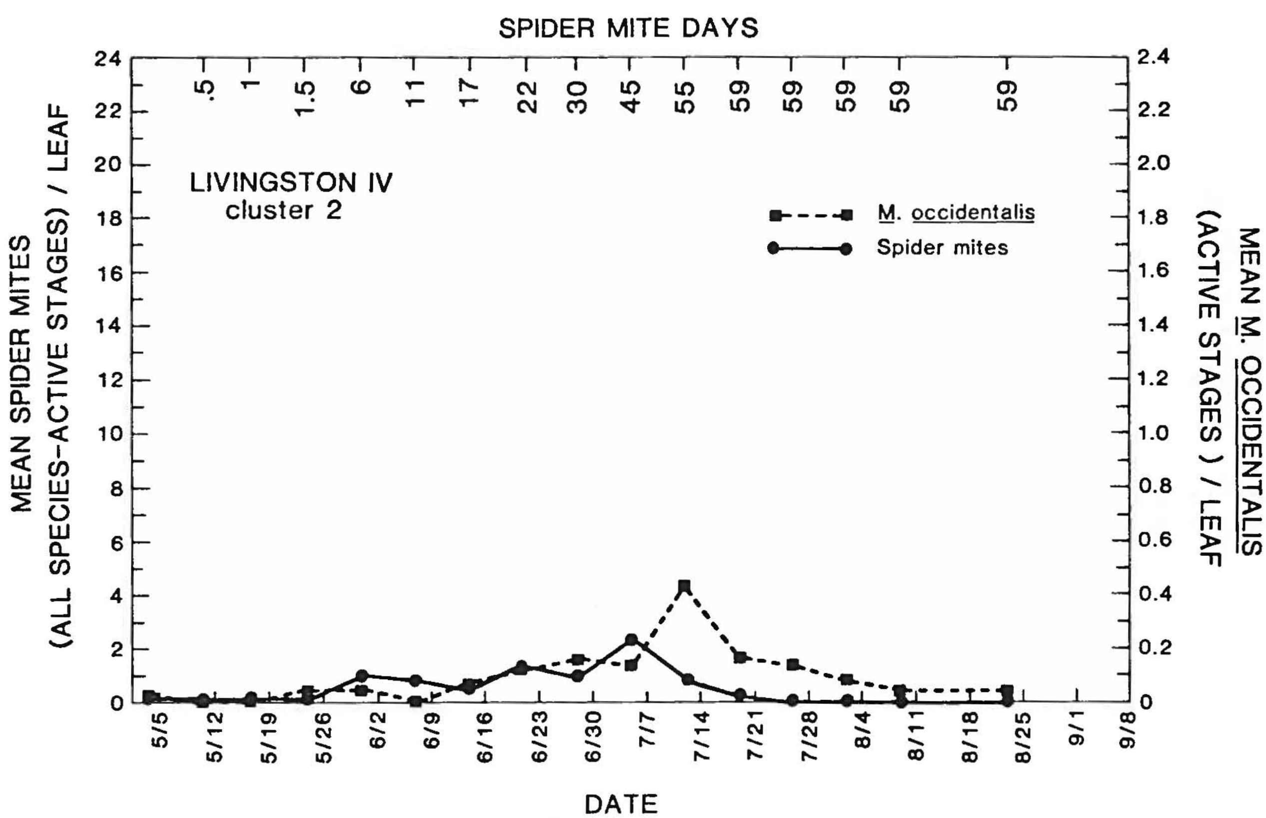


Figure IV-14 & 15. Predator-prey interactions in the two sample sites in the Livingston-IV orchard during 1983.

LIVINGSTON-V

Carbaryl-OP-sulfur resistant *M. occidentalis* were released into this orchard on Magnolia Avenue between Robin and Lincoln near Livingston on August 18, 1982 using predators reared in the soybean plot at the Kearney Field Station. Bill Barnett released ca. 350 predators into every tree in every third row, although apparently the last few rows failed to receive predators. This block was treated with Ambush and Omite prior to the release in 1982.

During 1983, four sample sites were set up (see plot map). One application of Omite (1 lb 30 WP/acre) was applied in mid June to adjust the predator-prey ratio in cluster 4. The trees in this block are small, and have bacterial canker and nematode problems. Thus, it was believed crucial to protect the trees from additional stress due to spider mite feeding. The Omite was effective, and 78 SMD accumulated in cluster 4 over the season (Fig. IV-20). The rest of the orchard had fewer spider mites and the Omite treatment was unnecessary through the rest of the block (Figs.IV-18-20. Most of the spider mites in this block were European red mite, although *T. pacificus* was present in low numbers in June and early July. Both *M. occidentalis* and *A. hibisci* were present in the orchard.

It appears that carbaryl resistance is not well established in this orchard. Individuals collected from this block in June 1983 had only 2% survival on 2.4 g. a.i./liter water. This suggests either that the predators collected were natives, and/or that the predators did not establish. Another survey should be conducted to learn if carbaryl resistance is present in *M. occidentalis* elsewhere in the block.

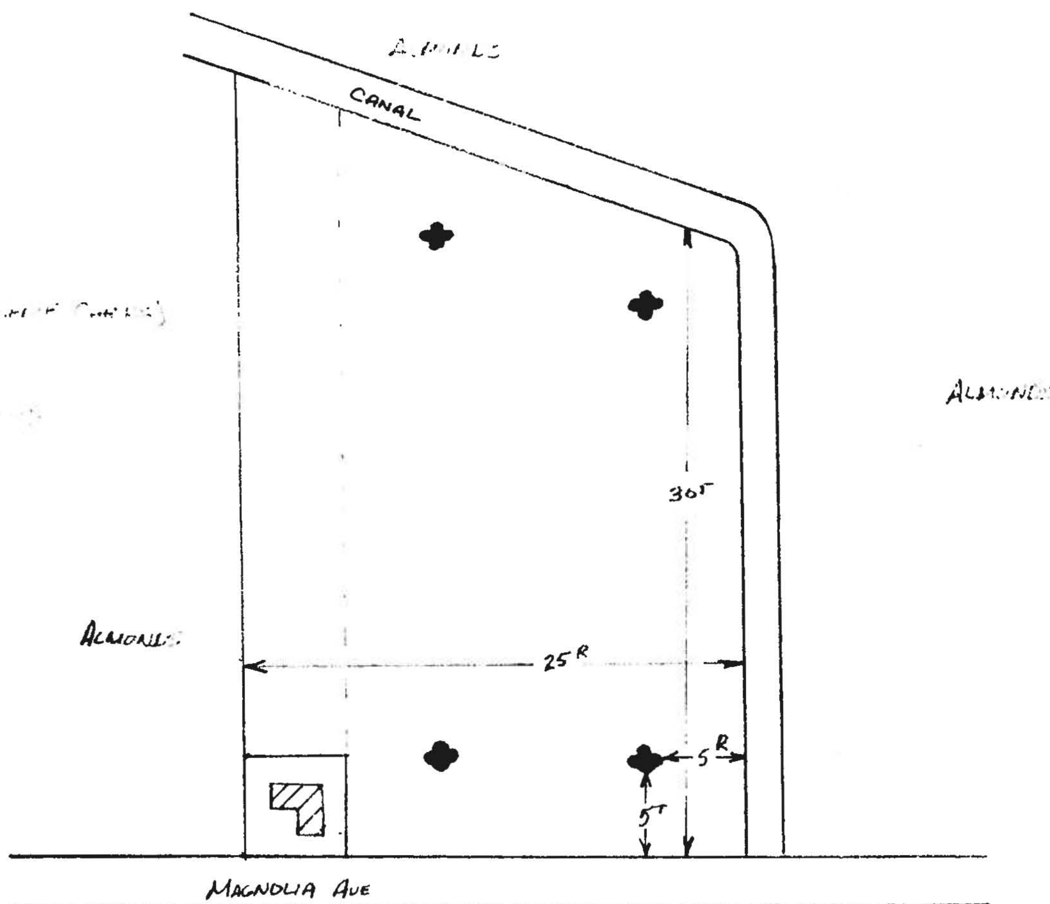
PLOT MAP

LIVINGSTON V

1983 Field [illegible]

- Sample Site Locations
(Leaf counts and presence/absence of [illegible])

Note:
[illegible]



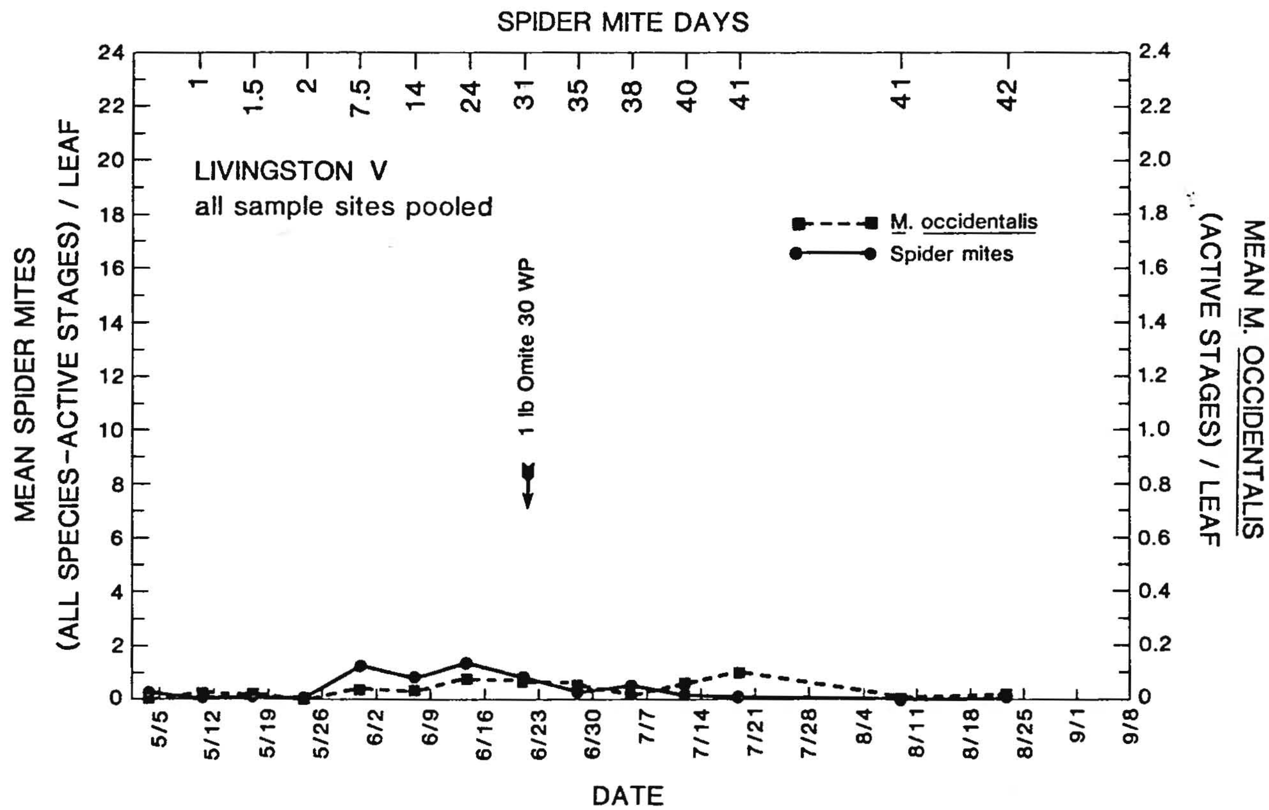
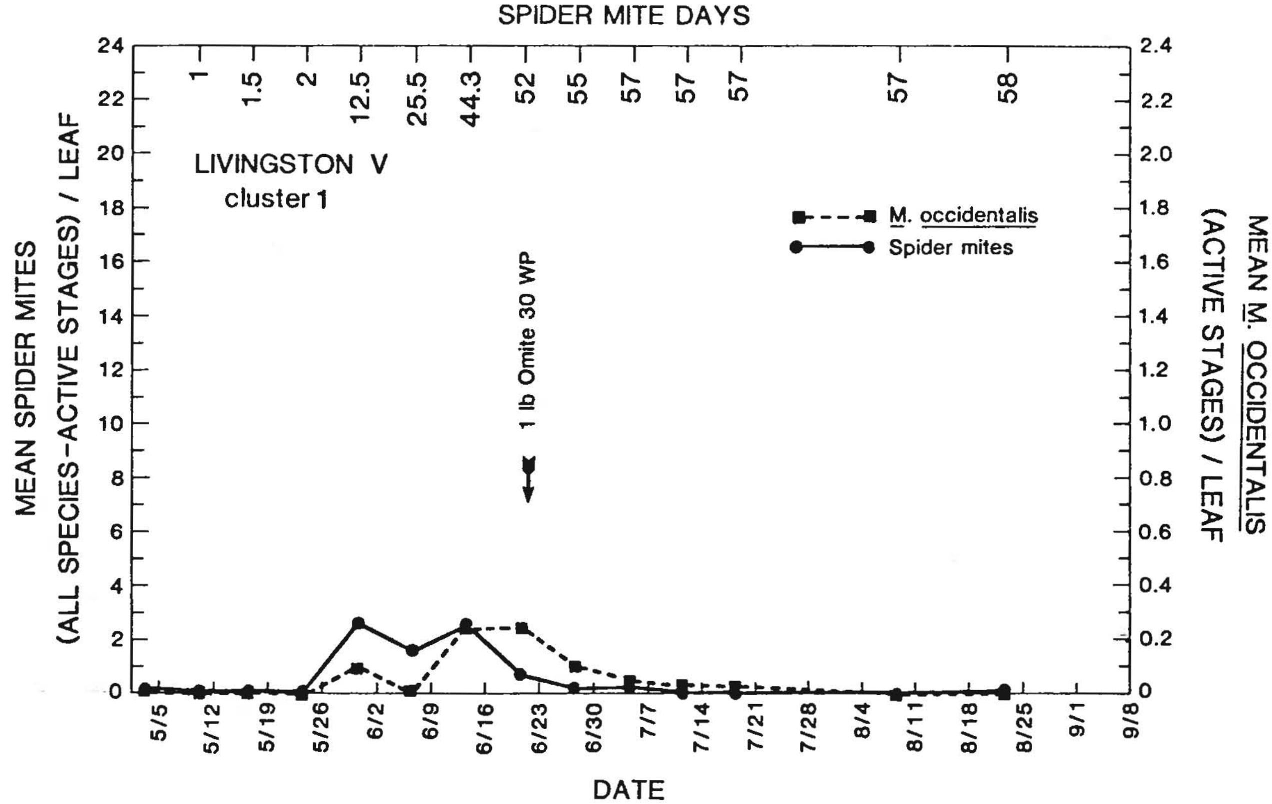


Figure IV-16. Predator-prey interactions in the Livingston-V almond orchard during 1983.



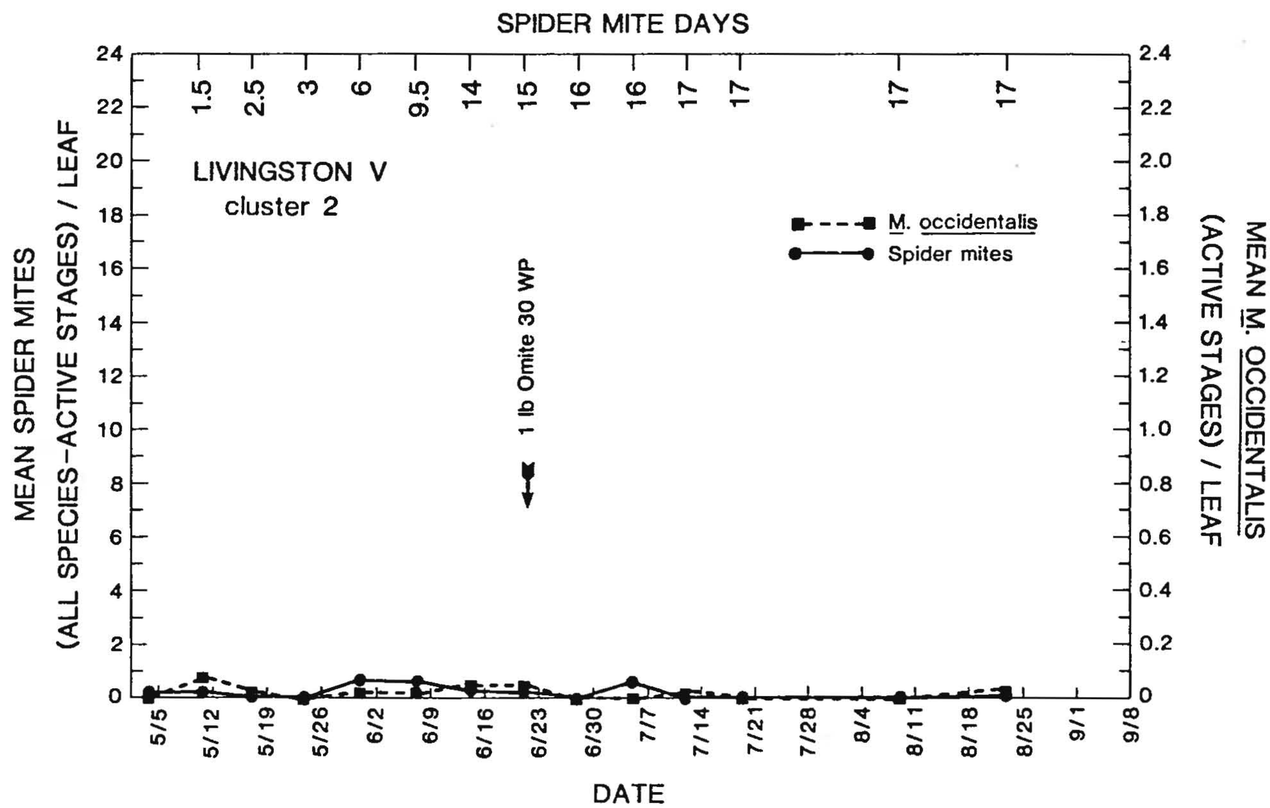
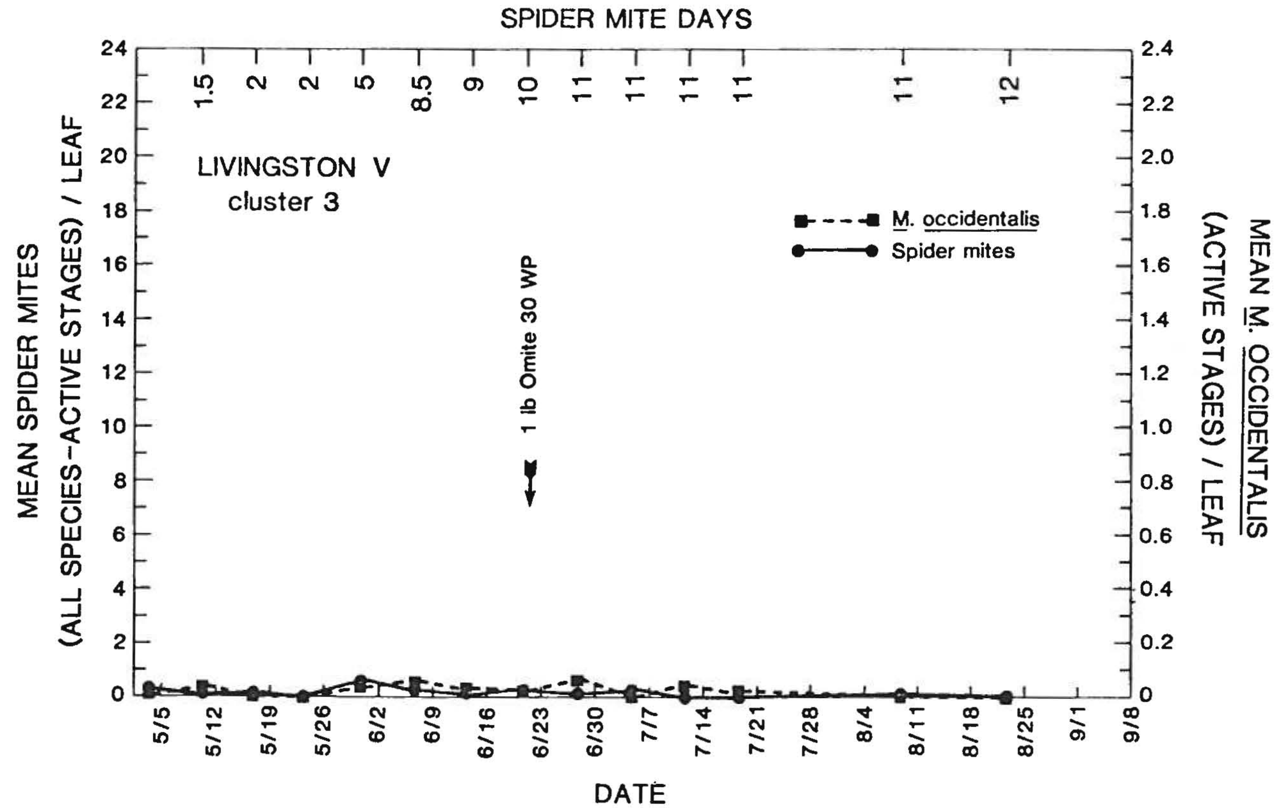


Figure IV-17-18. Predator-prey interactions in the 4 sample sites in the Livingston-V almond orchard during 1983.



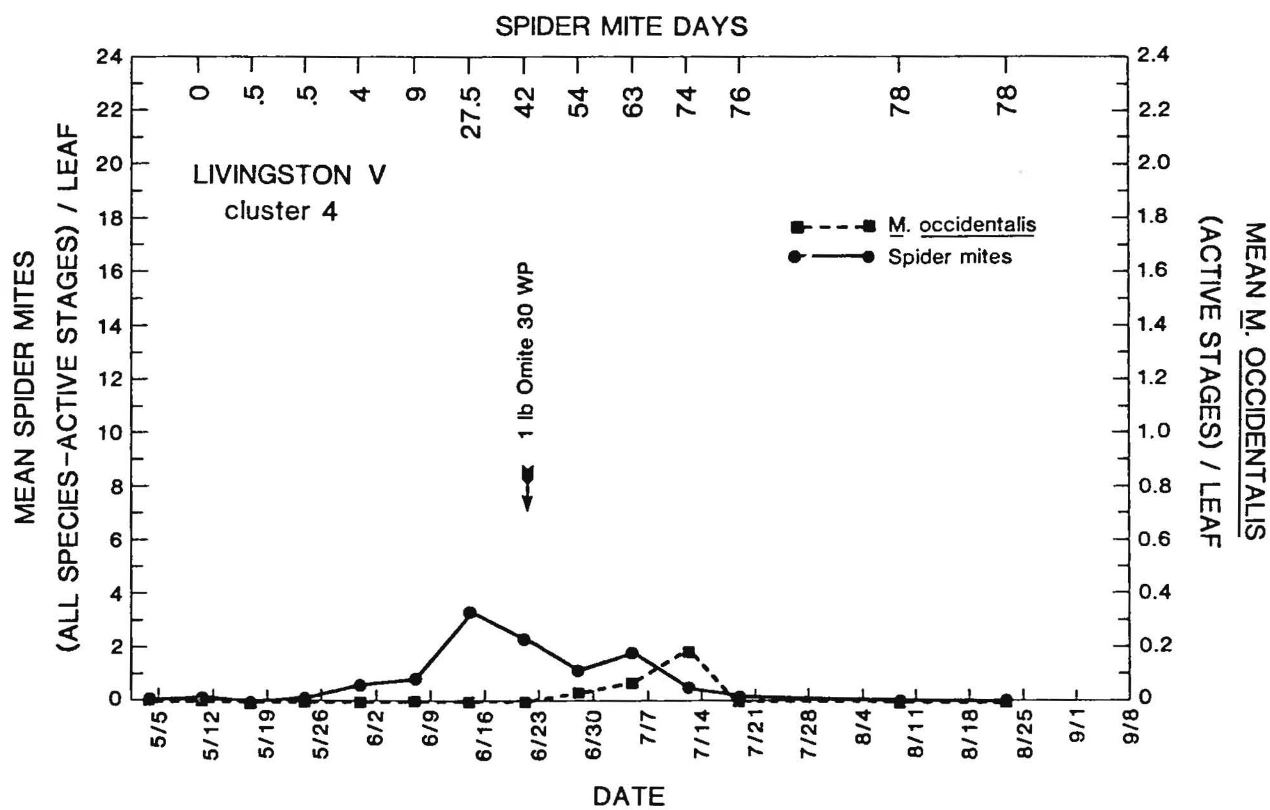


Figure IV-19-20. Predator-prey interactions in the 4 sample sites in the Livingston-V almond orchard during 1983.

BAKERSFIELD (Bidart) ALMONDS

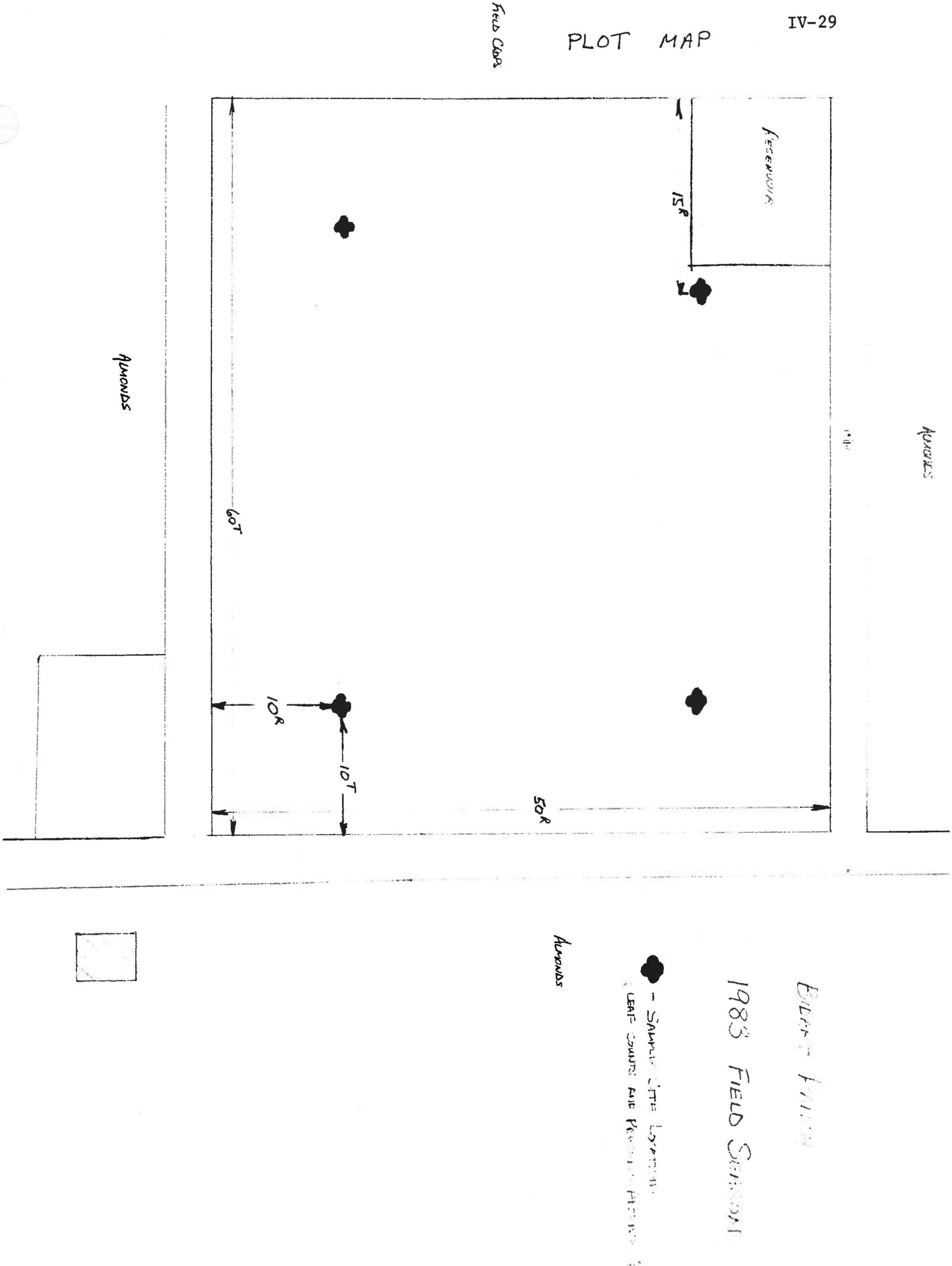
Carbaryl-OP resistant M. occidentalis were released into the Bidart almond orchard in August 1979 into a few trees only. By 1980, the carbaryl-resistant predator had spread throughout the orchard and gave substantial control of the spider mites. Carbaryl was applied once in 1980. During 1981 and 1982, carbaryl was not applied to this block and we did not monitor here. Because we knew that carbaryl-resistant predators were still present in the block, we monitored this orchard in four sites during 1983 (see plot map).

This Kern County orchard had very few European red mites early in the season, but most of the spider mites in this block were Tetranychus species. Because the predator-prey ratio was poor in late June in part of the orchard (clusters 3 & 4, Figs. IV-24 and 25), 0.75 lb 50 WP Plictran/acre was applied by helicopter (using 30 gal/acre). This suppressed the spider mites and allowed predators to gain control over the spider mites thereafter. About 72 SMD accumulated in the orchard on the average (Fig. IV-21), although 119 SMD accumulated in trees in the area surrounding cluster 4.

A sample of predators collected in June 1983 from this orchard had a high level of carbaryl resistance (76% survival when tested with 2.4 g.a.i. carbaryl/liter distilled water). This is impressive, since carbaryl has not been applied to this orchard since 1980. Thus, high levels of carbaryl resistance have persisted in this predator population. This is despite the fact that during 1981 high rates of acaricide were applied to this block and predator-prey ratios and distribution patterns were severely disturbed. These results suggest that the resistant predators, once established, can recover from some degree of acaricide mismanagement, particularly in larger blocks. During 1981, permethrin was applied to most of the almond blocks surrounding this one, decimating the susceptible native *M. occidentalis*. This could also help explain why the carbaryl resistance has not been lost--little migration into this block has occurred.

The Pacific mite increases during July are believed to be related to the fact that the grower was restricting water and fertilizer in order to increase yield. The relationship between this management practice and the Pacific mite "blow up" is unclear, but should be investigated.

PLOT MAP


FIELD CROPS
RESERVOIR
15R
ALMONDS
60T
10R
10T
50R
ALMONDS
ALMONDS
- SAMPLE SITE LOCATIONS
1983 FIELD SEASON

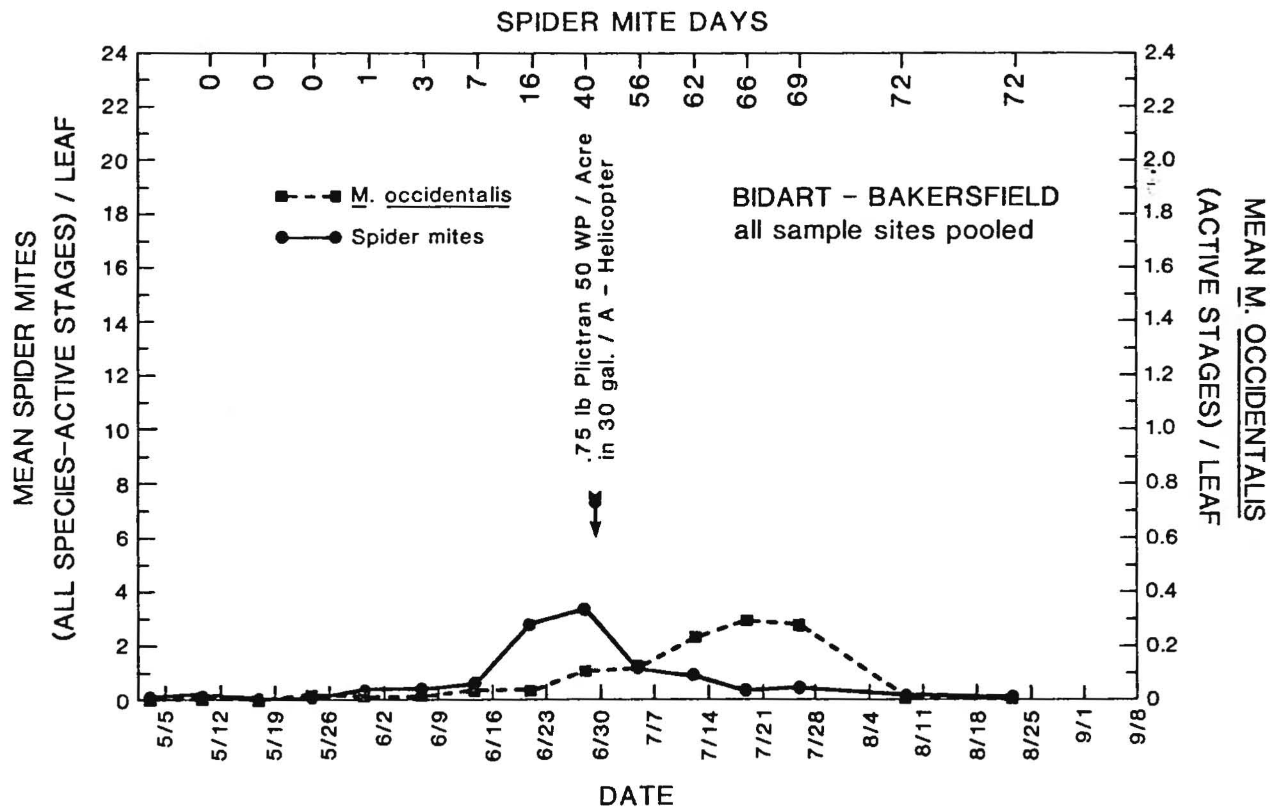
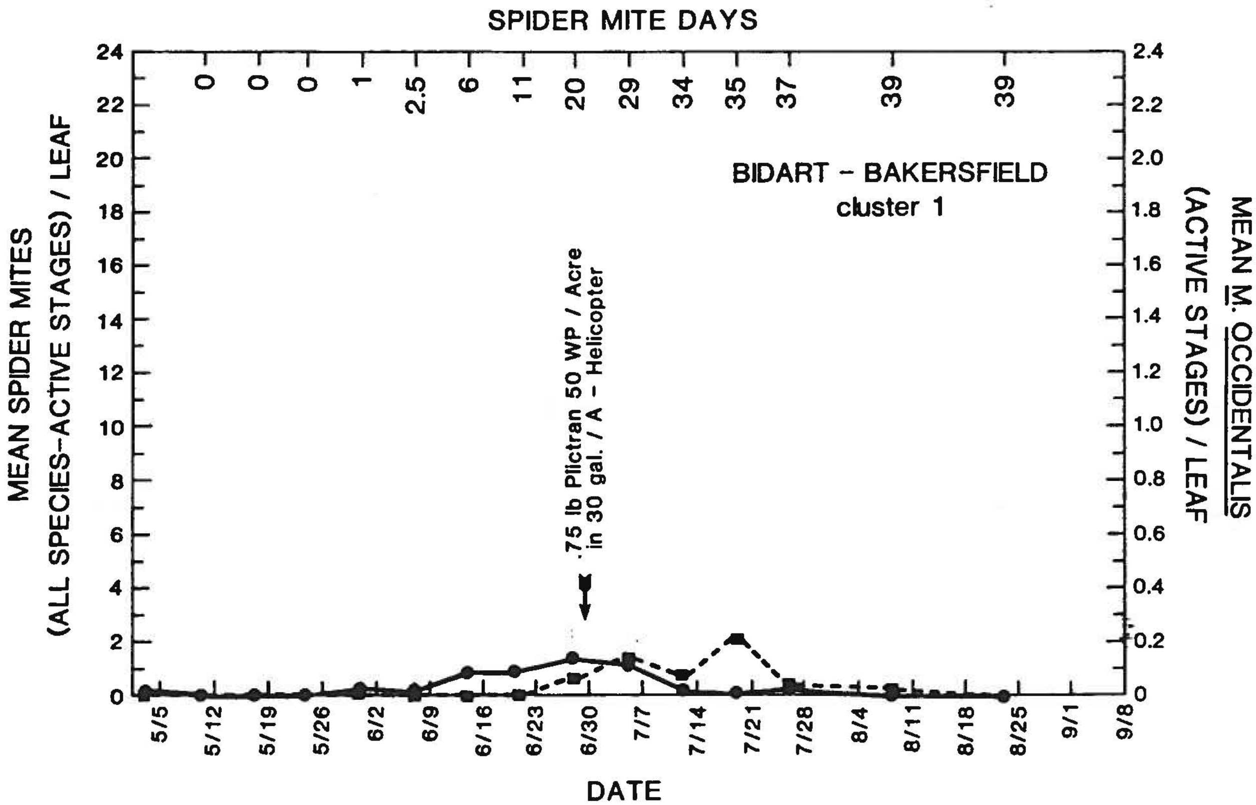
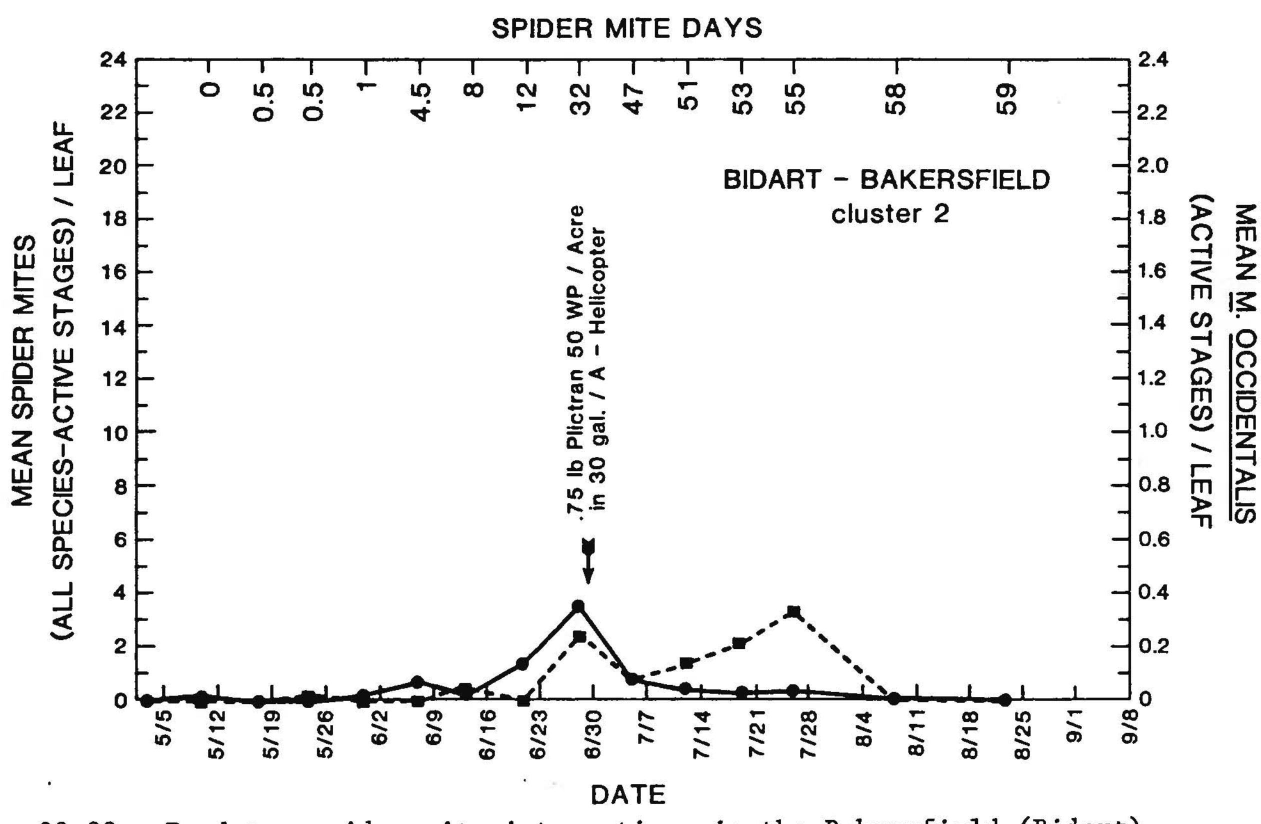
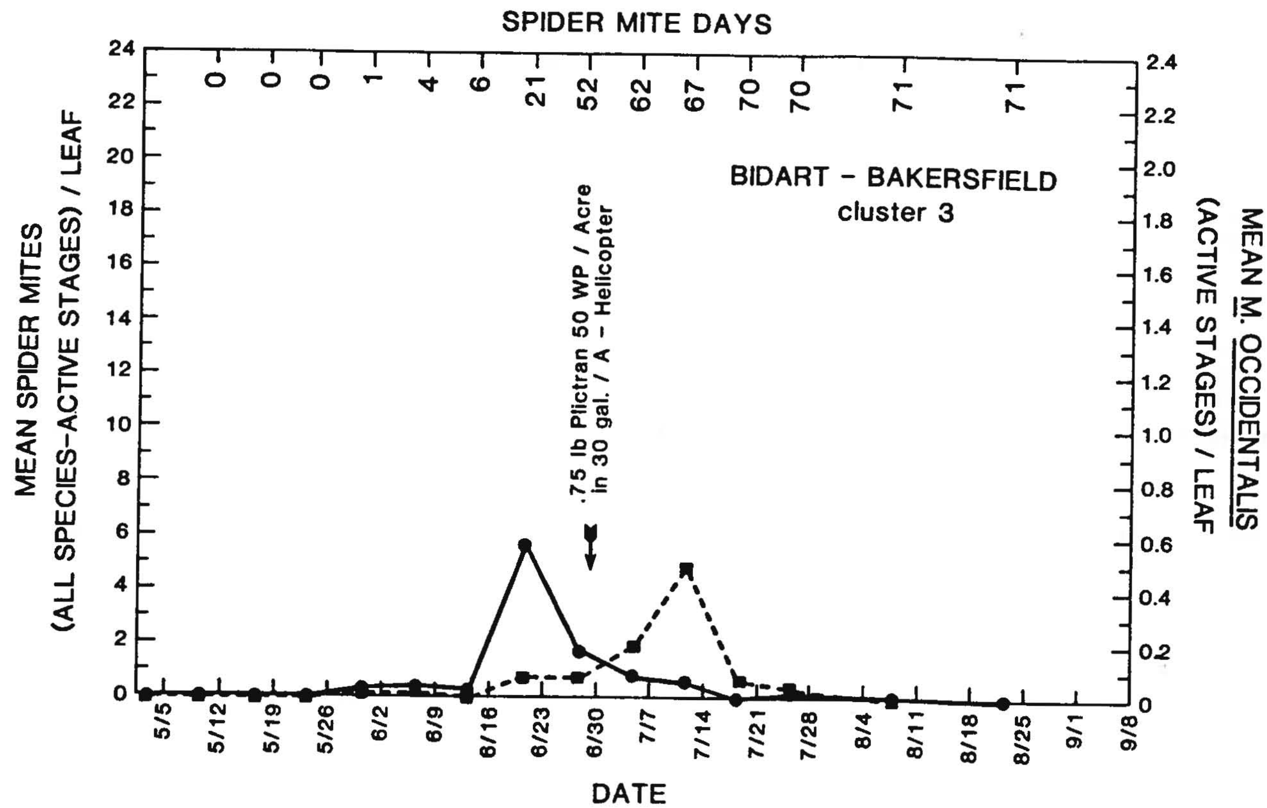


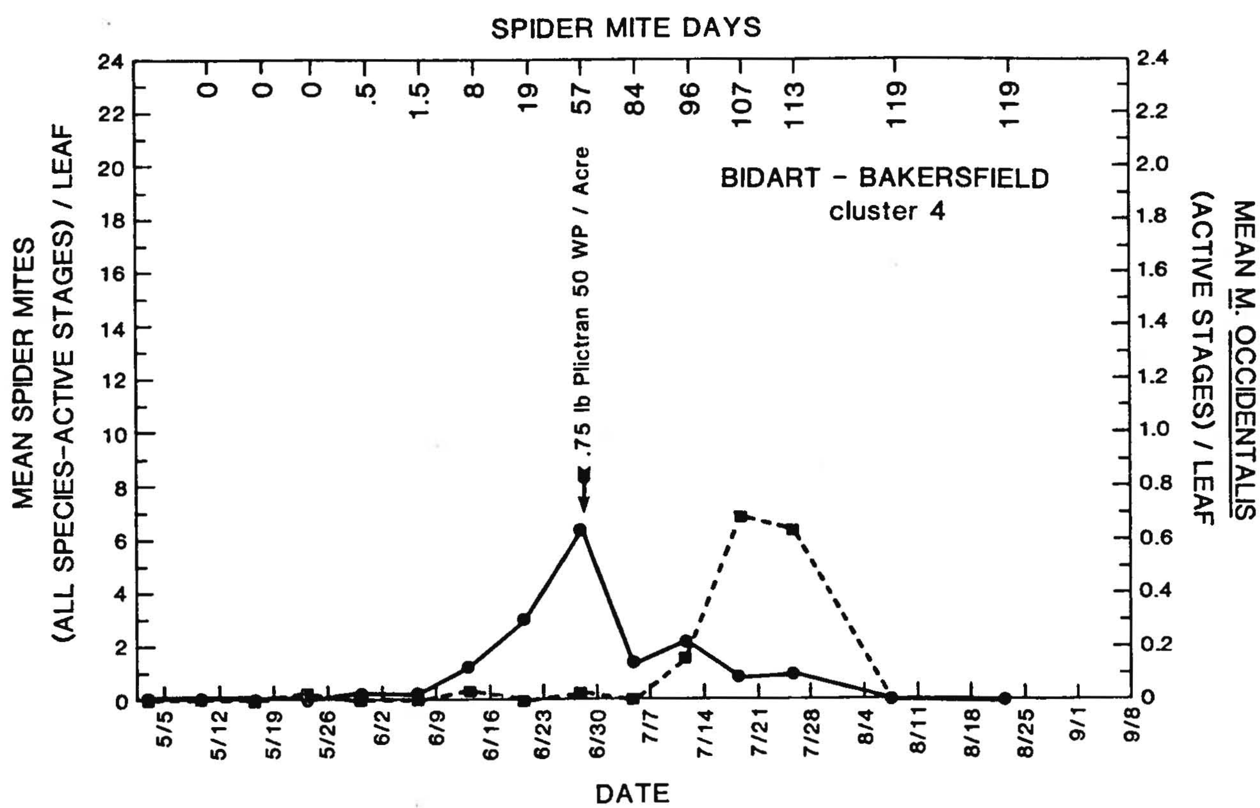
Figure IV-21. Predator-spider mite interactions in the Bakersfield (Bidart) almond orchard during 1983. Mean spider mites and mean M. occidentalis are indicated for the four sample sites (clusters of 5 trees each) and for the average of these 20 trees.





Figures 22-23. Predator-spider mite interactions in the Bakersfield (Bidart) almond orchard during 1983. Mean spider mites and mean M. occidentalis are indicated for the four sample sites (clusters of 5 trees each) and for the average of these 20 trees.





Figures 24-25. Predator-spider mite interactions in the Bakersfield (Bidart) almond orchard during 1983. Mean spider mites and mean *M. occidentalis* are indicated for the four sample sites (clusters of 5 trees each) and for the average of these 20 trees.

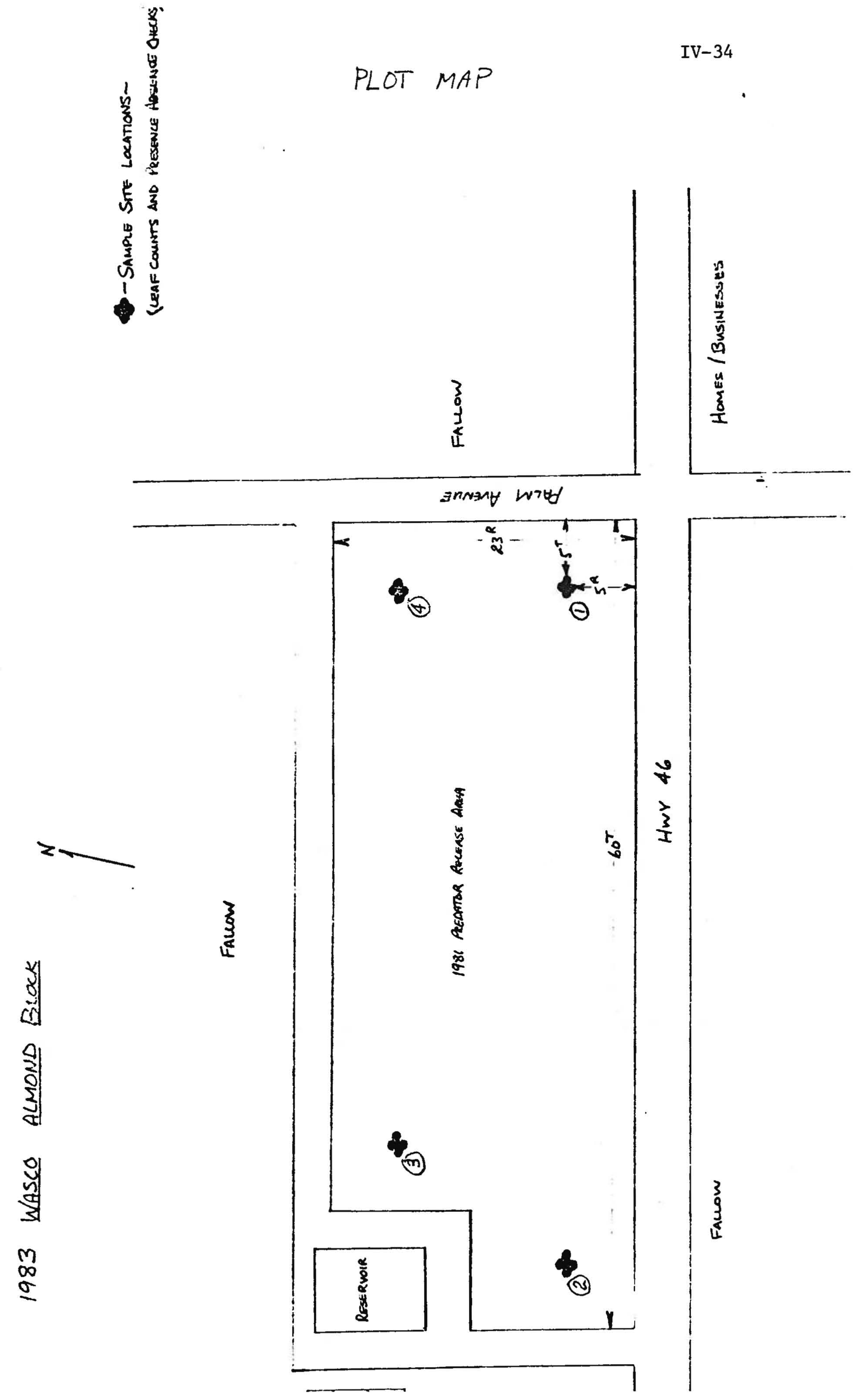
WASCO (Weddle) ORCHARD

Carbaryl-OP resistant *M. occidentalis* were released into this 15-acre block on May 28, 1981. Permethrin was applied by the grower during the 1981 season, yet despite this, the carbaryl-OP resistant strain established. During 1982, the carbaryl-OP resistant predators survived a carbaryl application and exerted good control over spider mites by the end of the season. During 1983, four clusters were sampled (see plot map). Guthion was applied at hull split for NOW.

M. occidentalis did an excellent job of controlling spider mites in this orchard during 1983 (Figs. IV-26-30). One application of Omite (1 lb 30 WP/acre) was applied in late May to adjust the predator-prey ratio, and the spider mites remained low the rest of the season. European red mites (ERM) were the only spider mites in this block during 1983; it is noteworthy that 1 lb of Omite (along with *M. occidentalis*) did a good job of controlling ERM. Guthion (4 lb 50 WP/acre) was applied at hull split, but no acaricide was required. Spider mite densities remained so low that only 62 SMD accumulated over the season, and the orchard was in excellent condition at the end of the season. European red mite was the main spider mite species throughout the season, and the fact that *M. occidentalis* controlled them is noteworthy.

This orchard appears to be in good balance and long term control of spider mites by *M. occidentalis* should continue unless disrupted with pesticides. This block has apparently become something of a Kern County showcase as it was well known for previously having serious spider mite problems year after year.

PLOT MAP


1983 WASCO ALMOND BLOCK
N
-SAMPLE SITE LOCATIONS-
(LEAF COUNTS AND PRESENCE ABSENCE CHECKS)
FALLOW
PALM AVENUE
HOMES / BUSINESSES
23R
5T
5A
1
2
3
4
1981 PREDATOR RELEASE AREA
60T
HWY 46
FALLOW
FALLOW
RESERVOIR

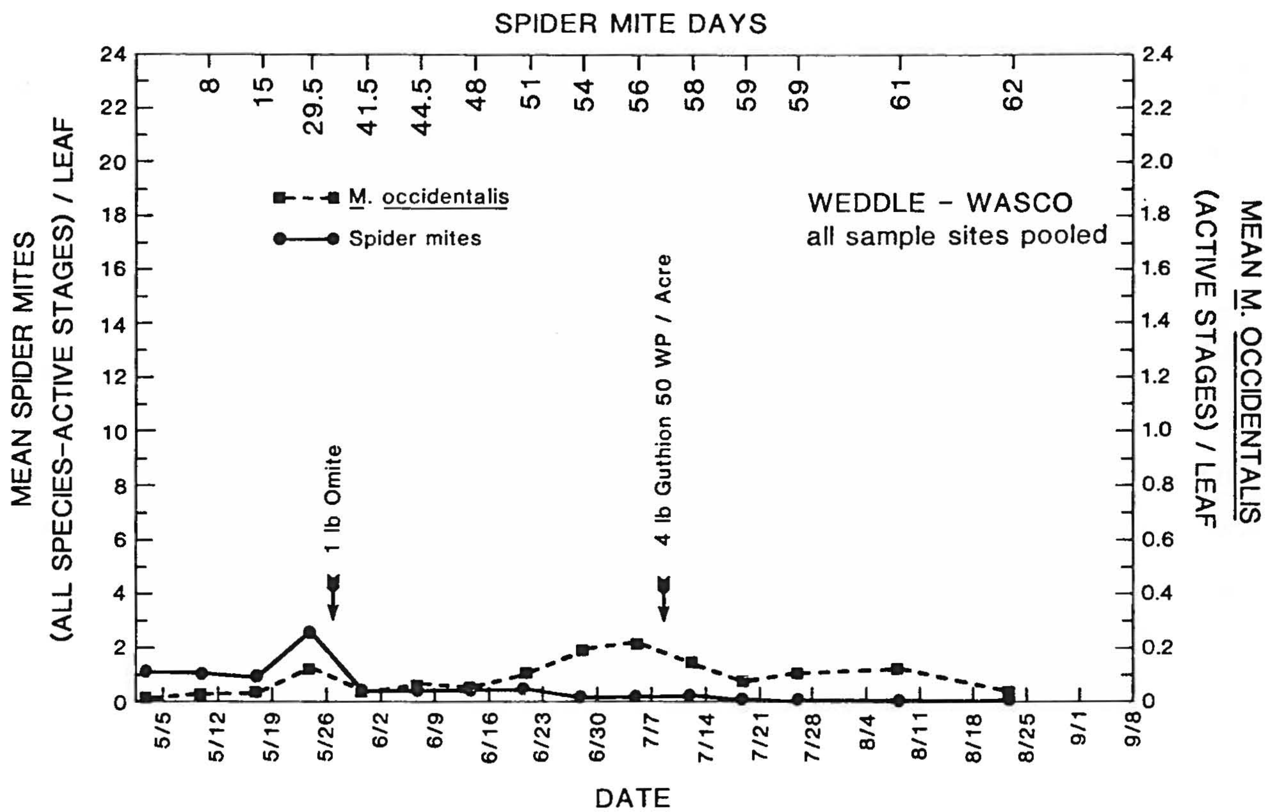
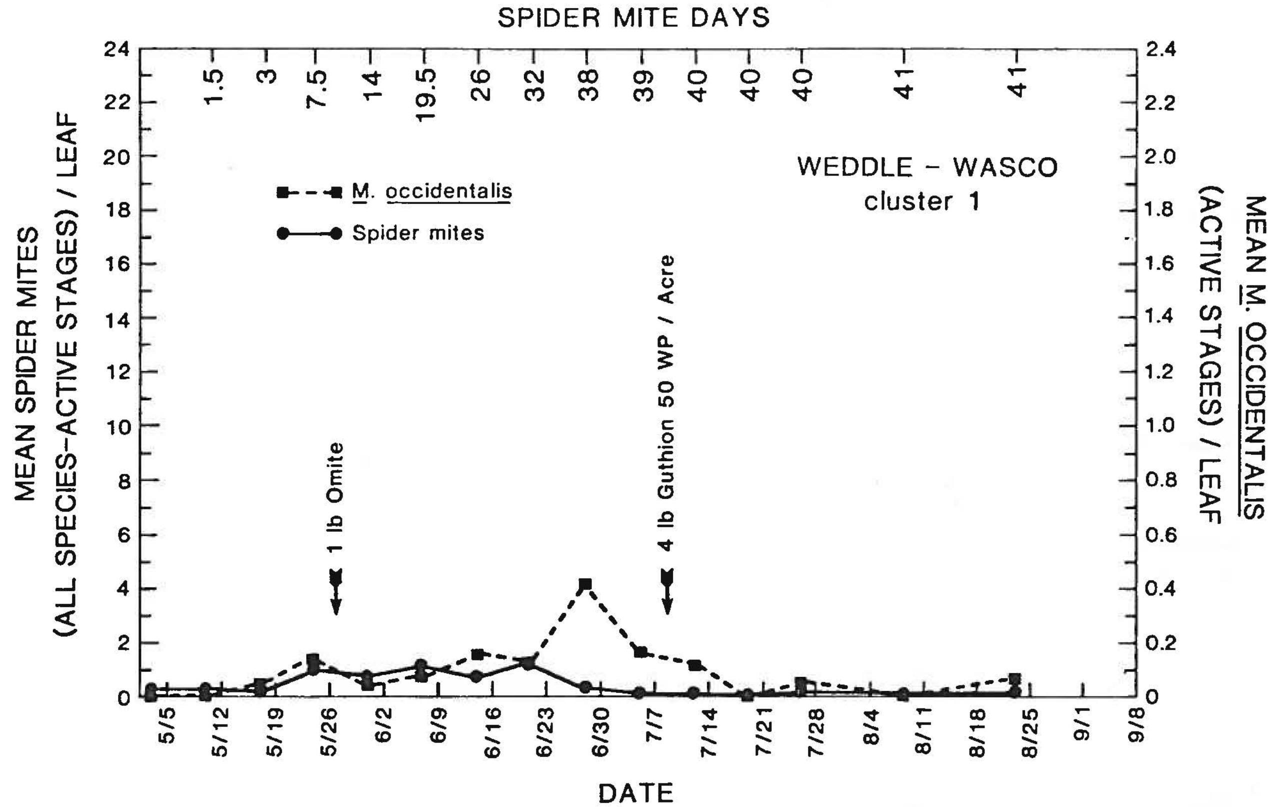
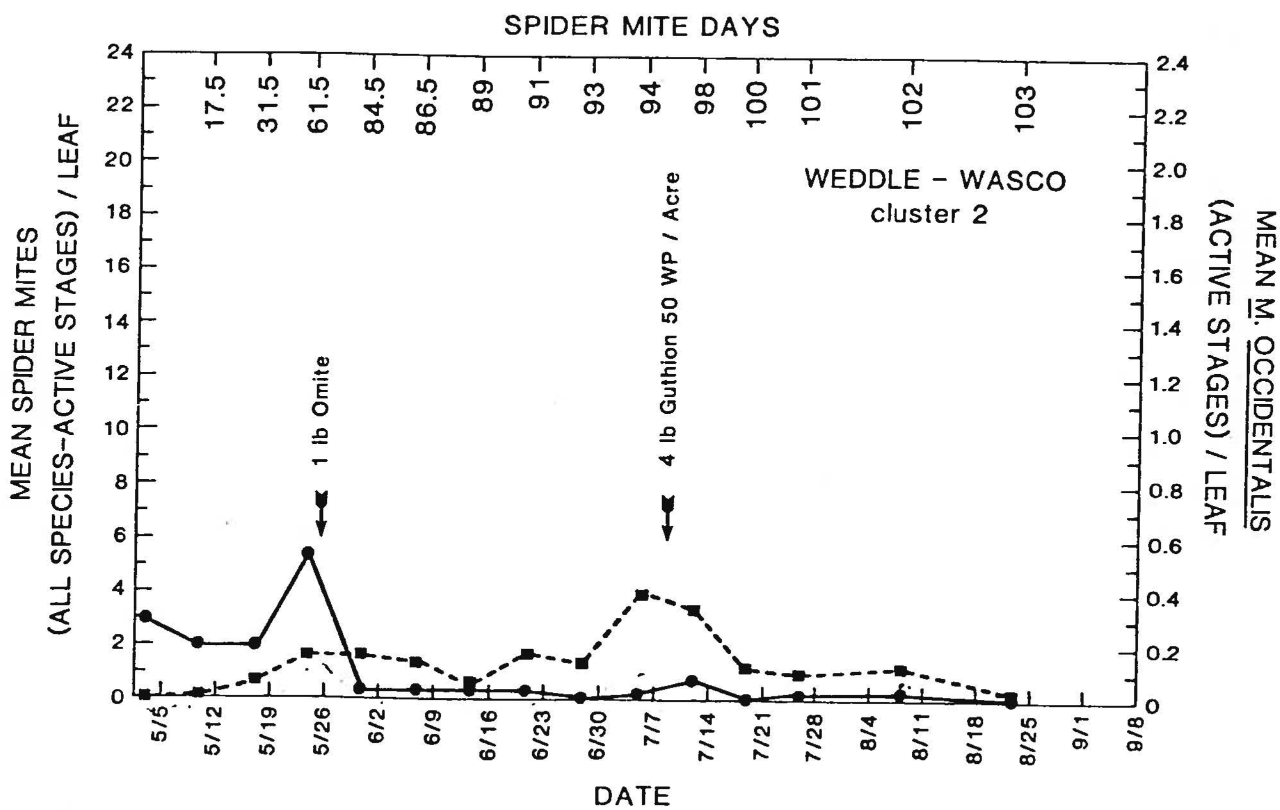
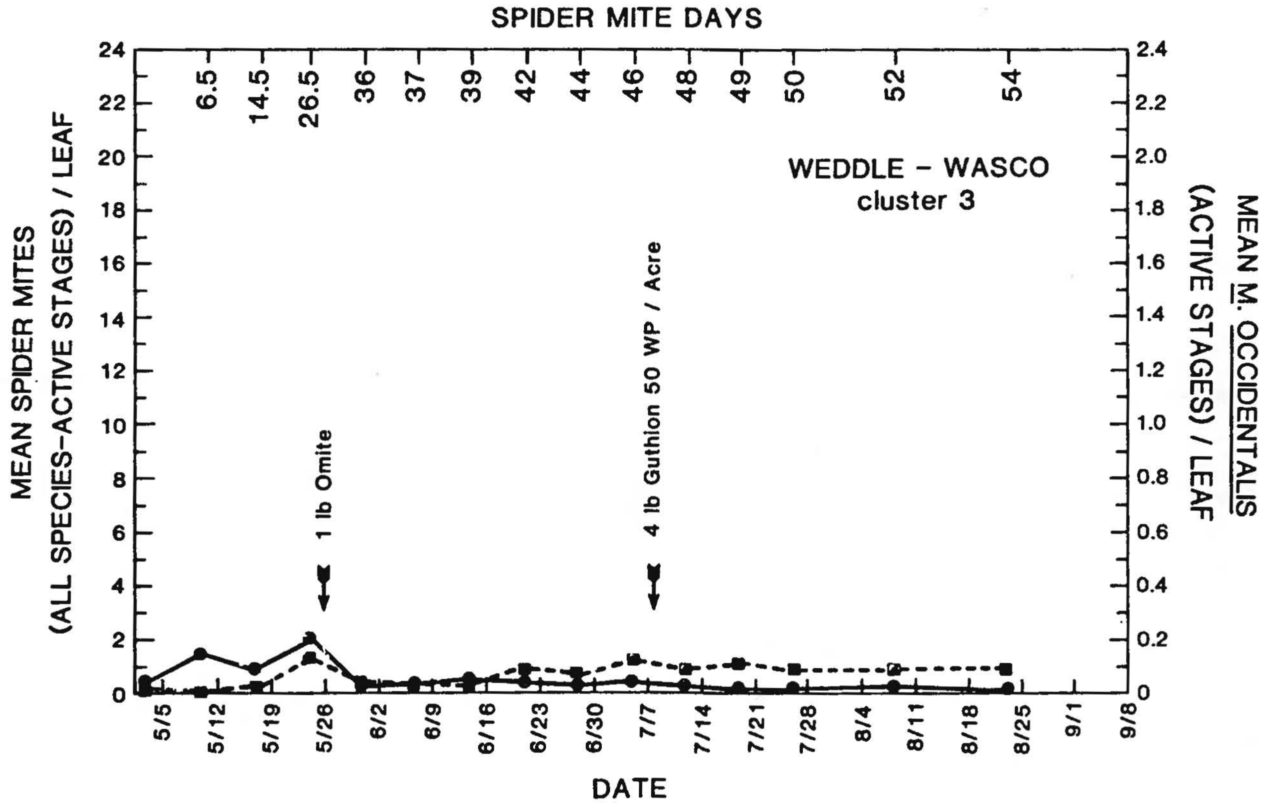


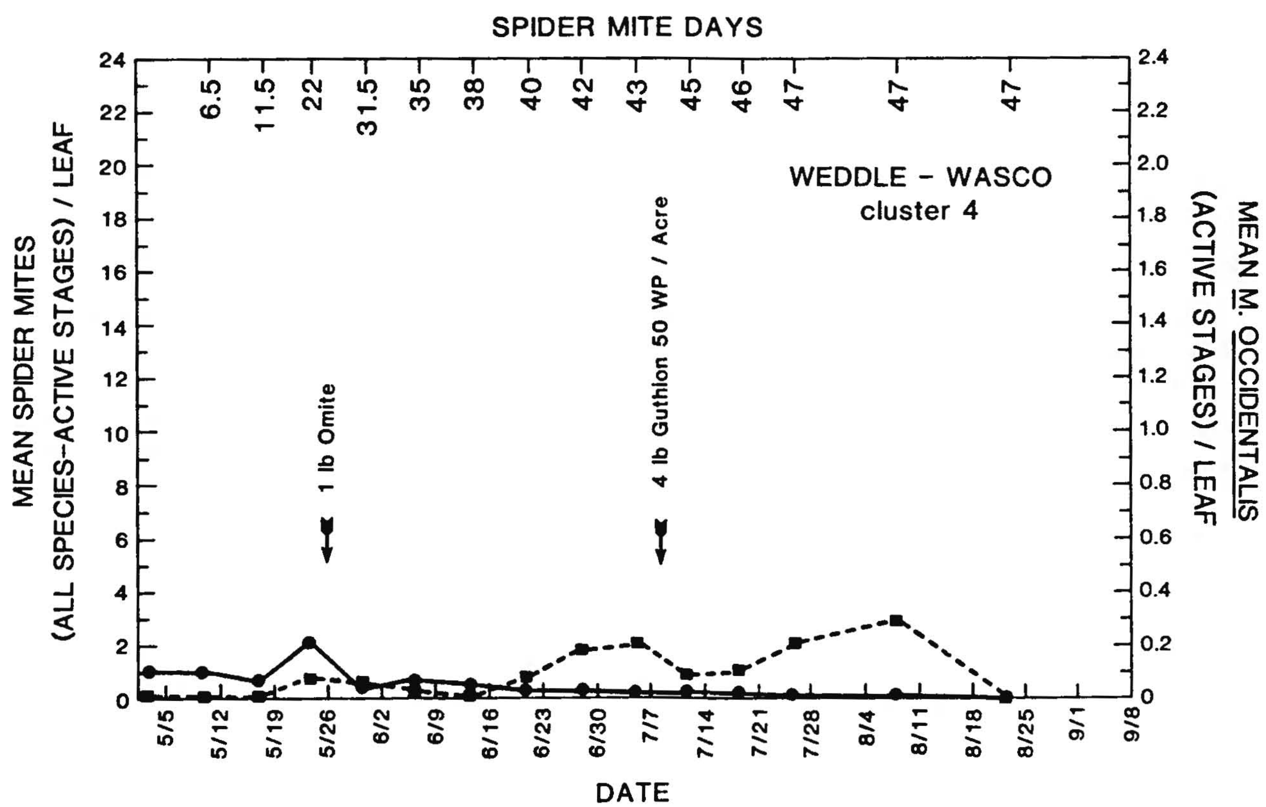
Figure 26. Predator-prey interactions in the Wasco (Weddle) almond orchard during 1983.





Figures 27-28. Predator-prey interactions in the 4 sample sites in the Wasco (Weddle) almond orchard during 1983.





Figures 29-30. Predator-prey interactions in the 4 sample sites in the Wasco (Weddle) almond orchard during 1983.

THREE ROCKS (Sumner-Peck Ranch)

This 80-acre almond block received carbaryl-OP resistant M.occidentalis on July 10, 1981. During 1982, spider mite counts were made by Bill Barnett. During 1983, we sampled 4 sites (5 trees/cluster) in the western half (rows 1-60 or ca. 30 acres) of the block (see plot maps). Guthion (4 lb 50WP/acre) plus 6 lb. 30 WP Omite was applied on July 7 to the portion of the orchard shown shaded in plot map A while Guthion only was applied to the first 20 rows (shown unshaded in plot map A).

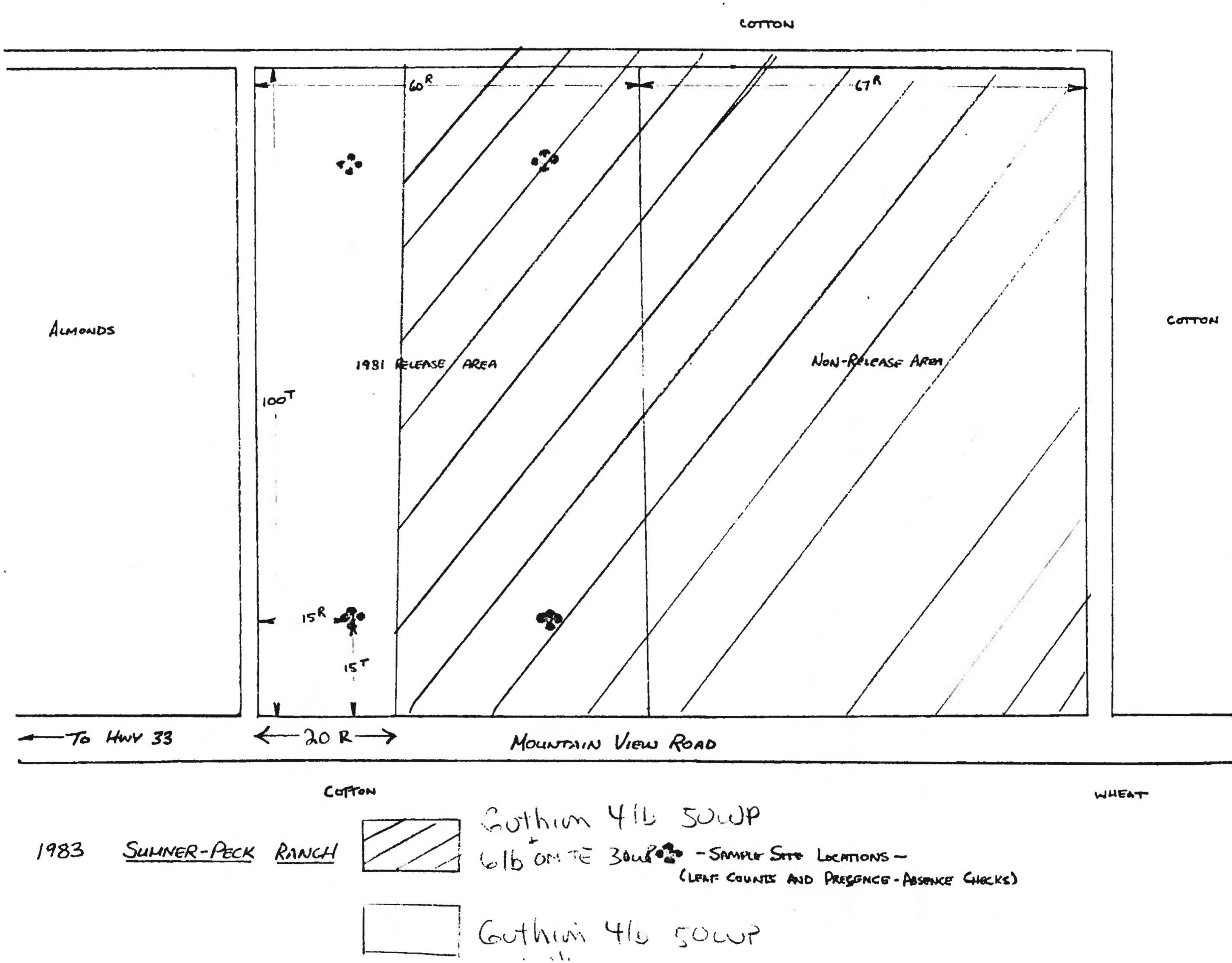
On May 12, we recommended that Omite be applied to control the European red mites in this block. Because the pest manager in charge did not believe that ERM is a serious pest in almonds, no acaricide was applied until June 9. On that date 1.5 lbs. 50 WP Plictran/acre were applied on the north half of the block; 2 lb. 30 WP Omite were applied on the south west section (plot map B). On July 7, an additional 6.0 lb. Omite 30 WP/acre was applied along with 4 lb. 50 WP Guthion/acre to half the block.

The acaricide application in June controlled the spider mites in this block and the July acaricide application was probably unnecessary (Figs. IV-31-34).

Substantial foliage damage due to ERM occurred in this block and variable levels of defoliation were evident throughout the orchard, with up to 50% defoliation in the south east section of the orchard. This block can not be included in our evaluation of the utility of our mite management guidelines since our recommendations were not followed. However, the major damage induced by ERM feeding indicates that this mite can be a serious pest in almond orchards. It is noteworthy that M.occidentalis numbers did increase in this block and did have a major impact on the population (Figs. IV-31-34). However, ca. 165 SMD on the average accumulated in this orchard, which is an excessive amount, and 469 SMD accumulated in the area around cluster 3. We believe that if the acaricide application had been made in early May, as recommended, that this could have been avoided.

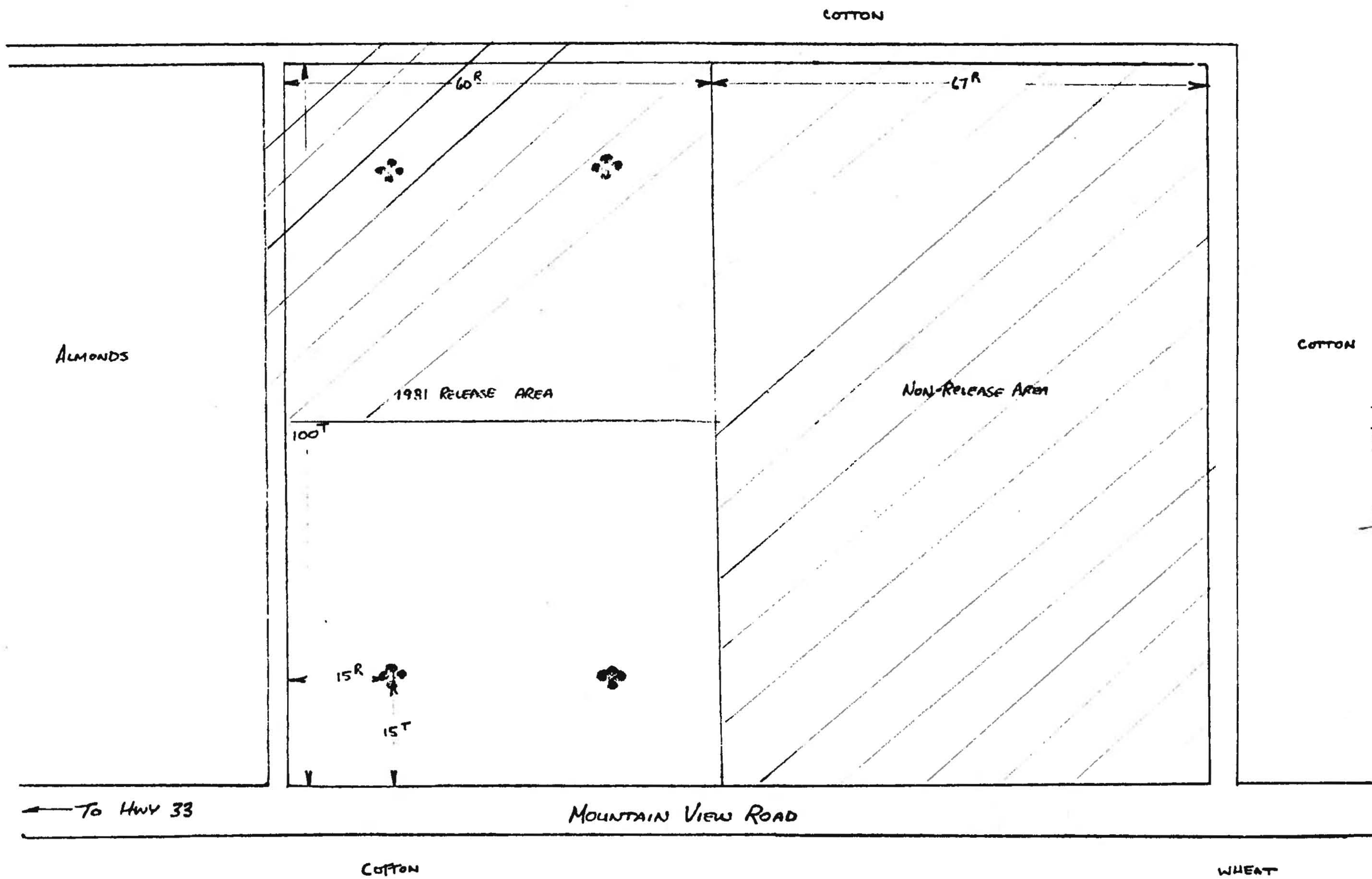
The graphs are presented for each of the 4 clusters only as the different sprays applied make it impossible to combine data for the entire block.

July 7, 1983 Sprays



Plot Map B

June 9, 1983 Sprays

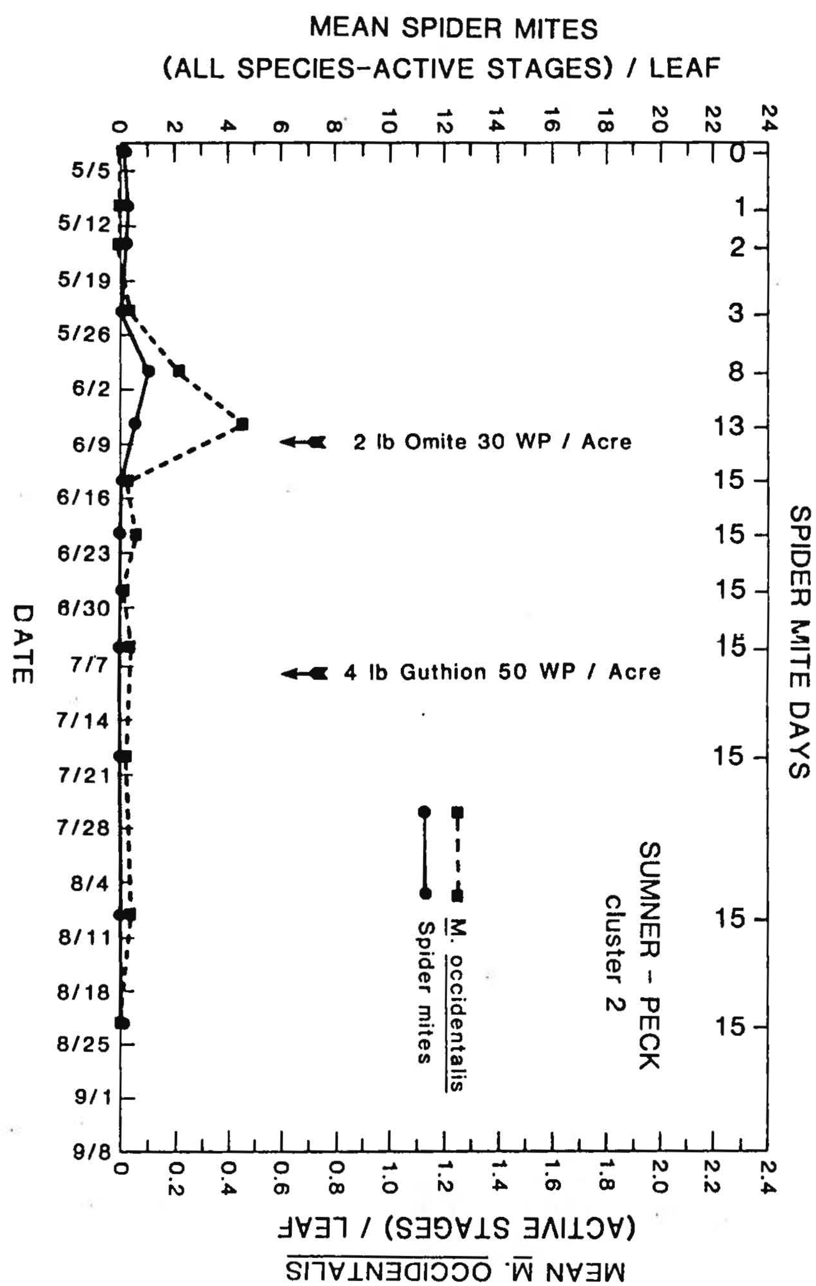


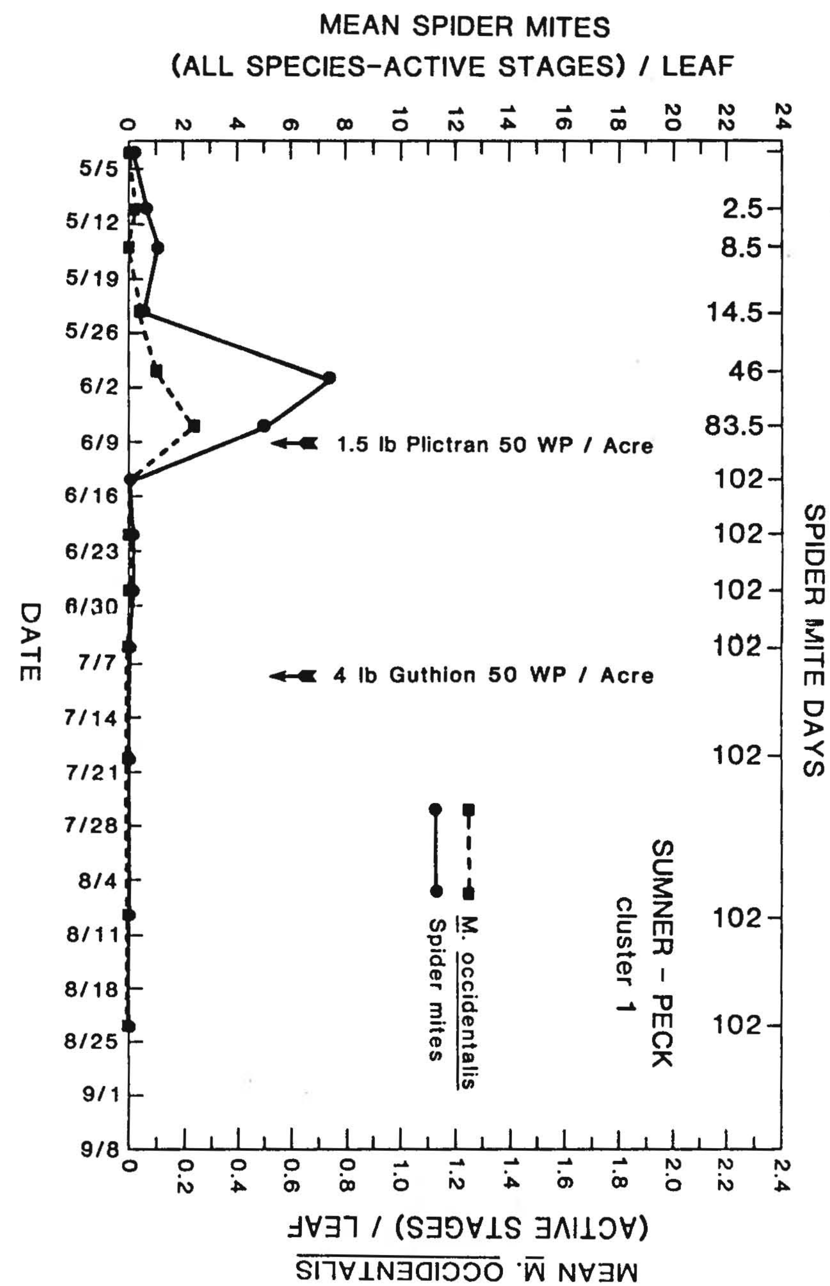
1983 SUMNER-PECK RANCH

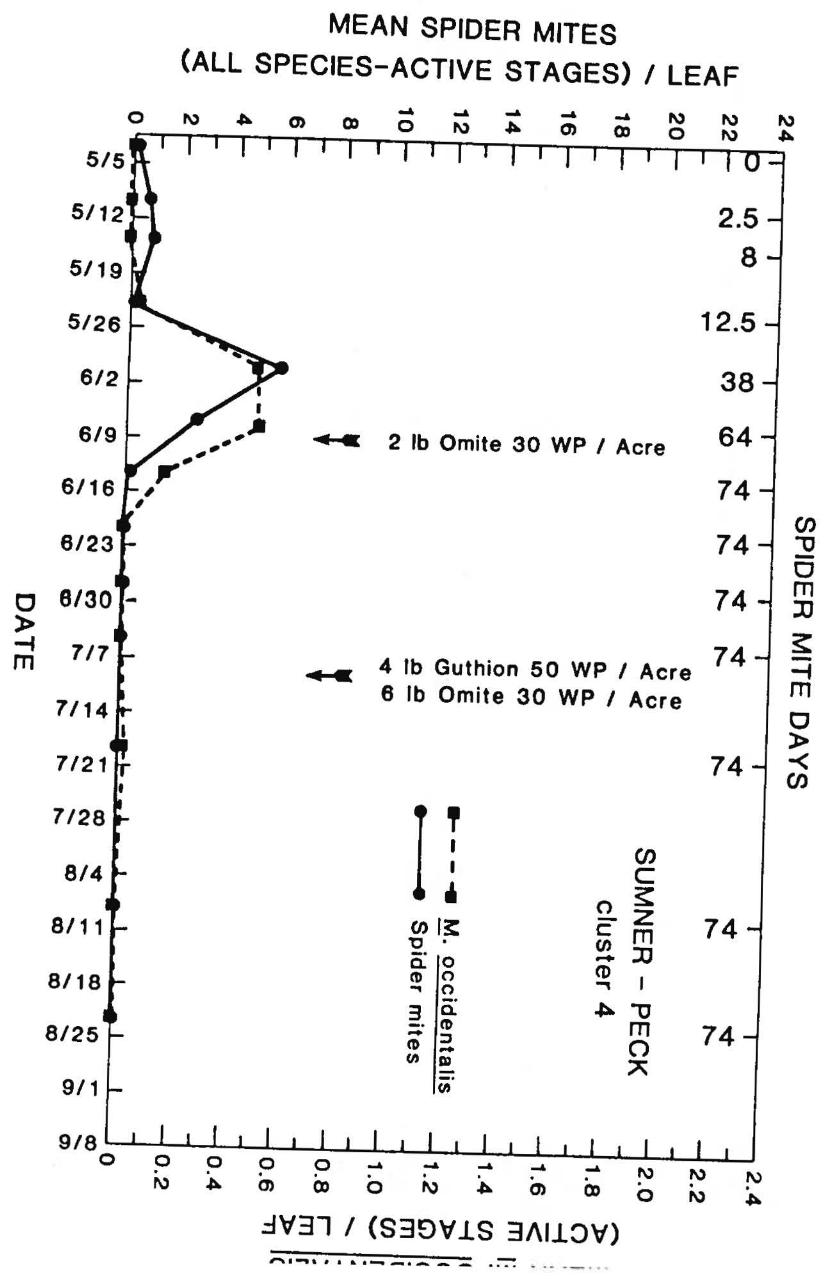
- SAMPLE SITE LOCATIONS – (LEAF COUNTS AND PRESENCE-ABSENCE CHECKS)

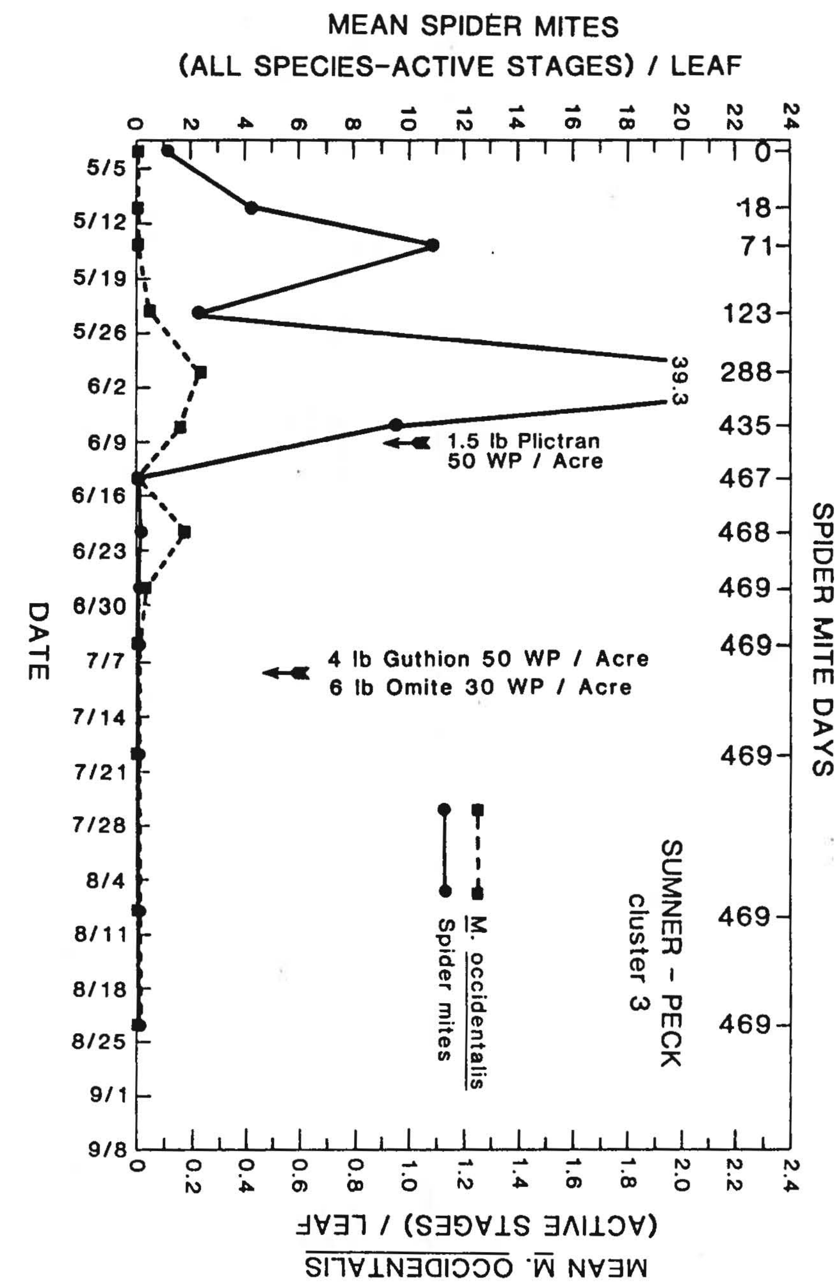
= 1½ lb Plictran 50WP

= 2 lb OMITE 30W


MEAN SPIDER MITES
(ALL SPECIES-ACTIVE STAGES) / LEAF
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
DATE
SPIDER MITE DAYS
2 lb Omite 30 WP / Acre
4 lb Guthion 50 WP / Acre
M. occidentalis
Spider mites
SUMNER - PECK
cluster 2


MEAN SPIDER MITES
(ALL SPECIES-ACTIVE STAGES) / LEAF
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
DATE
SPIDER MITE DAYS
1.5 lb Plictran 50 WP / Acre
4 lb Guthion 50 WP / Acre
M. occidentalis
Spider mites
SUMNER - PECK
cluster 1


MEAN SPIDER MITES
(ALL SPECIES-ACTIVE STAGES) / LEAF
SPIDER MITE DAYS
DATE
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
2 lb Omite 30 WP / Acre
4 lb Guthion 50 WP / Acre
6 lb Omite 30 WP / Acre
SUMNER - PECK
cluster 4
M. occidentalis
Spider mites


MEAN SPIDER MITES
(ALL SPECIES-ACTIVE STAGES) / LEAF
SPIDER MITE DAYS
DATE
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
39.3
1.5 lb Plictran
50 WP / Acre
4 lb Guthion 50 WP / Acre
6 lb Omite 30 WP / Acre
SUMNER - PECK
cluster 3
M. occidentalis
Spider mites

IV-42

Aerial Movements of Spider Mites and *Metaseiulus occidentalis* within and Outside of an Almond Orchard - 1983

Aerial dispersal of the carbaryl-OP-resistant strain of *Metaseiulus occidentalis* was documented during the 1981 and 1982 field seasons (Hoy 1982; 1982 Almond Board Report). During the 1983 field season, we monitored the aerial dispersal of spider mites and carbaryl-OP-resistant *M. occidentalis* in the Livingston-I almond orchard which has an open field located just south of it (Fig. 1). The following questions were asked: 1) At what time of the day do predators and spider mites disperse? 2) Is there a difference in height at which predators and spider mites disperse? 3) How far can carbaryl-OP-resistant predators disperse outside the almond orchard?

To answer these questions, greased panels were placed inside and outside the Livingston-I orchard during the weeks of July 18-25 and July 25-August 1, an interval which resulted in extensive dispersal in 1981 and 1982 in this orchard. This block is about 14 acres (5.6 ha) in size, with Mono, Yosemite and Mission varieties planted in a 1 : 2 : 1 pattern with trees 15 x 25 feet (4.57 x 7.62m) apart (Fig. 1). Carbaryl-OP-resistant *M. occidentalis* females (350) were released on 9 June 1981 into every third tree in every third row. During 1983, propargite (Omite 30 WP) was applied on June 6, using 0.5 lb/acre (0.57 kg/ha) by an air blast sprayer. No other acaricides (or insecticides) were applied in Livingston-I during the 1983 field season.

The same panels were used for the three experiments. Panels of clear perspex sheets 19.5 x 40" (1219 x 495mm) were nailed on to wooden frames (Fig. 2). The plastic panels were coated with a thin film of 90 weight gearbox oil on one side using a 6 inch rubber roller (Printmasters soft rubber).

Time of day.

The time-of-day dispersal experiment was conducted outside the orchard using two towers 20 feet (6.1 m) tall located 16.25 feet (8 m) south of the first row of trees (Fig. 1). Each tower had one panel with the greased side oriented towards the orchard. The panels were replaced every two hours during the first experimental period (July 18-19), and every four hours during the second experimental period (July 25-27). Every time the panels were changed, weather data (temperature, relative humidity, windspeed, wind direction) were collected. After the experiments, the plastic panels were cut into 40 strips each 1 inch by 19.5 inches and the spider mites and predators on these strips were counted using a dissecting microscope.

Variability in height.

Four panels were located on each of two towers 9, 15, 24 and 36 feet (2.75, 4.60, 7.30 and 10.8m) above ground level. The two towers were placed inside the Livingston-I orchard between two rows of trees (Fig. 1, Fig. 3). The panels were directed so that the greased surface faced north. The panels were left in the orchard for 7 days and replaced with new panels for a second week of trapping. Plastic strips with the spider mites and predators were counted using a dissecting microscope, as above.

Dispersal Distance.

Two rows of five trees in the southwest corner of Livingston I were dusted with fluorescent dust according to the method described by Brandenburg and Kennedy (1982). Fluorescent dust (2 lb or 0.91 kg) was applied twice, once each week, using a two-stroke powder duster. We hoped to score the fluorescent dust-marked spider mites and predators in a dark room using a UV light. However, this method didn't work, so the panels were cut in strips and scored as described above.

One panel was placed on each of 5 towers 20 feet (6.1m) (Fig. 4) above the ground surface. The 5 towers were placed across an open field 15, 25, 50, 100 and 200 m south of the Livingston-I orchard (Fig. 1). The greased side of the plastic panels faced northwest, in the direction of the prevailing winds.

Results

Time of day.

Dispersal of spider mites and *M. occidentalis* during the day doesn't follow a uniform pattern. During the first week, dispersal of predators and spider mites peaked during the interval from 4 pm - 10 pm, and there was very little or no dispersal of predators and spider mites from midnight - 8 am (Fig. 5, Table 1). Most of the spider mites collected on the greased panels were European red mites (*Panonychus ulmi*) although a few were Pacific mites (*Tetranychus pacificus*), which reflects the composition of the spider mite population as found in the weekly foliage counts in Livingston-I and Livingston-II. Most _M. occidentalis_ on the greased panels were adult females.

The peak movements occurred when the highest windspeeds were measured (Fig. 5, Table 3). The windspeed started to increase between 4 and 6 pm, and reached its peak value at 10 pm. The dispersal peak also coincides with an increasing relative humidity and decreasing temperatures (Table 3). Dispersal at this time by spider mites and predators would diminish the risk of dessication during dispersal. Laboratory experiments on the time adult females can survive in low humidities and high temperatures have shown a rapid decrease in survival when starved females are held under low relative humidities and high temperatures (Unpublished).

During the second experimental period, when the greased panels were changed every four hours instead of every two hours, almost no predators or spider mites were found on the traps (Table 2). The few predators and spider mites on the panels were trapped between 4 and 8 pm, which confirms the results of the first week, in which the dispersal peaked between 4 and 10 pm. There were fewer mites on the foliage during this week in the block (Figs. 8 & 9).

Variability in height.

During the first sample week there is no dramatic difference between the numbers of mites and predators found on the greased panels at the different heights, or between the numbers trapped on the east and west towers (Fig. 6, Table 4). On all panels at any height, the numbers of spider mites and predators caught were reasonably high. The spider mites found on the greased panels were mainly European red mite (P. ulmi), but a few Pacific mites (T. pacificus) were found. This reflects what was found in the weekly foliage counts in Livingston-I, in which almost no Pacific mites were found in this period.

During the second week there was a substantial difference in the numbers of spider mites and predators trapped on the greased panels on the east and the west towers (Fig. 7). The reason for this variability is not clear as there is no correlation with the foliage counts as illustrated in Figs. 8 and 9. In both the east corner of the orchard (cluster 4) and the west corner (cluster 1), the spider mite density was low (0 active stages/leaf). Predator densities were 0.15 and 0.1 active stages/leaf for the west and east towers, respectively. These densities are not reflected in the numbers of predators and spider mites found on the panels.

Long distance.

Although predators and spider mites were found on all greased panels which were placed across the field south of the Livingston-I block, we can't conclude anything about the dispersing distance, because none of the mites and predators found on the greased panels were marked with fluorescent dust. The only information this experiment provides is that the distance dispersed is at least 140 m, which was the distance between the Livingston-I and Livingston-II blocks and the panels on the farthest tower (Table 5, Fig. 10).

References.

Brandenburg, R. L. and Kennedy, G. G. 1982. Intercrop relations and spider mite dispersal in a corn/peanut agro-ecosystem. Ent. Exp. Appl. 32:269-276.

Hoy, M. A. 1982. Aerial dispersal and field efficacy of a genetically improved strain of the spider mite predator *Metaseiulus occidentalis*. Ent. Exp. Appl. 32:205-212.

Table 1. Number of *M. occidentalis* and spider mites collected on greased plastic panels on two towers located outside the Livingston-I almond block July 18-19, 1983.

Time 1/	East tower SM 2/	East tower MO 3/	West tower SM 2/	West tower MO 3/	Mean SM 2/	Mean MO 3/
July 18						
4 - 6 pm	31	8	63	7	47	7.5
6 - 8 pm	15	1	29	7	22	4
8 - 10 pm	16	5	22	8	19	6.5
10 - Midn.	1	1	0	1	0.5	1
July 19						
Midn. - 2 am	0	0	0	0	0	0
2 - 4 am	0	0	-	-	0	0
4 - 6 am	0	0	0	1	0	0.5
6 - 8 am	0	0	2	0	1	0
8 - 10 am	4	1	3	3	3.5	2
10 - noon	2	0	-	-	2	0
noon - 2 pm	1	1	4	1	2.5	1
2 - 4 pm	2	0	9	1	5.5	0.5

1/ Panels were changed every 2 hours for 24 hours.

2/ SM = Total number of spider mites/panel (48" x 19.5"; 0.604 m^2).

3/ MO = Total number of *M. occidentalis*/panel.

All numbers are based on counts of panel strips under a dissecting microscope.

Table 2. Number of M. occidentalis and spider mites collected on greased plastic panels on 2 towers located outside the Livingston-I almond block July 25 - 27, 1983.

Time1/	East tower SM2/	East tower Mo3/	West tower SM2/	West tower Mo3/
July 25				
noon - 4 pm	0	1	0	0
4 - 8 pm	0	0	0	0
8 - midn.	1	0	0	0
July 26				
midn. - 4 am	1	0	0	0
4 - 8 am	0	0	0	0
8 - noon	-	-	0	0
noon - 4 pm	1	1	0	0
4 - 8 pm	2	3	0	4
8 - midn.	0	1	0	1
July 27				
midn. - 4 am	0	1	0	0
4 - 8 am	0	1	0	0
8 - noon	0	0	0	0

1/ Panels were changed every 4 hours for 48 hours.

2/ SM = total number of spider mites/panel (48 x 19.5: 0.604 m^2).

3/ M. o. = total number of M. occidentalis/panel.

All numbers are based on counts of panel strips under a dissecting microscope.

Table 3. Relative humidity, wind speed and direction, and temperature July 18-19, 1983 during time of day experiment.

Time	Rel. humidity (%)	Windspeed (ft/min)	Wind direction	Temperature (^{o}C)
4 pm	23	50 - 70	from SW	30
6 pm	31	200	" NW	26.5
8 pm	38	250 - 300	" NW	22.5
10 pm	46	300 - 400	" NW	20
Midnight	63	100	" NW	17
2 am	74	100	" NW	15.5
4 am	83	100	" NW	14.5
6 am	92	70 - 80	" NW	13.5
8 am	85	200	" NW	14.5
10 am	55	300	" NW	19.5
Noon	40	200	" NW	24
2 pm	28	150	" NW	27
4 pm	30	150	" N	28

Table 4. Total number of spider mites and *M. occidentalis* on greased panels at 4 heights each, on two towers inside the Livingston-I almond orchard during the weeks of July 18 - 25 and July 25 - Aug. 1, 1983.

Date and Tower Location	Height of Panel							
	9 ft(2.75m)		15 ft(4.6m)		24 ft(7.3m)		36 ft(10.8m)	
Week I (7/18-7/25)	SM1/	MO2/	SM1/	MO2/	SM1/	MO2/	SM1/	MO2/
East tower	224	70	178	30	302	95	408	67
West tower	132	28	222	38	283	72	188	42
Week II (7/25-8/1)								
East tower	166	14	168	28	662	64	320	40
West tower	10	0	11	3	5	2	15	3

1/ SM = Total number of spider mites/panel (48" x 19.5"; 0.604 m^2).

2/ MO = Total number of *M. occidentalis*/panel (48" x 19.5"; 0.604 m^2).

All numbers are based on counts of panel strips under a dissecting microscope.

Table 5. Total number of spider mites and *M. occidentalis* on traps away from marked trees.

	15 meters		25 meters		50 meters		100 meters		200 meters	
Date sampled	SM 1/	MO 2/	SM 1/	MO 2/	SM 1/	MO 2/	SM 1/	MO 2/	SM 1/	MO 2/
July 18-25	84	30	98	37	40	17	32	21	27	8
July 25-Aug. 1	41	23	34	11	26	15	18	7	64	19

1/ SM = Total number of spider mites/panel (48" x 19.5"; 0.604 m^2).

2/ MO = Total number of *M. occidentalis*/panel.

All numbers are based on counts of panel strips under a dissecting microscope.

Figure 1. Map showing locations of greased panel towers during July 25-August 1. Three experiments were conducted to determine: the time of day spider mites and predators disperse, the distance they can disperse from the almond orchard, and differences in trap efficiency at different heights.

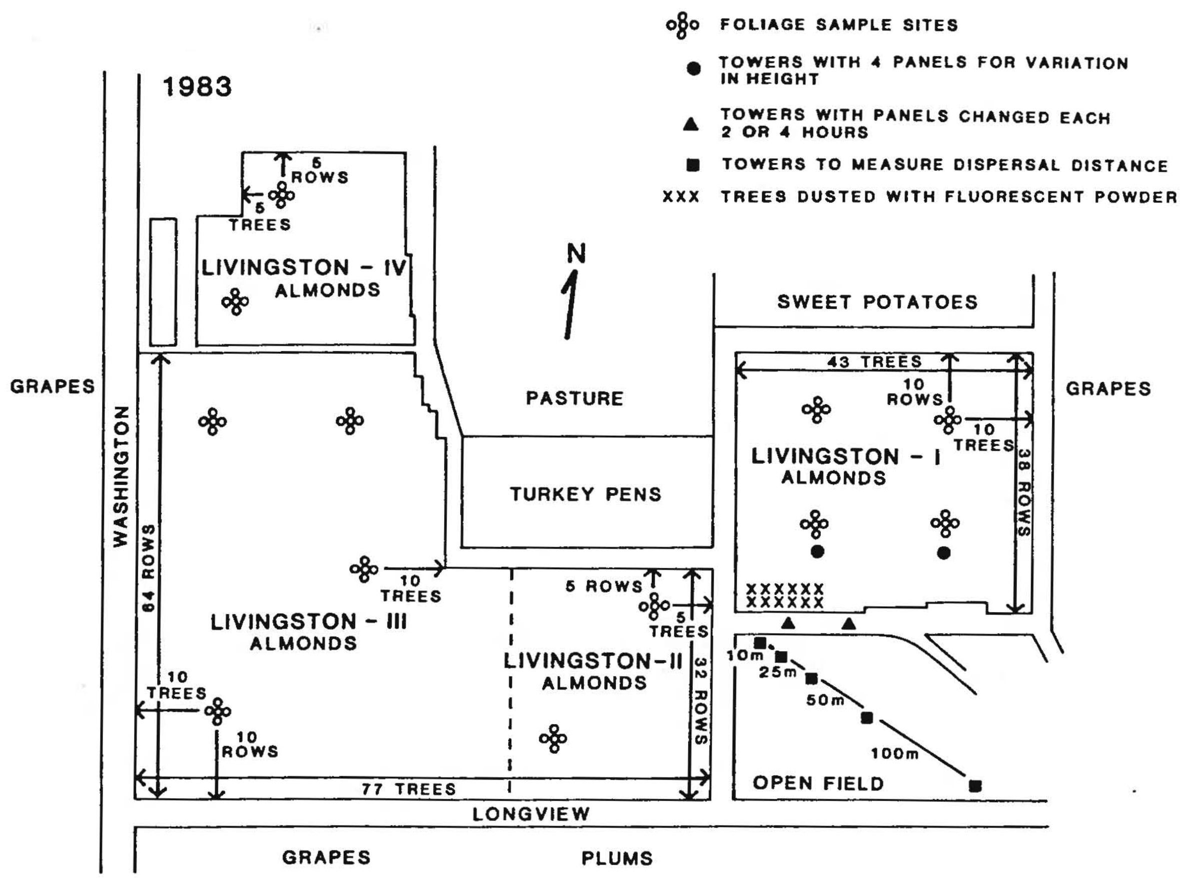


Figure 2. Design of greased panels that were bolted to towers to trap spider mites and *M. occidentalis* during July 1983.

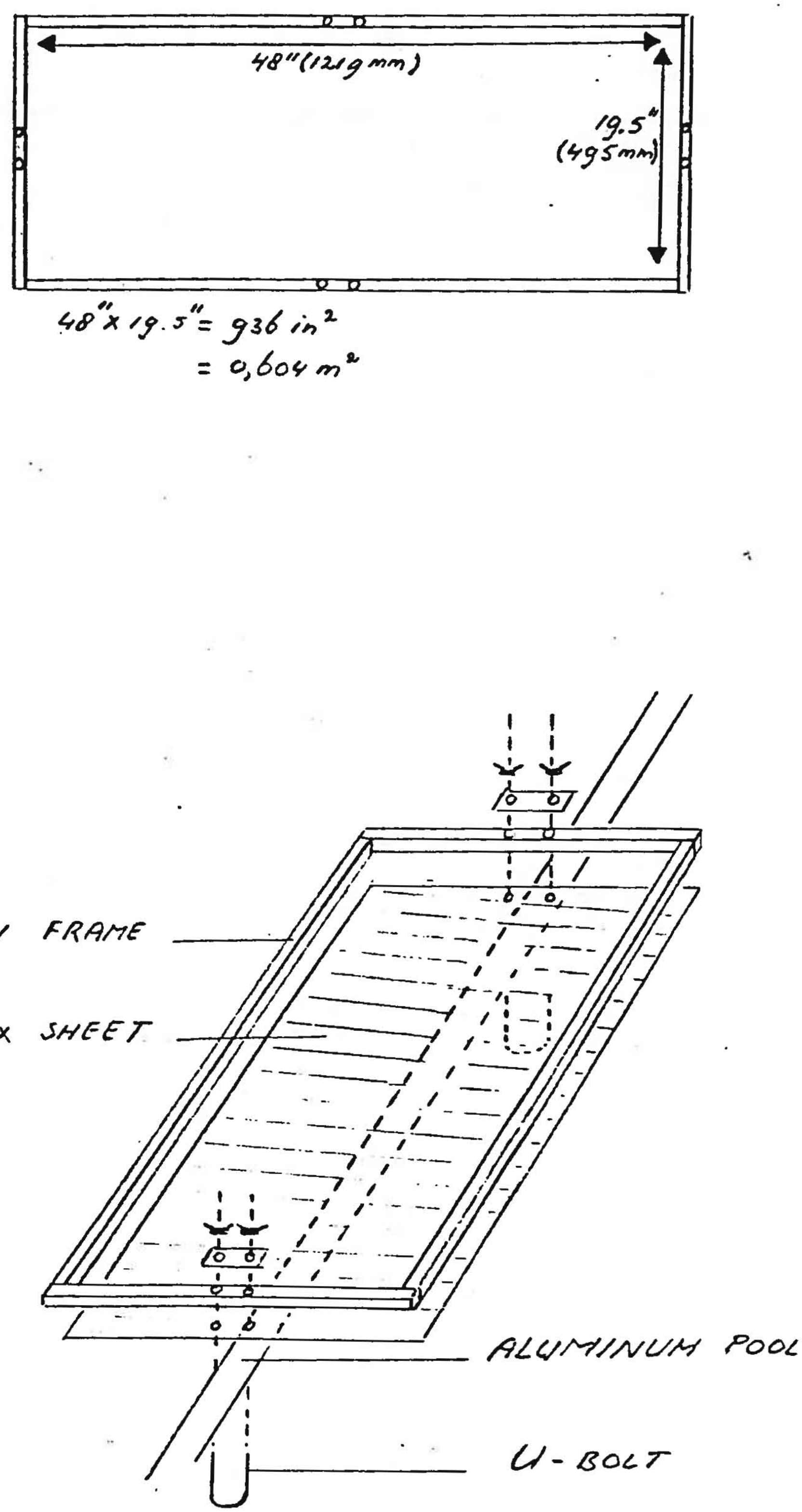


Figure 3. Variability in trap efficiency at 4 different heights was evaluated inside the Livingston-I almond orchard. Two towers were placed inside the orchard and greased panels were twice left for one week beginning July 18, 1983.

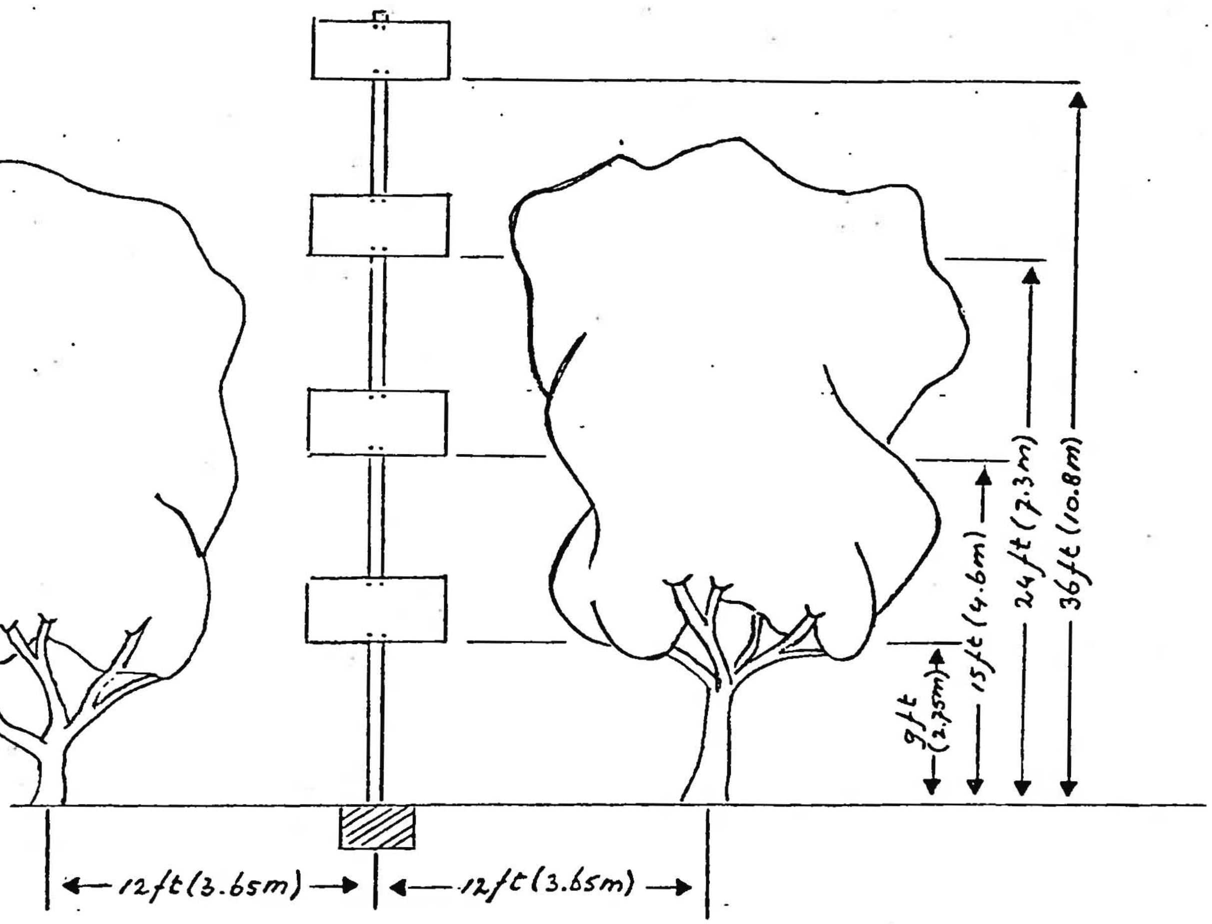


Figure 4. Design of the towers used in the long distance dispersal and time of day experiments in the area outside the Livingston-I almond orchard, 1983.

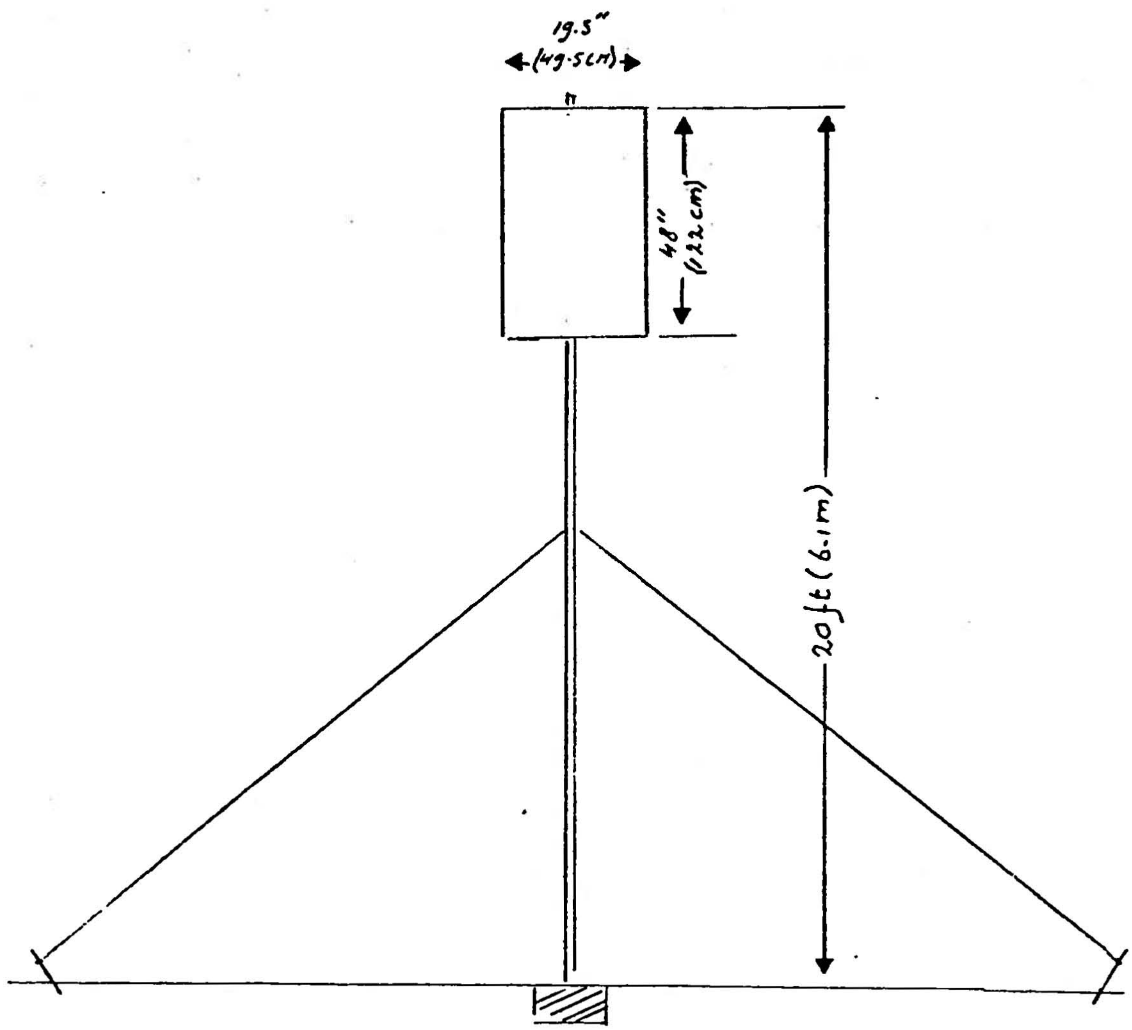


Figure 5. Number of spider mites and M. occidentalis trapped on greased panels located outside the Livingston-I almond orchard during July 18-19, 1983. Panels were changed every 2 hours for 24 hours.

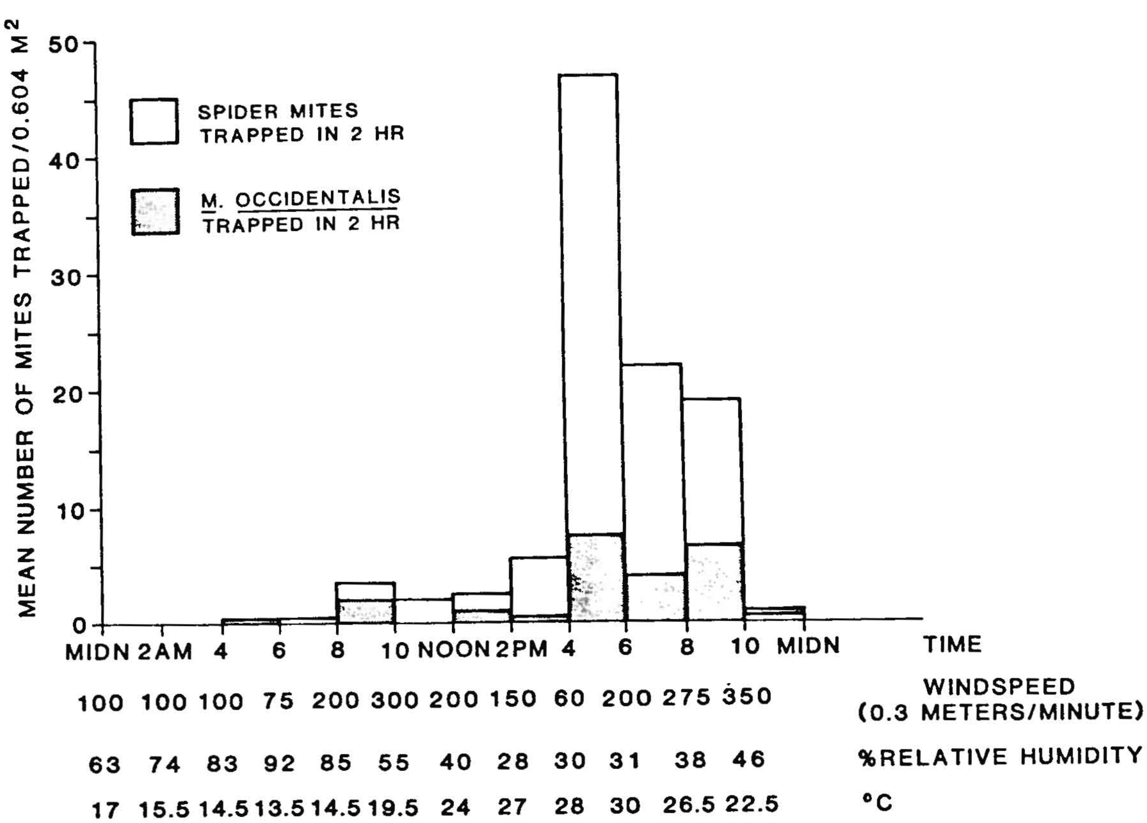


Figure 6. Mean number of spider mites and *M. occidentalis* trapped on greased panels located on two towers (east and west) in the Livingston-I almond orchard during July 18-25, 1983. Panels were located at 9, 15, 24, and 36 feet above ground level on each tower and the greased surface faced north.

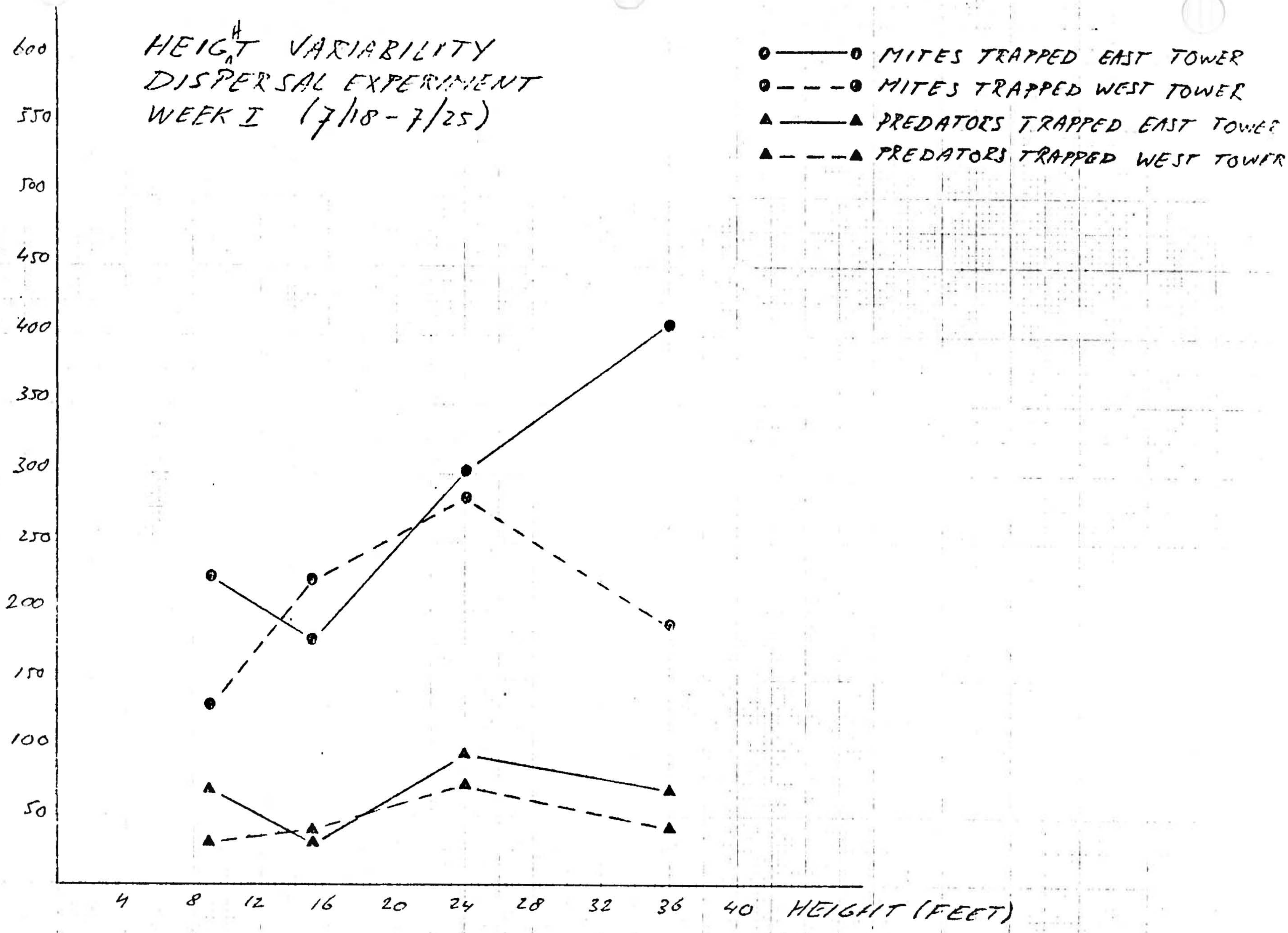
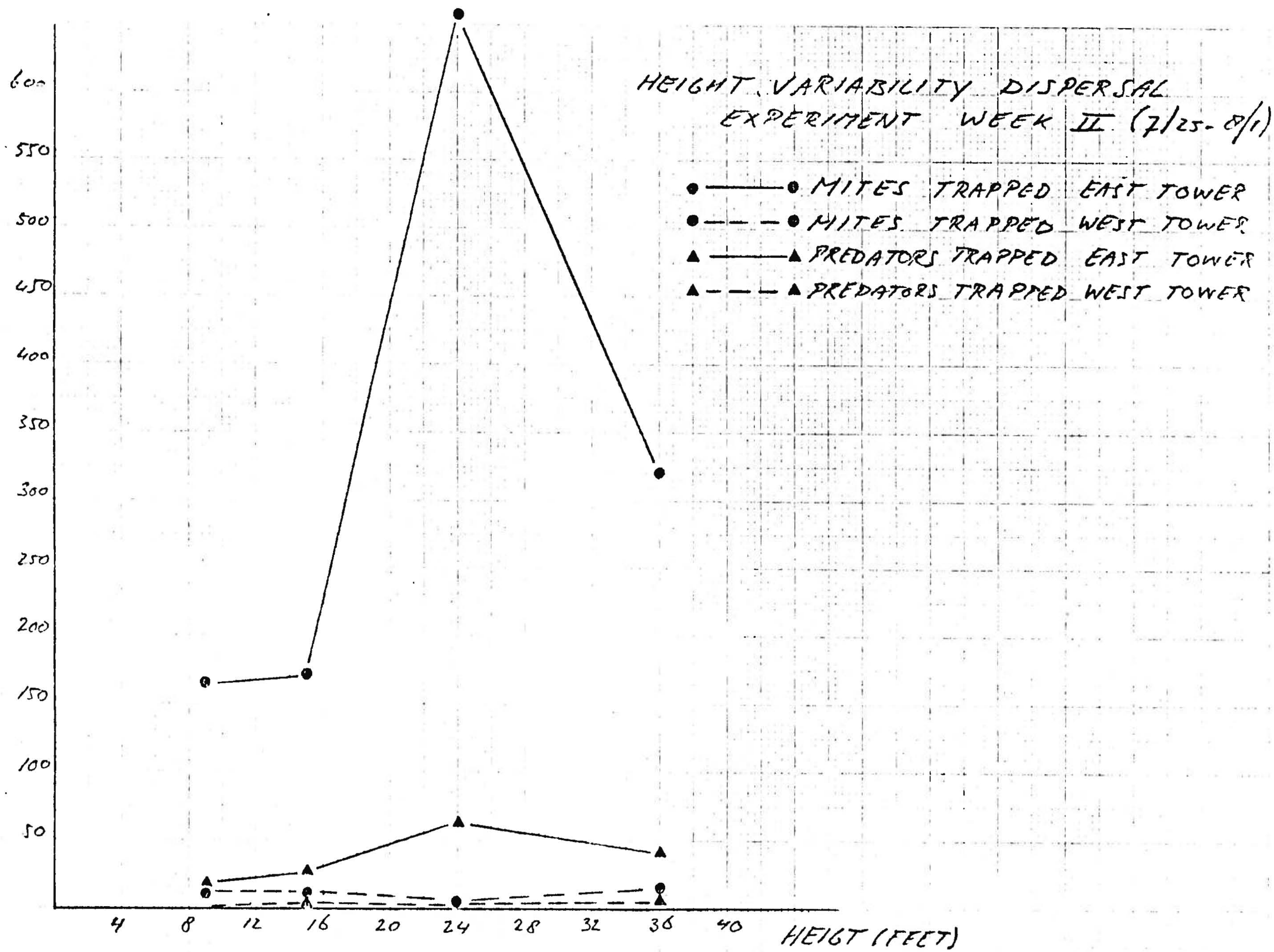
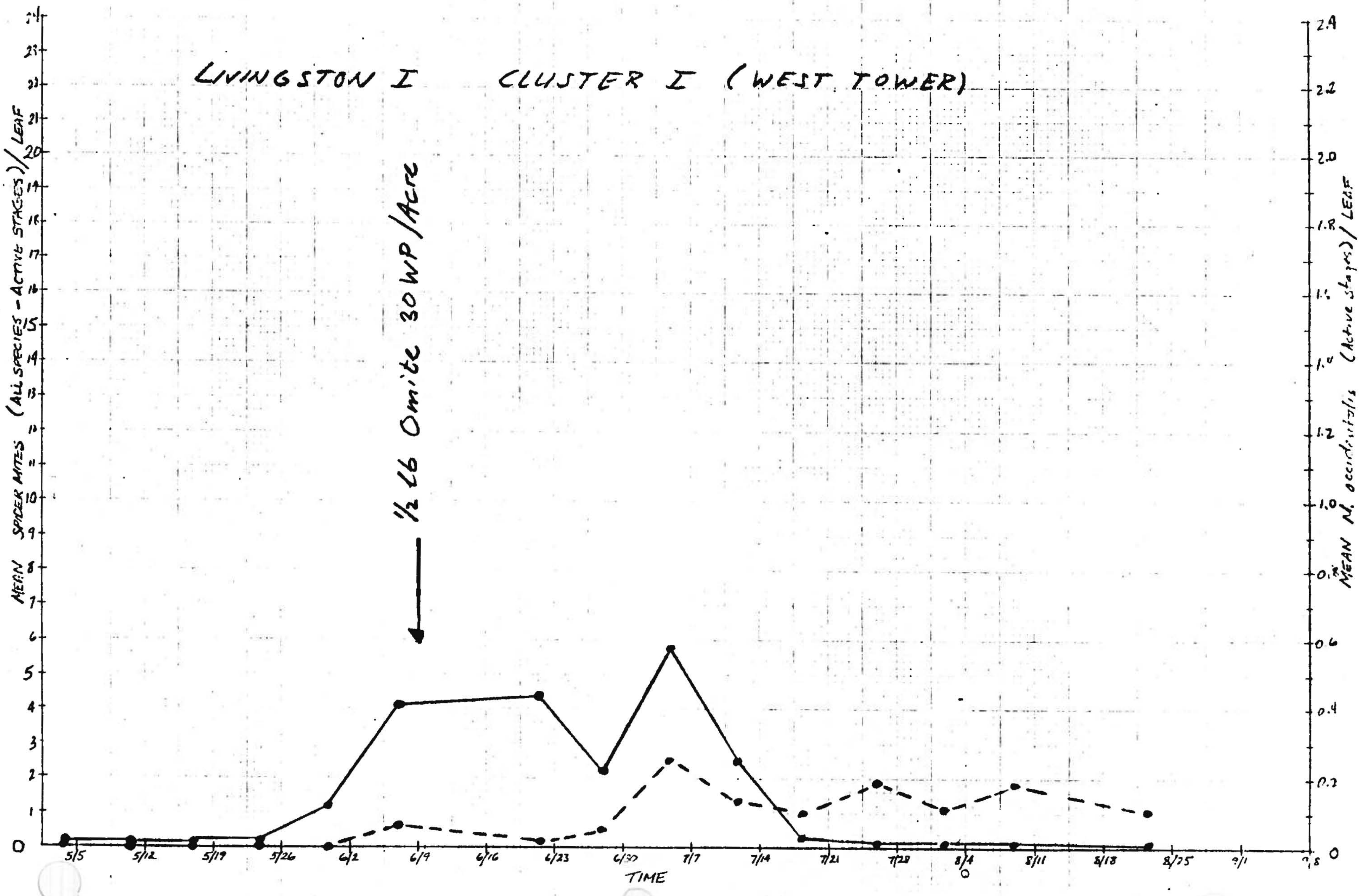

HEIGHT VARIABILITY
DISPERSAL EXPERIMENT
WEEK I (7/18-7/25)
MITES TRAPPED EAST TOWER
MITES TRAPPED WEST TOWER
PREDATORS TRAPPED EAST TOWER
PREDATORS TRAPPED WEST TOWER
600
550
500
450
400
350
300
250
200
150
100
50
4
8
12
16
20
24
28
32
36
40
HEIGHT (FEET)

Figure 7. Mean number of spider mites and <u>M.occidentalis</u> trapped on greased panels located on two towers (east and west) in the Livingston-I almond orchard during July 25-August 1, 1983. Panels were located at 9, 15, 24, and 36 feet above ground level on each tower and the greased surface faced north.


HEIGHT VARIABILITY DISPERSAL
EXPERIMENT WEEK II (7/25-8/1)
MITES TRAPPED EAST TOWER
MITES TRAPPED WEST TOWER
PREDATORS TRAPPED EAST TOWER
PREDATORS TRAPPED WEST TOWER
600
550
500
450
400
350
300
250
200
150
100
50
4
8
12
16
20
24
28
32
36
40
HEIGT (FEET)

Figures 8 and 9. Mean number of spider mites and predators (all species - active stages)/leaf in the two sample areas adjacent to the east and west towers used to sample for variability in height in panel efficacy.

158.



LIVINGSTON I CLUSTER I (WEST TOWER)
½ Lb Omite 30 WP/Acre
MEAN SPIDER MITES (ALL SPECIES - ACTIVE STAGES)/ LEAF
MEAN N. occidentalis (Active stages)/ LEAF
TIME
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1

Sc-9

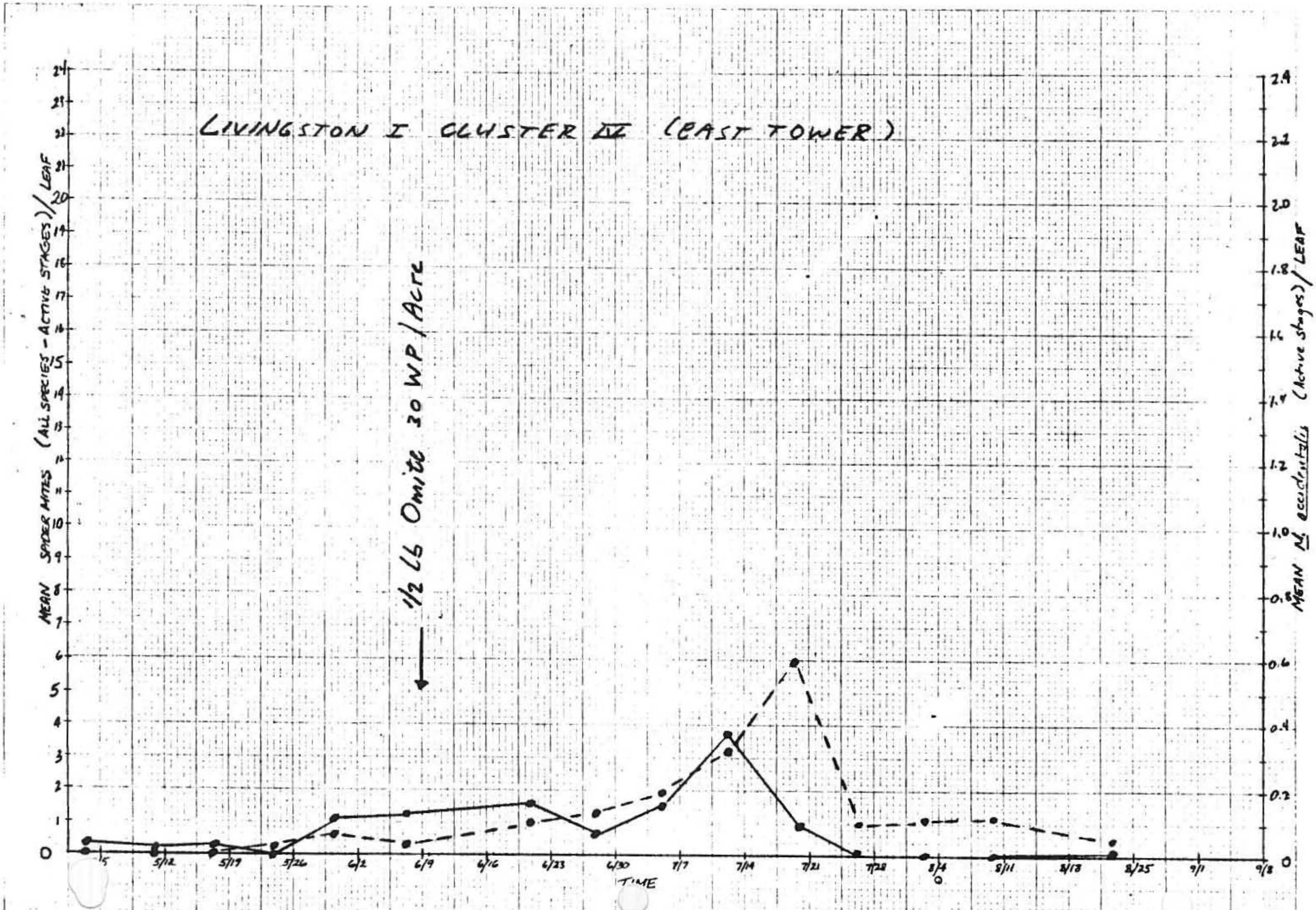
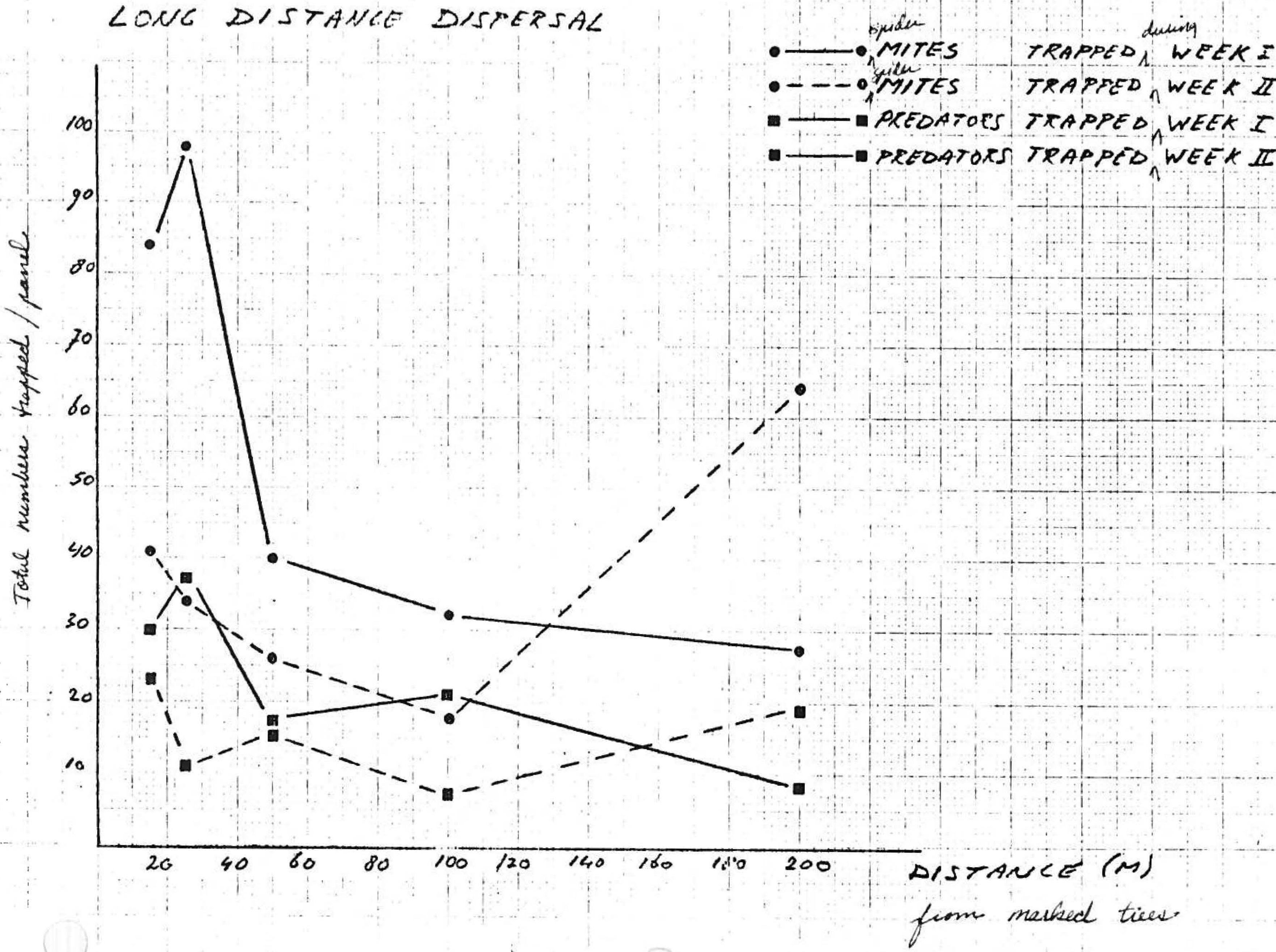

LIVINGSTON I CLUSTER IV (EAST TOWER)
1/2 Lb Omite 30 WP / Acre
MEAN SPIDER MITES (ALL SPECIES - ACTIVE STAGES) / LEAF
MEAN N. occidentalis (Active stages) / LEAF
TIME
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8

Figure 10. Total numbers of spider mites and predators trapped during one week on panels located on towers 25, 50, 100, and 200 meters from trees treated with fluorescent dust in the Livingston-I almond orchard during July 18-25 and July 25-August 1, 1983.

LONG DISTANCE DISPERSAL



V.d. Survey during 1983 for resistance in *M. occidentalis* from almond orchards surrounding the Livingston I, II, III and IV release sites.

On July 19, 25 and 26, almond orchards surrounding the Livingston I, II, III and IV release sites were examined for *M. occidentalis* in order to obtain colonies to test for carbaryl resistance (Fig. V-d-1 and Table V-d-1). Since native *M. occidentalis* typically exhibit no carbaryl resistance, the presence of even low levels of carbaryl resistance in *M. occidentalis* would support the hypothesis that the resistant strain has dispersed from the release sites into surrounding orchards.

Sixteen colonies were obtained from sites within a radius of 3 miles (Table V-d-1). The numbers of individuals obtained for initiating the colony and the exact locations are indicated in Table V-d-1. After the colonies had multiplied, 40-50 gravid adult females were placed (5/disc) on bean leaf discs and sprayed with 2.4 g a.i. carbaryl/liter distilled water. The carbaryl-OP resistant colony and a carbaryl-susceptible laboratory colony (WA-33 or Immature selection-37) were tested at the same time. Twenty females from each colony were also tested with water as a check of handling mortality or disease.

The results are indicated on Fig. V-d-1. Four colonies survived on the carbaryl-treated leaf discs. The highest survival rate (34%) was from an orchard located near the corner of Washington and Bell, which is about one-half mile due south of the release sites. A small abandoned almond orchard on Longview also had resistant predators (averaged 14% survival);

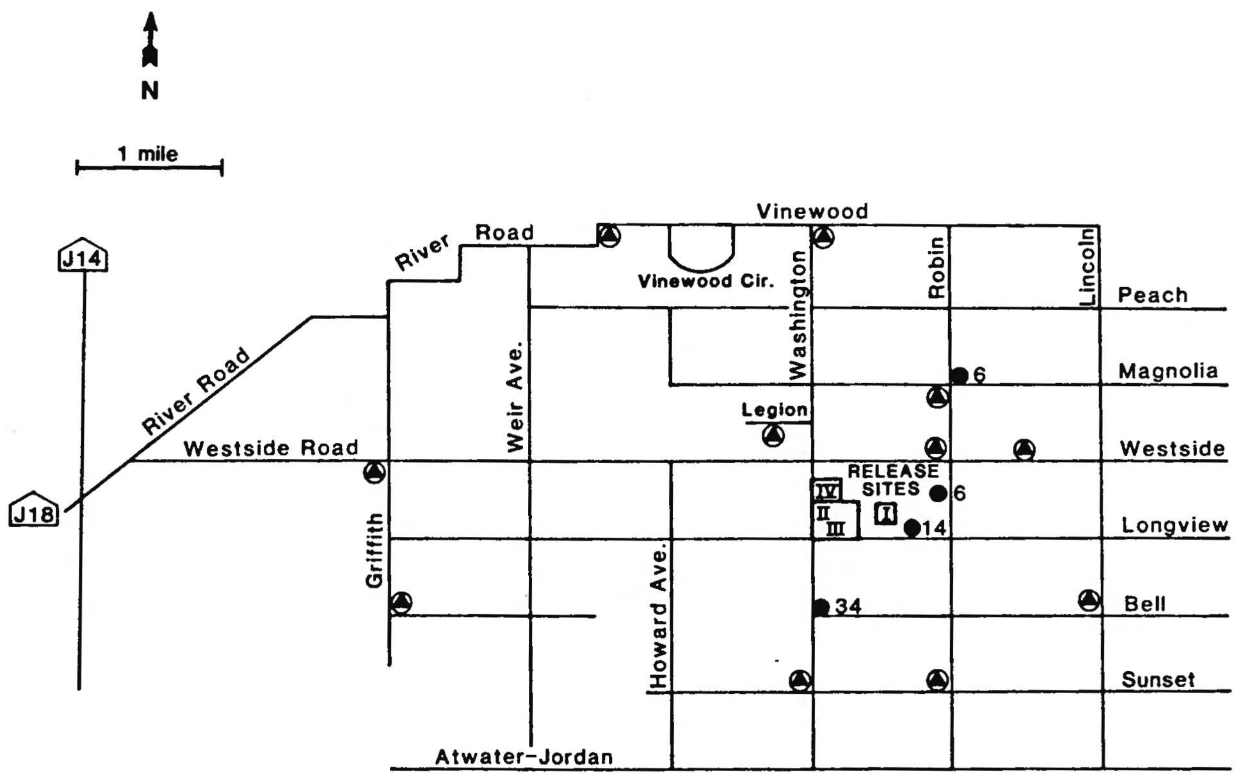
this orchard is about 200 meters from the nearest release site. The two orchards on Robin with resistant predators (6% survival rates for each) are about 0.5 and 1.0 miles from the release orchards. These survival rates are low to moderate, but may actually underestimate the resistance levels of the orchard populations since the carbaryl-resistant laboratory colony exhibited only 44% survival in the test, an unusually low level of survival, as this colony usually averages 80% survival at the standard (2.4 g a.i.) test dose.

Conclusions

Aerial dispersal of the carbaryl-resistant *M. occidentalis* has occurred from the Livingston release sites. Movements have occurred sometime since the original release in May 1981 into Livingston-I. The prevailing winds in this area are from the northwest, and the four positive finds are south and/or east of the release sites, as expected. The levels of carbaryl resistance are measurable and could be enhanced if a carbaryl selection were to occur in these sites. Dispersing predators have apparently not reached the orchards on Sunset and Bell, as these *M. occidentalis* colonies appear to be susceptible to carbaryl.

It is clear that the carbaryl-resistant strain is moving out from the release sites. What is unanswered is how much selection with carbaryl has gone on in the recipient orchards. Colonization success by these resistant predators (or any other dispersing phytoseiids) could be dependent upon a suite of factors being supportive to colonization. Thus, predators entering a new orchard must find prey available and they must experience a compatible pesticide program (i.e., no permethrin or excessive rates of acaricides which would eliminate prey). In addition, once there in the orchard, we have no reason to expect them to increase without carbaryl selection in the orchard, since we have no evidence it is more fit than the abundant native susceptible *M. occidentalis*. If other phytoseiids are present such as *Amblyseius hibisci*, which have the advantage that they can feed on pollen when prey is scarce, then it is possible that the carbaryl-resistant *M. occidentalis* would be at a competitive disadvantage as long as carbaryl was not applied. Future surveys should be conducted to determine how much further the carbaryl-resistant strain has dispersed.

Figure V Map of Livingston, California area where almond orchards were sampled for M. occidentalis to determine if the carbaryl-resistant strain has dispersed from the release sites (I, II & III, and IV). Solid circles indicate colonies with measurable carbaryl resistances with numbers referring to the % survival when tested with 2.4 g. carbaryl a.i./liter distilled water. Triangles indicate sites where the M. occidentalis colony exhibited 0% survival.



VI. Phytoseiid species collected from almond orchards near Livingston, California during June and July 1983.

During June and July 1983, almond orchards surrounding the Livingston I, II, III, and IV release sites (near the cross streets of Longview and Washington) were surveyed for _M. occidentalis_ in order to test them for carbaryl resistance (see Fig. VI-1). If we found that the _M. occidentalis_ were carbaryl resistant, then this would provide evidence that aerial movements away from the release sites had occurred.

During the course of that survey, the almond orchards were found to have abundant European red mite populations and numerous phytoseiids other than _M. occidentalis_. These species were removed from the foliage and slide mounted in Hoyer's medium and identified using Schuster and Pritchard's key to the phytoseiid mites of California (R. O. Schuster and A. E. Pritchard, 1963. Phytoseiid mites of California, Hilgardia _34_ (7):191-285.).

The species identified and their collection sites also are listed in Table VI-1. This table probably under-represents the phytoseiid fauna since these phytoseiids are more difficult to sample than is _M. occidentalis_; most do not remain on the chilled foliage during transport to the laboratory for counting/slide mounting. However, my observations indicated that many almond orchards had 3-4 species of phytoseiids other than _M. occidentalis_ and these were often quite abundant even when prey were scarce - suggesting that they are pollen feeders, at least in part. Probably the most abundant species was Amblyseius hibisci.

During 1982, predators were sampled from aerial dispersal panels in the Livingston-I and Livingston-III orchards. Phytoseiids were slide mounted and identified, and the following species were present: Neoseiulus caudiglans, Amblyseius hibisci, Typhloseiopsis citri, and another Typhloseiopsis species. Thus, these species were not only present in the orchard but apparently disperse aerially, as does M.occidentalis, although their relative densities were less than during the 1983 field season.

The extensive populations of phytoseiid species other than M.occidentalis during 1983 were surprising. The reasons for this could include the following points: 1) I had not looked extensively in the Livingston area previously, and; 2) during 1983, European red mite were exceptionally abundant, which might favor these species over M.occidentalis, and; 3) many of these orchards received no insecticides or acaricides during 1983, according to the growers I met as I sampled. It is known that M.occidentalis is replaced by other phytoseiid species in unsprayedapple orchards and that it does best in orchards where moderate levels of certain insecticides are used and low rates or no acaricides are used (due to their obligatory requirement for prey). Thus, the other speciesof phytoseiids could be favored in the unsprayed orchards.

Little is known about the biology of these species other than A.hibisci, which is common in citrus orchards where it is known to feed on citrus red mite and citrus thrips, as well as pollen. It has also been observed on Prunus species feeding on peach silver mite. Here, it was probably feeding on European red mite. A.hibisci does not have a diapause, and I don't know if it can overwinter in almond orchards or if it must reinvade almonds each spring.

Table VI-1. Phytoseiid species collected from almond foliage during June and July 1983 near Livingston, California during a survey for carbaryl-resistant _M. occidentalis_[1/].

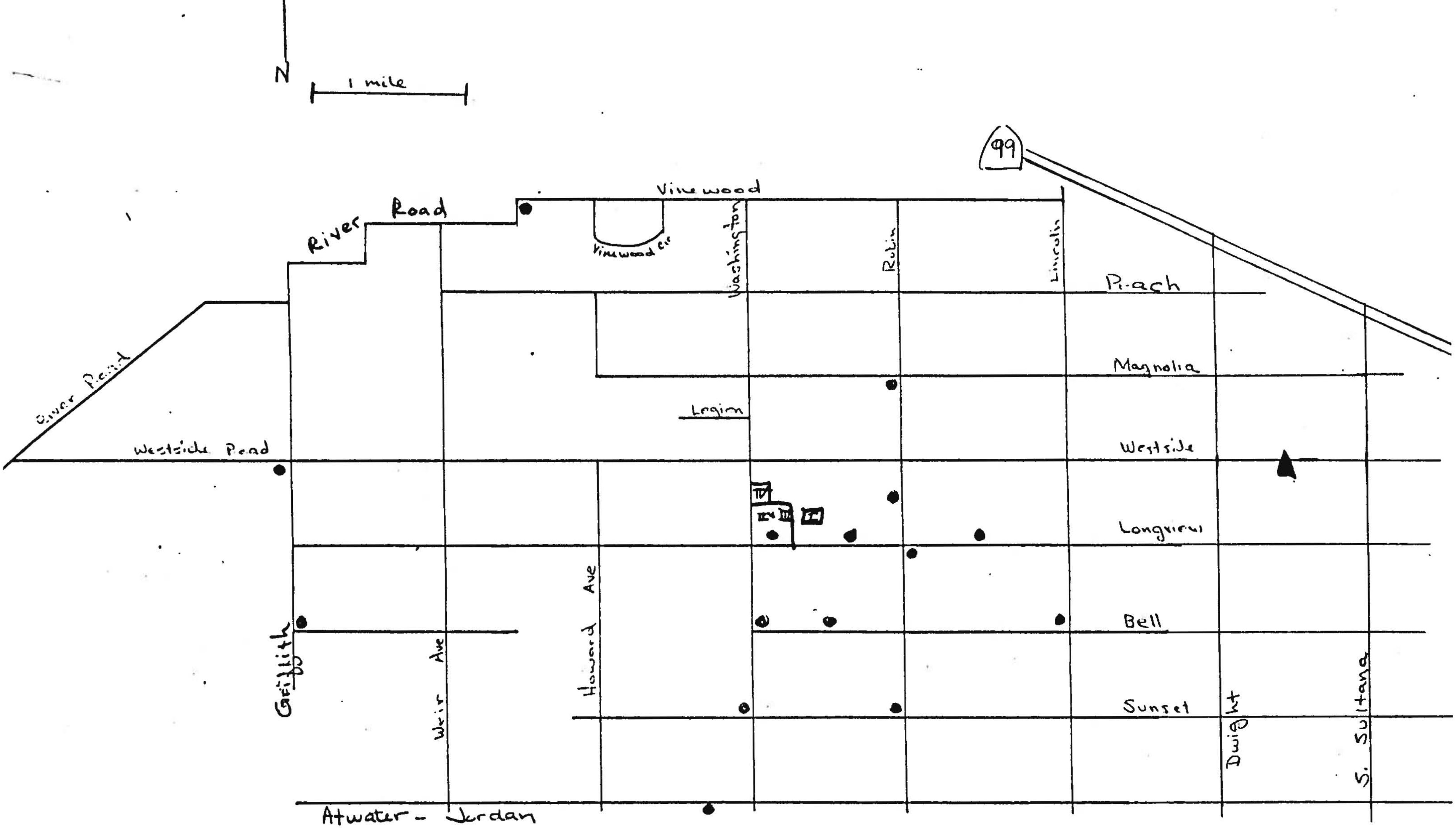
Name	No. and stage slide mounted	Source and collection date	
Typhlodromini			
(but not _M. occidentalis_)	1♀	Abandoned almonds nr. Longview	19 July
Neoseiulus caudiglans	1♀	Sunset & Robin (NW corner) ex colony	19 July
	1♀	Sunset & Washington (NW corner)	19 July
Neoseiulus sp.	2♀	Sunset & Robin (NW corner) ex colony	19 July
	1♀	Robin nr. Livingston I vineyard	19 July
Typhlodromus pyri	1♀	Atwater-Jordan nr. Washington	26 July
Typhloseiopsis sp.	1♀	ex colony from Livingston II&III	15 June
Amblyseius hibisci	7♀	Robin nr. Livingston-I vineyard	19 July
	1♀	Sunset & Robin (NW corner)	19 July
	1♀	Abandoned almonds nr. Longview	19 July
	2♀	Sunset & Washington (NW corner)	19 July
	1	Washington nr. Bell	25 July
	1	Robin & Longview	25 July
	6♀	Griffith & Bell	26 July
	7♀	Griffith & Westside	26 July
	1♀	_T. pyri_ release site	26 July
	3♀	Lincoln nr. Bell	26 July
	3♀	Atwater-Jordan nr. Washington	26 July
	2♀	1/2 mi. east from Washington on Bell Dr.	25/26 July

Table VI-1. (cont'd)

Name	No. and stage slide mounted	Source and collection date	
Amblyseius sp.			
(probably hibisci)	1 imm	Magnolia & Robin (SW corner)	25 July
	1	Robin & Longview	25 July
	1 imm	Longview almonds nr. 14326	25 July
	1♀	Vinewood & River Rd.	26 July
	1 imm	Griffith & Bell	26 July
	4 imm + ♂	Lincoln nr. Bell	26 July
	1 imm	Atwater - Jordan nr. Washington	26 July

1/ See map showing sampling site of M. occidentalis colonies tested for carbaryl resistance for locations.

Fig. VI-1. Survey of almond orchards during July 1983 for M. occidentalis yielded other phytoseiid species as well. The circles indicate sites where phytoseiids other than M. occidentalis were collected. The triangle indicates the *Typhlodromus pyri* release site. Livingston-I, II & III, and IV are indicated near the corners of Washington & Longview.



VII. Spray Trial in Livingston-I with Water, Carbaryl and Permethrin

A spray trial was set up in the Livingston-I almond orchard to compare the effects of carbaryl, permethrin and water on spider mite control in an almond orchard with a carbaryl-OP resistant M. occidentalis strain that was released in the orchard in 1981. By the time the carbaryl and permethrin sprays were applied on July 18, 1983, the predators had already achieved substantial control of the spider mites and densities of both spider mites and predators were very low. An average of 66 spider mite days (SMD) had accumulated prior to the carbaryl and permethrin applications (and see graph for Livingston-I block), despite the fact that only 0.5 lb OWP Omite/acre was applied on June 9, 1983.

A prespray foliage sample consisting of 30 leaves was taken from each of 6 trees randomly assigned among rows 6 and 7 in the northern portion of the block (Fig. VII-1). Each experimental tree was separated by two untreated trees. Immediately after the foliage sample was taken, trees were sprayed with water, carbaryl (5 lb. Sevin 80S/acre) or permethrin (0.2 lb. a.i./acre), using rates that assumed that 400 gallons of tank mix were applied/acre. The trees were sprayed to drip using a handgun with a total of ca. 25 gallons applied to the six trees in each treatment. Postspray foliage samples (30 leaves/tree) were collected on July 26, August 1, 9, 22, and September 6. Foliage samples were chilled, brushed and counted, and the number of active stages of all spider mites and predators were recorded.

Results

Spraying the almond trees with water had no negative impact on spider mite control by *M. occidentalis*. Spider mite densities remained low and the species present remained the same as before the water spray until the last sample date in September, with only 5.8 spider mite days accumulating over the number already achieved prior to July 18 (Fig. VII-2 and Table VII-1). Spider mites in the water-sprayed trees were predominantly *Panonychus ulmi* early in the season, and only a few *Tetranychus* species were found in these six trees after the water spray. These trees had substantial numbers of *Amblyseius hibisci* (up to 50% of the predators) throughout the season and these were believed to be exerting part of the spider mite control.

In contrast, both the spider mite and predator species compositions changed after the carbaryl and permethrin treatments (Figs. VII-3 and 4).

Immediately after carbaryl was applied on July 18, total predator densities were reduced, *A. hibisci* was eliminated and spider mite densities increased to a peak on August 23 (Fig. VII-3, Table 1). Prior to the carbaryl spray, *P. ulmi* had predominated, but afterward, most of the spider mites were *Tetranychus* species. By August 23, the number of *M. occidentalis* had increased dramatically and controlled the spider mites, but not before 121 SMD were added to the 66 SMD already accumulated. Thus, the carbaryl application resulted in a brief spider mite upsurge, probably in part due to the fact that the *M. occidentalis* in this block were not all resistant to carbaryl. Also, since *A. hibisci* was eliminated, their control effort after the carbaryl treatment was lost. Also, carbaryl is known to be stimulatory to spider mite reproduction. Thus, the combination of these factors probably contributed to this upsurge.

The conclusion that carbaryl resistance in _M. occidentalis_ was low is based on a sample of _M. occidentalis_ collected from this block on June 20, 1983. Only 34% survived when tested with 2.4 g a.i./liter water while the carbaryl-OP resistant laboratory strain had a 70% survival rate in the same test and a susceptible strain had a 6% survival rate. Predators in this block were also tested in December 1981 using females collected from bands; these females had a 34 or 68% survival rate, depending upon where they were collected in the orchard. The resistance level in _M. occidentalis_ populations thus is not as high as it could be. This could be due to low selection pressure with carbaryl, or to the fact that susceptible native _M. occidentalis_ are abundant in the area. Carbaryl was applied to Livingston-I twice during 1981 (once before and once after the _M. occidentalis_ release) and once in May 1982. No carbaryl, other than to the 6 trees sprayed for this trial, was applied during 1983 in this block. However, despite the only moderate level of carbaryl resistance in _M. occidentalis_ in this block, this predator did control the spider mites by the last sample date and resulted in substantially less foliage damage in these trees than in the trees treated with permethrin (Table VII-1). _A. hibisci_ populations never did recover in these trees, so contributed nothing to the control effort.

Posttreatment samples of *M. occidentalis* were collected from the six water-treated and 6 carbaryl-treated trees on 23 August 1983. Only four females were found in the postspray water-treated sample, but thirty females were found in the carbaryl-treated colony. The predators from trees treated with carbaryl exhibited an 84% survival rate when tested with 2.4 g. a.i. carbaryl/liter distilled water on sprayed bean leaf discs. This contrasts with 50 and 0% survival for the carbaryl-OP resistant laboratory strain and a susceptible laboratory strain, respectively. The *M. occidentalis* from the water-treated trees had a 4% survival rate. This is substantially lower than the 34% survival rate exhibited from the colony collected from this block on 20 June 1983. This may be due to the small sample size (4 females) of the 23 August sample. This test indicates that a single field selection with carbaryl can dramatically increase carbaryl resistance in an orchard population, in this case from 34 to 84% survival using a standard test. Thus, interbreeding of the resistant strain with susceptible native predators can reduce resistance levels, but these can be increased again with a field selection.

M. occidentalis and *A. hibisci* populations were decimated in the trees treated with permethrin and they never really recovered (Fig. VII-4). Spider mite populations exploded and a total of 277 SMD were added to the 66 accumulated prior to July 18; this damage was due primarily to *Tetranychus* species. Foliage damage was severe and substantial defoliation occurred in these trees by September. It was possible to walk into the orchard and pick out the permethrin-treated trees from the adjacent unsprayed trees or those treated with water or carbaryl.

Conclusions

This trial documents that the carbaryl-OP resistant strain is giving impressive spider mite control in the Livingston-I almond orchard. Pesticide disruption of the carbaryl-OP resistant predators with permethrin yielded dramatic and statistically significant increases in spider mite densities (Table VII-1). Despite the less than complete level of carbaryl resistance, presumably due to interbreeding with carbaryl-susceptible natives, substantial control was given by *M. occidentalis* within a short time after treatment.

While it is impossible to attribute the spider mite outbreaks in the permethrin-treated trees to predator disruption alone, it seems likely that a major portion of the outbreak can be attributed to this effect since carbaryl is known to have stimulatory effects on spider mite reproduction and yet the carbaryl-OP resistant *M. occidentalis* was able to give better control in the carbaryl-treated trees than in the trees treated with permethrin.

The dramatic increase in carbaryl resistance (34 to 84% survival) in the *M. occidentalis* collected from pre- and post-carbaryl treatments during 1983 shows that carbaryl can be used once every few years without loss of the carbaryl resistance, just as insecticide-resistant pest insect populations don't lose their resistance completely even though they are not exposed to the pesticide for several years.

Table VII-1. Mean number of spider mites in 6 trees treated with water, carbaryl, or permethrin in the Livingston-I almond orchard July 18, 1983.

Sample date	Mean Number Spider Mites (active stages) in Trees Treated with		
	Water	Carbaryl	Permethrin
July 18 - prespray sample	0.23 a[1/]	0.07 a	0.20 a
July 26	0.03 a	0.53 b	0.23 ab
August 1	0.04 a	0.66 b	0.52 ab
August 9	0.04 a	3.46 b	2.55 b
August 22	0.19 a	5.30 ab	10.44 b
Sept. 6	0.13 a	0.14 a	13.17 b

1/ Letters following means in the same row are significantly different ($P < 0.05$) using Duncan's mean separation.

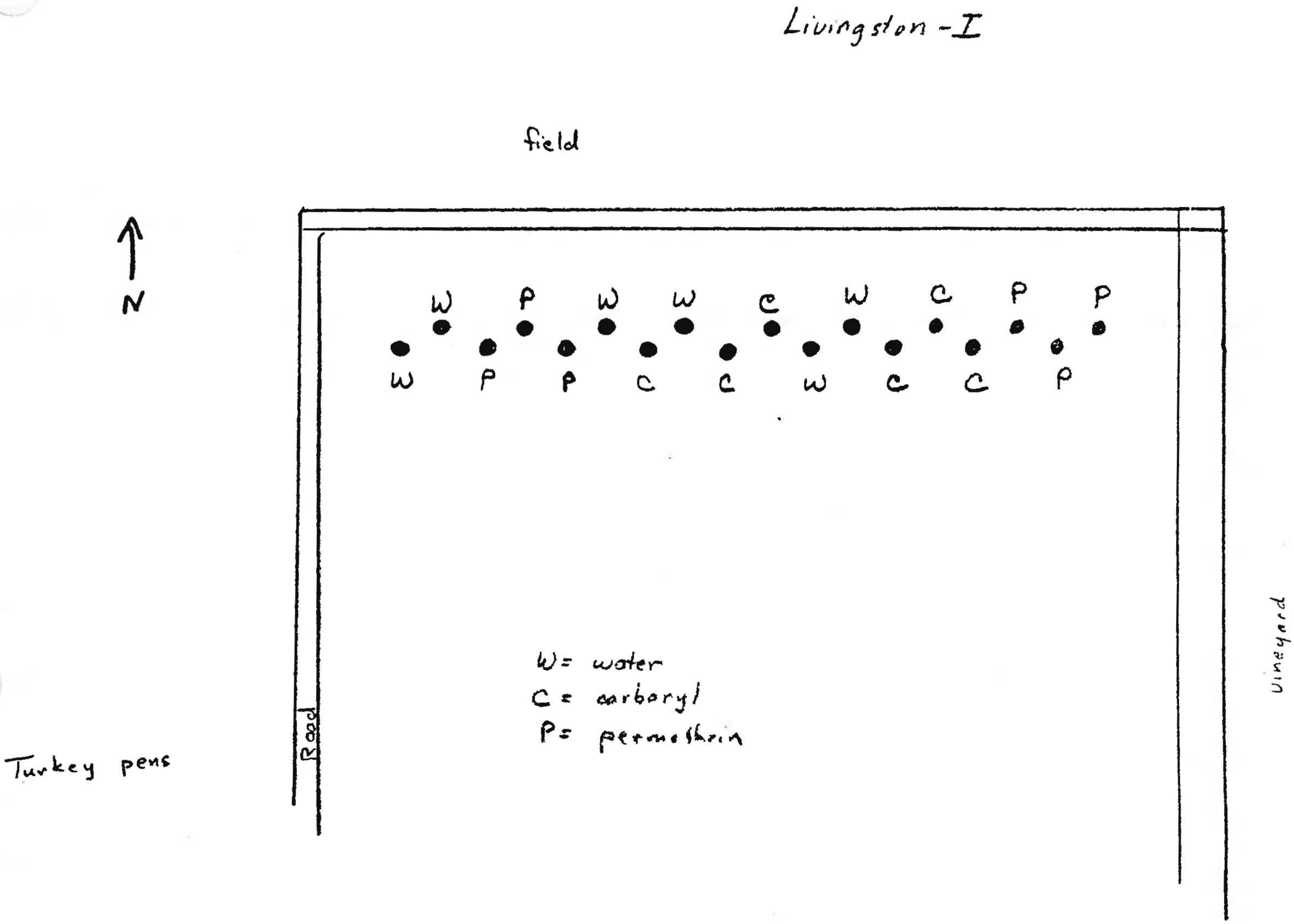


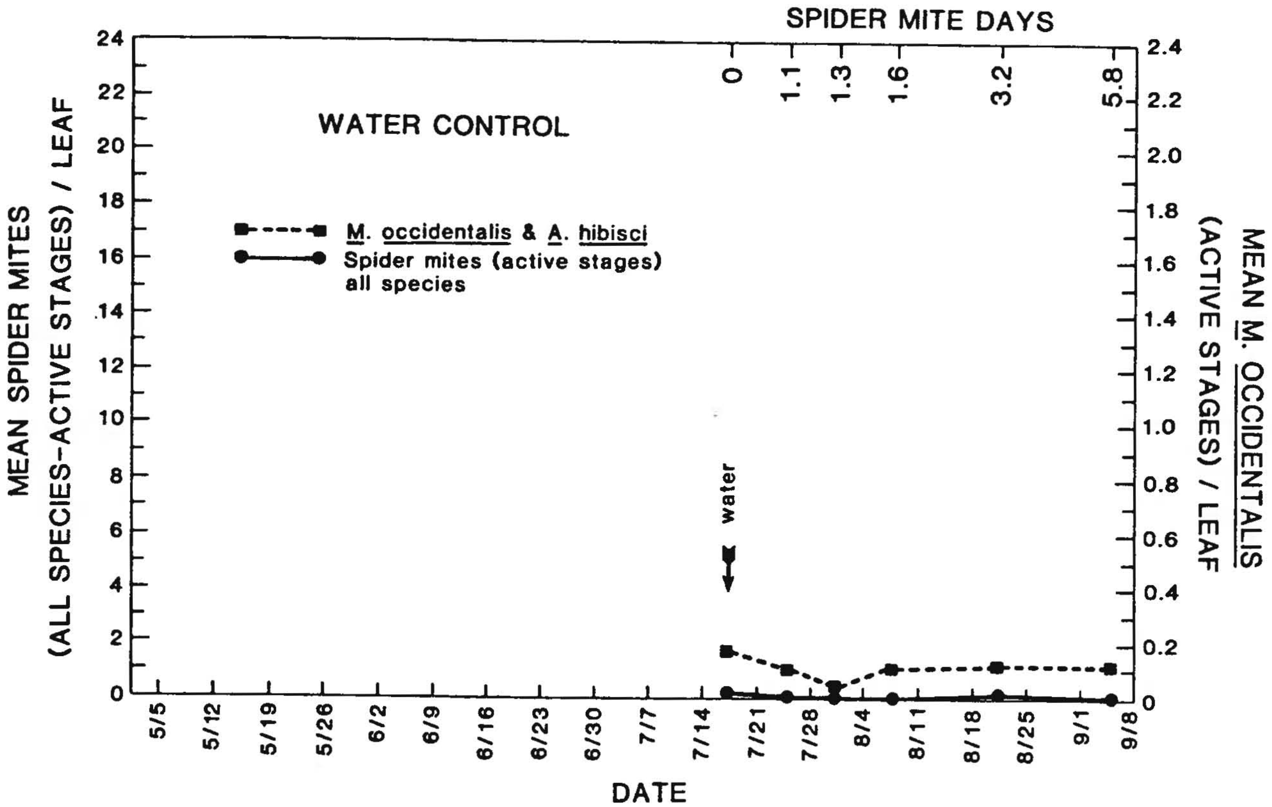
Fig. VII-1. Map of the trees treated with water (w), carbaryl (c) or permethrin (p) in the Livingston-I almond orchard July 18, 1983.

Figure legends.

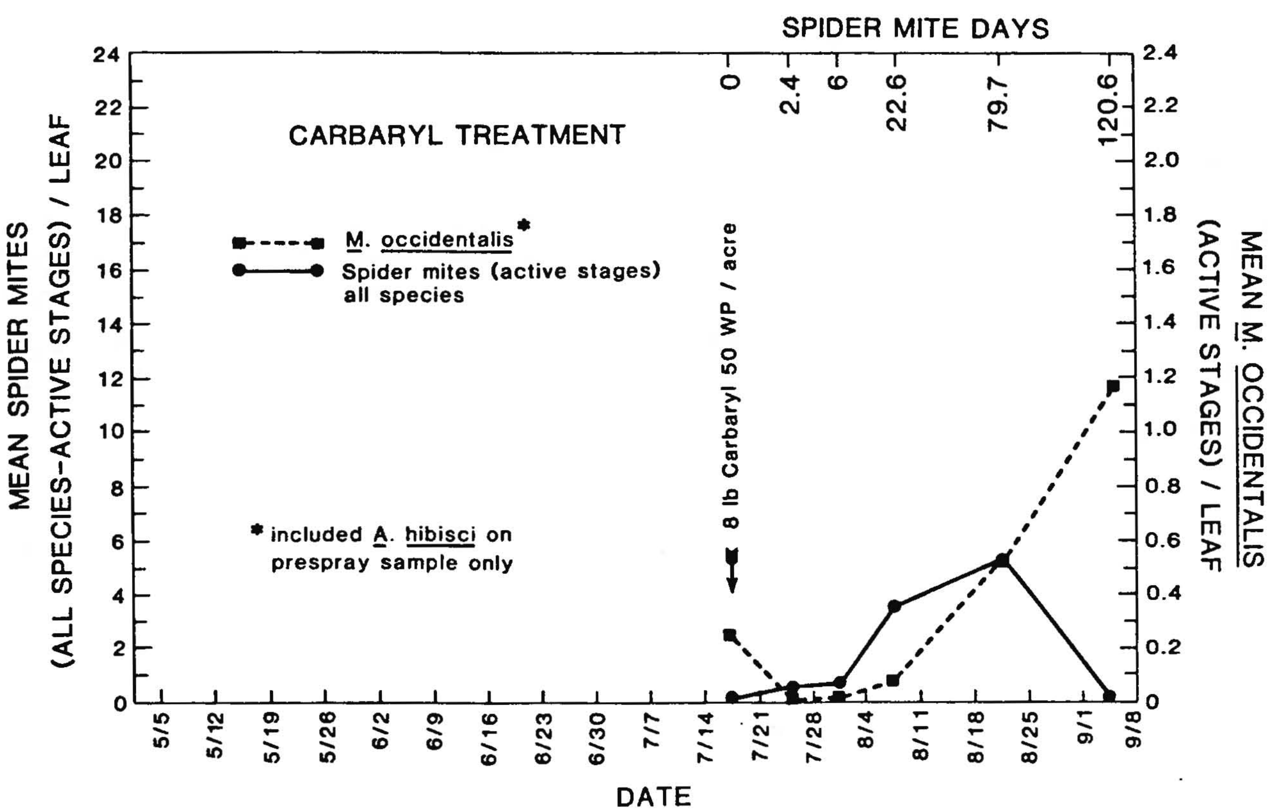
Fig. VII-2. Mean (active stages) spider mites and predators/leaf in the 6 almond trees sprayed with water July 18,1983 in Livingston-I. Spider mite days accumulated after the water spray are shown at the top of the graph.

Fig. VII-3. The legend is the same except that carbaryl was applied

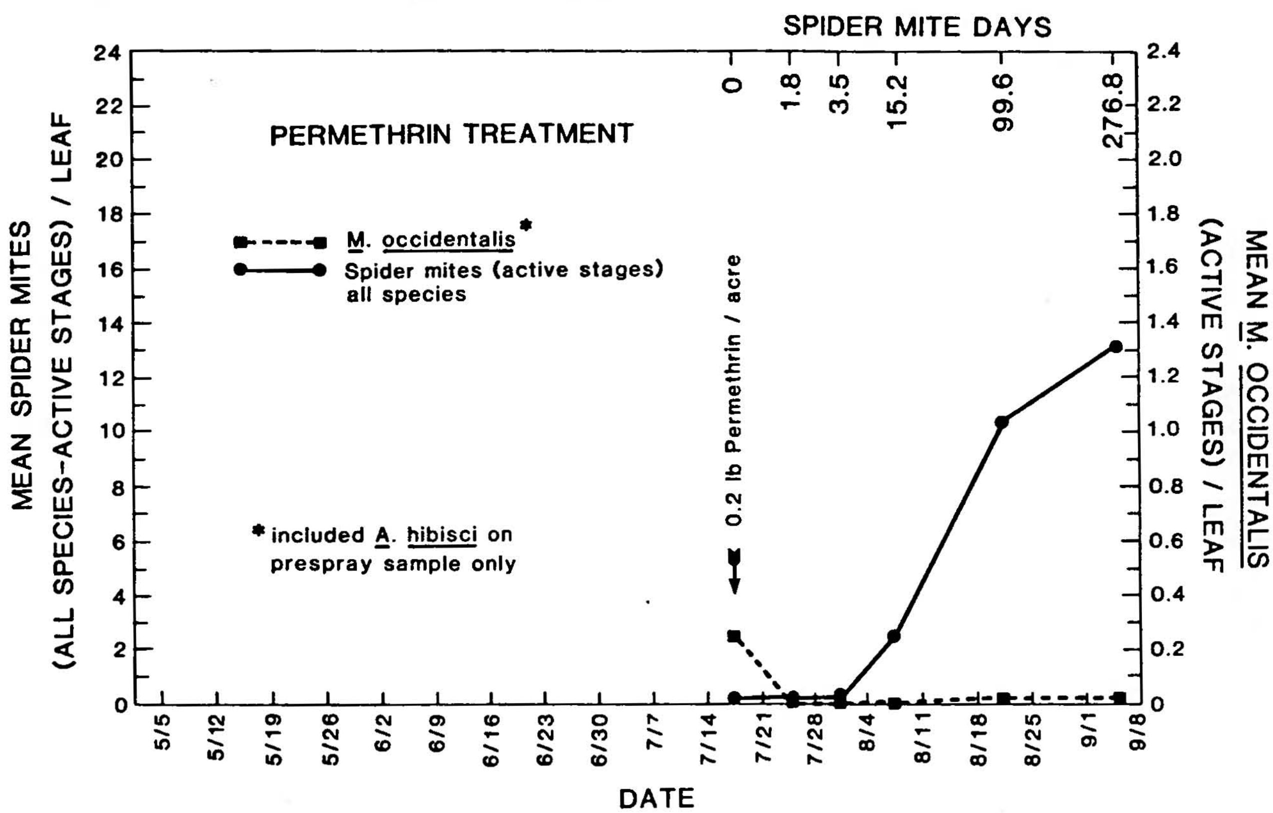
Fig. VII-4. The legend is the same except that permethrin was applied.



SPIDER MITE DAYS
0
1.1
1.3
1.6
3.2
5.8
WATER CONTROL
M. occidentalis & A. hibisci
Spider mites (active stages) all species
water
MEAN SPIDER MITES (ALL SPECIES-ACTIVE STAGES) / LEAF
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
DATE
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8



SPIDER MITE DAYS
0
2.4
6
22.6
79.7
120.6
CARBARYL TREATMENT
M. occidentalis*
Spider mites (active stages) all species
* included A. hibisci on prespray sample only
8 lb Carbaryl 50 WP / acre
MEAN SPIDER MITES (ALL SPECIES-ACTIVE STAGES) / LEAF
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
DATE
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8



SPIDER MITE DAYS
0
1.8
3.5
15.2
99.6
276.8
PERMETHRIN TREATMENT
M. occidentalis*
Spider mites (active stages) all species
* included A. hibisci on prespray sample only
0.2 lb Permethrin / acre
MEAN SPIDER MITES (ALL SPECIES-ACTIVE STAGES) / LEAF
MEAN M. OCCIDENTALIS (ACTIVE STAGES) / LEAF
DATE
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8

Typhlodromus pyri Rearing and Releases

A *T.pyri* colony that is tolerant of carbaryl and resistant to organophosphorus insecticides was obtained while I was in New Zealand in July 1982. After the colony was released from the Division of Biological Control's quarantine facility in Albany, we worked on various methods of rearing this predator. It will feed on pollen, European red mite, and *Tetranychus* mites, but has usually been associated with European red mite in the field. However, since ERM is difficult to maintain in large numbers in the laboratory or greenhouse, we have reared this predator with a combination of pollen and *T.urticae* eggs. *T.pyri* does not like dense spider mite webbing, and thus *T.urticae* eggs alone are provided. Presently, we are rearing this species on paraffin-coated paper discs and adding prey and pollen to the disc. Large scale rearing on pinto bean plants has been attempted, but has not been effective to date, probably due to the webbing that develops when *T.urticae* populations become dense.

Releases into orchards during 1983 were small due to limited numbers available. We reared enough to release into four sites during 1983: an almond orchard near Livingston (Sherman Kishi Ranch, 0.5 mile east of Dwight on Westside Blvd, Livingston, 200 females in 8 trees on 6 June 1983 in NW corner of orchard), another Livingston almond orchard (Livingston-IV, Mr. Horton's orchard near Westside & Washington, 200 females into 12 trees on 20 June 1983), an apple orchard near Watsonville (released by C.Pickel), and an apple orchard (Mr. Delfino's orchard) near Placerville. The orchards were checked several times during the season to determine if prey (ERM) were present. All growers agreed to avoid acaricide applications in the release area prior to the release. Two cloth bands were placed on release trees in the 2 almond orchards to sample for *T.pyri* during the winter.

Results

The Kishi almond orchard release site had no ERM left on July 26 and spray residues were present on the leaves. Samples of predators did not provide any *T.pyri* during the season. These trees were banded and the bands will be recovered during late November/early December to determine if *T.pyri* are present. If none are found, we will be unable to resolve whether establishment has occurred. Both *M.occidentalis* and *A.hibisci* are present in this release site and they could have excluded *T.pyri*. The lack of prey at the end of the season, due to an unscheduled acaricide application, was unfortunate and could explain the low densities.

No *T.pyri* were recovered from the Livingston-IV almond orchard during the season, but bands will be sampled during the winter. The apple orchard sites in Placerville and Watsonville also failed to yield *T.pyri* in foliage samples.

IX. Resistance levels in M. occidentalis recovered from almond orchard release sites.

During May and June 1983, M. occidentalis was collected from the following California almond orchards where carbaryl-OP or carbaryl-OP-sulfur resistant strains had been released: Livingston I, II & III, IV, V, Sumner-Peck (Three Rocks), Wasco (Weddle), and Bidart's (Bakersfield) (see also Table IX-1 for details).

These predators were colonized and numbers increased before laboratory testing with 2.4 g. a.i.carbaryl/liter distilled water. Adult gravid females (5/disc, 8-10 replicates per colony) were placed on bean leaf discs and sprayed with carbaryl. Survival was assessed after 48 hours at 25 - 27C. In addition, 20 females from each colony were sprayed with distilled water as controls but since survival was always 95-100% these are not reported in Table IX-1.

Results

Survival of the recovered M. occidenatlis colonies ranged from 2 to 76%. Survival rates for the carbaryl-OP resistant laboratory colony tested at the same time as a control ranged from 70-78% while a carbaryl-susceptible laboratory colony exhibited 5-6% survival.

All colonies but the Livingston V site indicated moderate to strong levels of carbaryl resistance. The very low carbaryl resistance in the Livingston V colony (2%) could be due to the fact that the predators were released in August 1982 without any carbaryl treatments preceding the release: the sample was taken in June 1983, and because relatively few were sampled it is possible only natives were collected since resistant

M. o. were released into every third row only.

The Bidart (Bakersfield orchard) results are particularly interesting. These predators were released in August 1979 into a small segment of the block. Carbaryl was applied during July 1979 (prior to the release) to part of the block only during July 1980. No carbaryl was applied to this orchard during 1981, 1982 or 1983. The very high rate of resistance (76% survival) in this sample taken in 1983 is remarkable, and suggests that the carbaryl resistance can persist for lengthy periods in the field without selection with carbaryl. It is unlikely that movement into this block by susceptible *M. occidentalis* is occurring at a high rate.

Besides evaluating colonies recovered from foliage, three other colonies were tested. During the fall trees were banded in most of the almond orchards monitored during 1982. These bands were collected on December 7, 1982 and sufficient numbers were found in the Deniz (Madera), Wasco, and Livingston-III black cloth bands to initiate colonies. These were tested with carbaryl as described above. All three orchards have good levels of carbaryl resistance (Table IX-2), ranging from 60-78% survival. The results for the Livingston-III and Wasco orchards are remarkably similar (77 vs. 74% survival and 60 vs. 62% survival), suggesting that our assays are good predictors of resistance levels (Tables IX-1 and 2).

Conclusions

Despite the fact that annual treatments with carbaryl did not occur the carbaryl resistance levels in the almond orchard release sites are holding up very well. This means that carbaryl could be used once every two or three years without creating substantial spider mite outbreaks. As was reported in Section VII, even where carbaryl resistance is only moderate (34% in Livingston-I), the surviving predators were able to control the spider mites after 6 trees were treated with carbaryl in July 1983.

Table IX-1. Laboratory screening to determine relative carbaryl resistance levels in M. occidentalis colonies recovered from release sites during May-June 1983.

Sample site	Predator release date	Year and no. post release carbaryl sprays[3/]	No. individuals collected in 1983	% survival[1/]
Livingston I	June 1981	1981-1	4♀ + 5 imm/♂	34
		1982-1		
Livingston II+III[2/]	Sept 1981	1982-2	39♀ + 32 Imm/♂	74
	May 1982			
Livingston IV	August 1982	none	4♀ + 5 imm/♂	72
Livingston V	August 1982	none	17♀ + 15 imm/♂	2
Sumner-Peck	July 1981	1981-1	5♀ + 4 imm/♂	68
		1982-1		
Wasco	May 1981	1982-1	?	62
Bidart's	August 1979	1980-1	2♀ + 1 egg	76
Controls: Carbaryl-OP resistant laboratory colony				70-78
Carbaryl-susceptible laboratory colony				5-6

1/ Adult gravid females (40-50) were placed on bean leaf discs, 5♀/disc, and sprayed with carbaryl (2.4g AI/liter distilled water). Survival was scored after 48 hours. In addition, 20 females of each colony were sprayed with distilled water; the survival was always 95-100%, so is not reported here.

Table IX-1. (cont'd)

2/ Predators were released into Livingston II in September 1981. Block III is adjacent to II; since resistant predators were released into III in May 1982 these blocks were monitored and sampled as a single unit during 1983.

3/ No carbaryl was applied to these orchards during 1983.

Table IX-2. Laboratory screening to determine carbaryl resistance levels in overwintering *M. occidentalis* colonies recovered from release site tree bands on December 7, 1982.

Sample site	Predator release date	# individual ♀♀ collected from bands	# ♀♀ tested	% survival[1/]
Deniz (Madera	July 1981	15	50	78
Wasco (Weddle)	May 1981	35	50	60
Livingston-III	May 1982	2	30	77
Controls:	Carbaryl-OP resistant lab. colony		50	42
	Carbaryl susceptible lab. colony		50	2

1/ Adult gravid females were placed on bean leaf discs, 5♀/disc, and sprayed with carbaryl (2.4 g a.i./liter distilled water). Survival was scored after 48 hours. In addition, 20 females of each colony were sprayed with distilled water; these always demonstrated 90-100% survival.

X. Survey for resistance to carbaryl, permethrin and sulfur in native *M. occidentalis* from almond orchards.

Native *M. occidentalis* were collected from various almond orchards and tested for organophosphorus (OP) insecticide resistance levels using azinphosmethyl (Guthion) in a slide dip test. The results were reported in 1982 but summarized again here in Table X-1 and Fig. X-1. There were substantial differences in OP resistance levels in these native populations which would make it difficult for a pest manager to predict the impact of an OP application on spider mite control in an orchard unless there is specific information of the impact of previous OP applications.

Four of the colonies that were collected from almond orchards during August 1982 were tested during the winter of 1983 to determine their resistance/tolerances to sulfur, carbaryl and permethrin (Table X-2).

Results

None of the four colonies tested are resistant to permethrin. Survival ranged from 0-4% as compared to 64% survival of the resistant laboratory strain (Table X-2). This lack in resistance was expected, as detectable levels of permethrin resistance have never been found in California populations previously.

The four colonies gave 0-10% survival with carbaryl, as compared to 42% with the carbaryl-resistant laboratory strain in this test (Table X-2). The 10% survival rate of the Madera county colony is unexpectedly high, as previous field colonies have never exhibited such high survival rates with carbaryl. Possibly this colony was collected near sites in Madera county where carbaryl-resistant M. occidentalis have been released. This collection site is 2.5 miles north of the Deniz almond orchard (located at Avenue 18 and Road 20) where carbaryl-OP resistant predators were released in July 1981. The 0-4% survival rates exhibited by the other colonies are sufficiently low that it is unlikely that carbaryl resistance is present in these colonies.

The four colonies are variable in their responses to sulfur, with survival of larvae ranging from 24-78% (Table X-2). Since the susceptible laboratory colonies typically have 20-22% survival rates at this dose, the Los Banos colony with its 24% survival rate is probably not sulfur resistant. This almond orchard is not located near any vineyards. Colonies from the Brawley (SE of Manning) site in Fresno county and the Golden State and Road 20 site in Madera county had 78 and 74% survival rates. These orchards are both surrounded by numerous vineyards. Sulfur resistance has been found in San Joaquin Valley vineyards in previous surveys, but not in apple or pear orchards. These almond orchards have populations of M. occidentalis with usable levels of sulfur resistance. The Livingston (Merced county) almond orchard colony exhibited only 38% survival -- a low level of sulfur resistance. This orchard is located in an area with some vineyards in the area, but fewer than the Madera and Fresno county sites All four orchards had moderate levels of OP resistance (Table X-1).

Conclusions

Low to high levels of sulfur resistance exists in three of the four *M. occidentalis* colonies obtained from sites with numerous vineyards in the surrounding area. There is no detectable permethrin resistance in native *M. occidentalis* populations tested to date from almonds - or other crops. It is unclear if there is carbaryl resistance in the Golden State & Road 20, Madera county colony. If this colony is partially resistant, the reasons for the carbaryl tolerance/resistance could be due to natural resistance or to the fact that laboratory-selected resistant predators were released into surrounding orchards in the past.

Table X-1. LC_{50} values for M. occidentalis colonies tested for Guthion resistance - Fall, 1982 using a slide dip technique.

Colony	No. tested	LC_{50} a/	95% limits	LC_{90}	95% limits
Modesto almonds	598	8.69	-	22.77	-
Steffans almonds	599	1.21	-	105.03	-
DeFreitas almonds	698	10.33	-	240.92	-
Wasco almonds	498	2.48	1.39-3.45	8.79	5.75-26.34
Sumner-Peck Ranch	620	4.42	2.45-7.60	39.68	18.09-266.94
Sunset & Dwight	500	3.04	1.41-4.60	18.64	10.04-134.65
Brawley & Manning	600	3.25	1.63-6.51	43.12	15.03-1702.62
Golden State & Rd. 20	600	4.49	3.35-5.32	8.64	6.93-15.38
Los Banos	496	2.75	1.39-5.03	16.02	7.52-204.30
Carbaryl-OP-sulfur	600	6.57	4.25-9.18	22.81	14.22-93.34
Raven vineyard	500	6.46	-	24.89	-

a/ lbs. active ingredient azinphosmethyl/100 gallons water.

Table X-2. Native *M. occidentalis* collected in August 1982 from almond orchards and tested for resistance to sulfur, permethrin and carbaryl.

Colony source	% survival when treated with		
	permethrin[1/]	carbaryl[2/]	sulfur[3/]
9200 Brawley, southeast of Manning Fresno county	2	4	78
Los Banos, Hwy 152 & Rd. 6, Merced county	4	4	24
Golden State & Rd. 20, Madera county	0	10	74
Sunset & Dwight, Livingston Merced county	0	0	38
Controls			
Relevant resistant lab. colony	64	42	82
Relevant susceptible lab. colony	0	2	22
Test colonies - water only	95-100	95-100	85-95

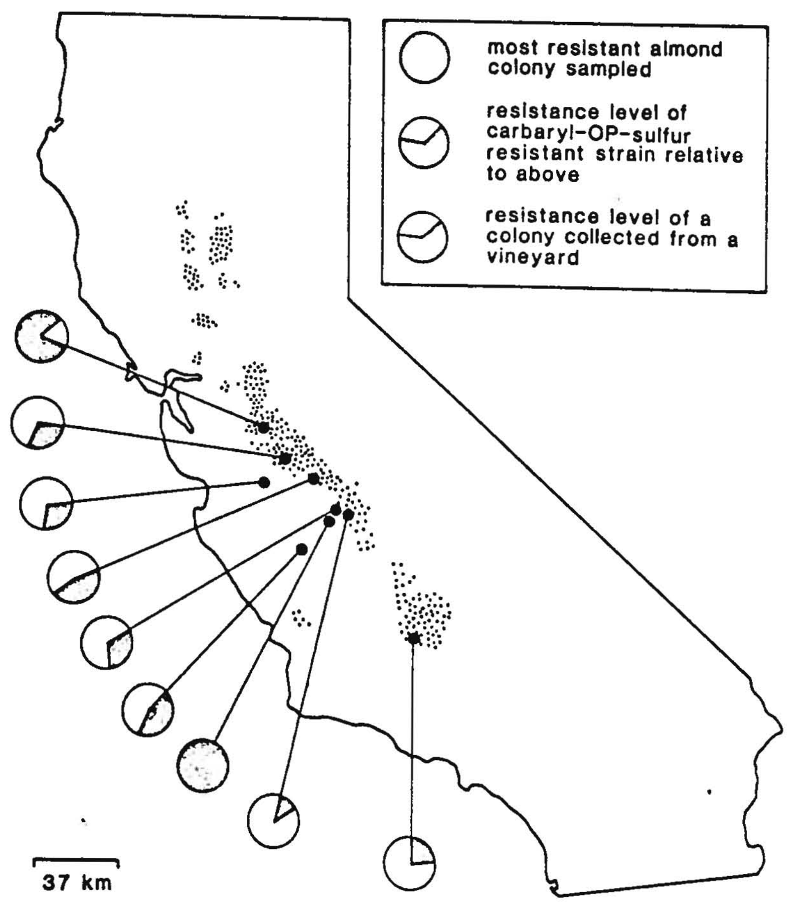
1/ Fifty gravid females (10/disc) were placed on bean leaf discs and sprayed with 2 g a.i. permethrin/100 liters distilled water (Pounce 3.2 EC).

2/ Fifty gravid females (5♀/disc) were placed on bean leaf discs and sprayed with 2.4 g. a.i. carbaryl/liter distilled water (Sevin 50 WP).

3/ Fifty larvae (10/disc) were placed on bean leaf discs dipped in sulfur (2 pts/100 gallon THAT flowable). Survival to the nymphal stage was determined after 48 hr. at 25-27°C.

Figure X-1

Distribution and abundance of almonds in California are indicated by the small black dots, which represent 100 acres of almonds. The shaded circles represent colonies of native M.occidentalis collected from almond orchards. The fully shaded circle represents the colony with the highest LC 50 value for azinphosmethyl using a slide dip method. The proportion shaded in the other circles indicates their resistance levels relative to that colony. The box contains relative resistance levels of the carbaryl-OP-sulfur resistant laboratory colony and a native colony from a commercial vineyard for comparison.



Screening additional pesticides used in almonds for toxicity to *M. occidentalis*.

Thiodan, Supracide, Vendex, and Dithane are registered for use in almonds, and we have received queries regarding the toxicity of these materials to native *M. occidentalis* and to the carbaryl-OP-sulfur resistant strain of *M. occidentalis*.

Adult females of the carbaryl-OP-sulfur resistant strain, the native colony from DeFreitas almond orchard, and from the Wasco almond orchard were tested with the "field dose" of: Thiodan, Supracide, Vendex, and Dithane. Diazinon and Imidan (phosmet) were also tested at the same time, as a control. The following doses were sprayed on bean leaf discs as the "field dose:" after adult females were placed on the discs, 5/disc Supracide (1 qt 3.2 EC/100 gal water); diazinon (1.0 lb 50 WP/100 gal water); Imidan (1.0 lb 50 WP/100 gal water); Thiodan (1 qt 3 EC/100 gal water); Vendex (1/4 pt/100 gal water); and Dithane (2 lb 8 WP/100 gal water).

One hundred carbaryl-OP-sulfur resistant females were tested at the field dose; 20 females from the DeFreitas and Wasco colonies were tested at the same dose, and 20 females from each colony were used as water controls.

RESULTS

Thiodan is very toxic to all the colonies tested, with only 5% survival observed on the leaf discs after 48 hours. Vendex has low toxicity to all the colonies tested, with survival ranging from 60-85%. Dithane is not toxic to any of the colonies tested, with survival ranging from 90-100%. Supracide was very toxic, with 0% of the predators surviving. It was also toxic to the spider mites (T. urticae) on the test leaf discs, and all active stages were killed by Supracide. Diazinon, as expected, exhibited very low toxicity to the colonies tested; survival ranged from 78-90%. Imidan also was not toxic to the predator colonies tested, with survival ranging from 85-100%. Imidan also exerted high levels of mortality on the T. urticae present on the leaf discs.

CONCLUSIONS

The carbaryl-OP-sulfur resistant colony can be treated with the following materials without substantial mortality: Guthion (azinphosmethyl), diazinon, Imidan (phosmet). Omite (propargite), Plictran (cyhexatin), Vendex (hexakis), Dithane (maneb), sulfur (dusts, wettable powders, or flowable), Sevin (carbaryl), Benlate (benomyl), and Baygon (propoxur).

The following pesticides are highly toxic to the carbaryl-OP-sulfur resistant strain: Ambush/Pounce (permethrin); malathion; Orthene; Supracide; and Thiodan. (Others may also be toxic.)

A graduate student working in my lab, Ross Field, evaluated the effects of these pesticides on the carbaryl-OP resistant strain of M. occidentalis as well: Pirimore (pirimicarb); Pentac (dienochlor); Triforine; Parnon (parinol); Pipron (piperalin) and Plantvax (oxycarboxin). Of these, he felt that Pirimor, Thiodan, Pentac, Triforine, Parnon, Pipron, and Plantvax were relatively nontoxic to the carbaryl-OP resistant strain of M. occidentalis. The discrepancy in his results and ours for Thiodan are unclear. Thiodan will be tested further to clarify this.

MITE MANAGEMENT GUIDELINES

The draft mite management guidelines were written during the winter of 1982-83 based upon our experiences with pesticide-resistant M. occidentalis over the course of several years. The purpose of the guidelines is to predict at which point M. occidentalis can no longer keep spider mite damage below our working threshold (currently 120-130 spider mite days, SMD). At this point the guidelines then suggest the application of different rates of acaricide, depending on the number of predators present and their ratio with respect to spider mites. These guidelines were tested in all of the orchards we monitored during 1983.

The guidelines, and the threshold on which they are based, were developed with Tetranychus spp. as the major spider mite pest. The 1983 season was unusual because 6 our of 7 of our orchards were predominately populated by European red mite. However, the guidelines still worked well in all cases where the grower followed our recommendations. The Livingston I, III, IV, V and Weddle-Wasco orchards were treated with one-half or 1 lb of Omite 30 WP (Livingston-I = 0.5 lb.) in accordance with the guidelines and required no additional acaricide treatments for the season. Mite control was better in each of these orchards than in the previous 2 seasons when more applications and higher rates of acaricide were applied.

Sumner-Peck Ranch

The Sumner-Peck Ranch had the highest European red mite populations of any orchards samples during the 1983 season, and portions of this block were defoliated.

On our second sampling date (May 9) the number of mites in northeast cluster was high and close to the level that would result in a treatment decision based on our guidelines. (This was because nearly 20 SMD had accumulated in a single count period, and predator mites were so low that control was not expected soon.) Without waiting further, we recommended 1 lb. Omite 30 WP/acre on May 11. At this time, the southern half of this block had non-threatening levels of ERM.

Our recommendation was not heeded. The grower's PCA had not had ERM problems in this block before and was convinced, based on his previous experiences, that ERM was not a pest. On May 16 we sampled again and recommended again that an acaricide be applied. By this time, 71 ERM days had accumulated in cluster 3. The PCA did not visit this orchard until early June, at which time 300+ ERM feeding days had accumulated and defoliation was beginning in the northeast portion of the block. A full rate of Plictran was made in the northern half of the block.

In addition, 2 lb. Omite 20 WP/acre was applied in the southern half of the block to control ERM and peach silver mite. This was unfortunate, since by application time the phytophagous mites in this half of the block were under control by M. *occidentalis* and little damage had occurred. Following these treatments, no significant numbers of phytophagous mites were seen for the rest of the season.

At hullsplit (July 7), despite the absence of phytophagous mites in all counts, another application of acaricide was made. This second application probably disrupted the predator population in the block due to the virtually complete lack of prey during the last two months of the season.

We used the guidelines only moderately well in this orchard because we did not know if they could be applied to ERM. This experience allowed us to learn a great deal about ERM damage. For instance, some 300-400 ERM days were required to initiate defoliation in this orchard; in contrast, our guidelines were written for a SMD budget of 100-120 Tetranychus SMD for a similar level of damage.

Based on our experience in May, we have altered the guidelines so that if 20 ERM SMD, or more, accumulate in a single week and the predator:prey ratio is worse than 1:20, then a treatment of lower-than-label rate should be made using 1 lb 30 WP Omite/acre.

Bidart's - Bakersfield

The Bidart almond orchard was unique during 1983 in that it was the only block that we managed where European red mite was not present in significant numbers. The spider mite population here was composed almost entirely of Tetranychus pacificus.

The tetranychid population began rising at Bidart's, at a relatively slow rate, in late May. In mid-June, starting in the northern half of this bloci, the spider mite population rather rapidly reached outbreak status. On June 20, our guidelines recommended application of 2 lb. Omite 20 WP/acre. This recommendation was initiated because the mean spider mites/leaf in the area around cluster 4 had shown an increase for four consecutive weeks and the predatory mites, while present, were clearly not at a level that would soon result in biological control. At the same time, 15 SMD accumulated during a single week in cluster 3. This level of SMD is very close to our treatment threshold level of 20 or more SMD within one week.

The actual treatment was delayed by one week. Because of this delay, and the high rate of increase visible in the spider mite population, the acaricide rate to be applied was increased. On 27 June, 0.75 lb Plictran 50 WP/acre was applied to this block by helicopter. By the next count (July 5) the spider mite population had fallen off and a 1:10 predator:prey ratio had been attained. The predator:prey ratio continued to improve throughout July and spider mites were maintained at insignificant levels by predators from July 12 to the end of the season.

In summary, the guidelines worked well here and a treatment was applied when, in fact, it was needed. In view of the rapid growth of the Pacific mite population, timely treatments are a must when using lower-than-label rates of acaricides. A delay of more than 7 days between recommendation and application would require higher rates of acaricide to achieve the same level of control.

Wasco-Weddle

The 1983 season began quite early in this block. Prior to our first sample on May 2, the European red mite population had emerged and was numerous. By the second count, the predator-prey ratio suggested the need for a treatment, but the guidelines were not clear in this instance because they were not designed with ERM in mind. However, the density of ERM and the predator:prey ratio indicated that a treatment would probably be needed. Treatment was suggested by the guidelines on May 15, based on the assumption that ERM SMD is equivalent to Tetranychus SMD. In any event, we did not wait for the May 15 count but immediately issued a recommendation for 1 lb Omite 50 WP/acre on May 11 because the predators were present but unlikely to give rapid control. The use of lower-than-label rates for the suppression of ERM was a controversial matter and most of our extension cooperators strongly recommended against it. Despite this, the grower and Farm Advisor, in the spirit of experimentation, went along with the recommendation. The grower applied the spray May 24, roughly two weeks after the recommendation. By the count following the treatment, the numbers of ERM declined, and in the most heavily populated area, a 1:5 ratio of M. occidentalis to ERM was established. Following the treatment, spider mites remained under control for the remainder of the season.

A hullsplit application of 4 lb. Guthion 50 WP/acre was made and no disruption of spider mite control occurred. (The LC_{50} value for the M. occidentalis strain established in this orchard is estimated to be in excess of 12 lb Guthion 50 WP/acre.) This year we showed that lower-than-label rates of acaricide do give suppression of ERM that is similar in effect to that obtained against Tetranychus spp. We believe that, excepting treatments made during periods of abnormally cool early season weather, there is no major difference in the activity of Omite or Plictran against ERM or Tetranychus spp. (Both Omite and Plictran are slow in their action and this delay of activity is enhanced in cool weather.) Because of our experiences in 1983, we have altered the guidelines so that if 20 ERM SMD, or more, accumulate in a single week and the predator:prey ratio is worse than 1:20 in May, then a treatment should be made using 1 lb 30 WP Omite/acre.

One additional point is that timing the application of lower-than-label rates of acaricides within a narrow time frame appears to be less critical with ERM than with Tetranychus spp. A two week delay in application occurred between the time we issued our recommendation and when the application actually took place. Such a delay with Pacific mite, for instance, could have disasterous effects because the rate of population growth is so much more rapid.

Livingston-I

In 1983, shothole was a serious problem in this orchard and was followed by a large ERM infestation. Tetranychus spp. were present throughout the season, becoming rare after the July 12 count, but were never a problem. ERM activity was highest from May 31 to July 12.

The treatment guidelines suggested a treatment was necessary after the June 6 count in cluster 1. This was due to an increasing spider mite population and low predator levels. We immediately recommended application of 0.5 lb Omite 30 WP/acre instead of the 1-2 lb rate suggested by the guidelines. This was done as an experiment because we were interested in the efficacy of this rate.

The treatment halted population increase of ERM but did not reduce the population. However, this provided time for the predator population, and by July 12 the spider mites were clearly under biological control.

Despite the successful employment of the 0.5 lb rate in combination with the predator mites, we have dropped this rate from further consideration because it does not provide enough spider mite suppression.

Over the season, this orchard suffered only light mite damage, averaging 100 SMD. About two-thirds or more of the SMD were due to ERM feeding.

Livingston-II and III

Livingston-III had a mixed population of spider mites composed of European red mite and Tetranychus spp. during the 1983 season. For a number of reasons this block is non-uniform, and we used six sampling clusters to monitor it despite the fact that it is not large.

Early in the season, a high population of ERM developed in the extreme southern region of this block and on May 31 a treatment decision for clusters 1 and 2 was reached based on 3 weeks of increasing spider mites while the predators remained low. Also, more than 25 SMD accumulated during May and there was a poor predator:prey ratio.

This recommendation was disregarded because all of the mite population was ERM. We waited an additional week until we were certain that this ERM population would be damaging if it were left untreated. In the next count on June 6, conditions in both clusters 1 and 2 indicated a treatment was necessary due to 4 weeks of increasing ERM with predator mite populations trailing badly. We recommended that 1 lb Omite 30 WP/acre be applied, and treatment followed within a few days. This application was highly successful and suppressed spider mites so that the predator:prey ratio became 1:10, or better, throughout the block. Spider mites remained under control throughout the block for the rest of the season. Later in the season a small flareup of Pacific mites occurred in the northeast area of the block, but the resident predators brought them under rapid control without the need for an acaricide.

The guidelines functioned better than our own judgement in this block. If 1 lb Omite 30 WP/acre had been applied when the guidelines first indicated a treatment was necessary, less damage would have accumulated, and the wait clearly showed a treatment was necessary.

Livingston-IV

In Livingston-IV we were able to rely entirely on *M. occidentalis* activity for spider mite control. Throughout this season, a mixed population of roughly 50% European red mite and 50% *Tetranychus* spp. was was present.

M. occidentalis trailed the spider mite population until late June, when it became apparent that the predator:prey ratio approached 1:10 and would probably achieve biological control. Despite this, had cluster 1 not shown a decrease in the mean spider mites/leaf in the July 12 count, a treatment would have been recommended because the maximum acceptable number of SMD was exceeded during the preceding week (more than 20).

In this block, the guidelines functioned well when modified to allow increased ERM mite day thresholds. By early June, because of our experiences in the Sumner-Peck ranch, we recognized that twice as many SMD could be tolerated if ERM were present compared to *Tetranychus* SMD.

Livingston-V

Predatory mites were released into this block in August, 1982, and it is not clear that the resistant *M. occidentalis* are present or well-distributed throughout the orchard. This block suffered from a number of soil-related problems and the trees are non-uniform in their growth. Bacterial canker is common and nematode problems are also suspected. Thus, the trees are stressed and have a lower tolerance for spider mite feeding damage.

The spider mite population was composed of both ERM and Pacific mite during 1983. In 3 of the 4 clusters it is highly probable that no treatment for spider mites was needed throughout the season as biological control was achieved from a mixed population of *M. occidentalis* and *A. hibisci*. These 3 clusters accumulated an average 29 SMD for the season.

As early as May 31, a treatment decision was indicated for cluster 4. This was due to increasing spider mites while no predators were present. This site was not treated because insignificant SMD (9) had accumulated. The June 15 count showed a gain of almost 20 SMD in a single week and was the second sample in June in which no predators were found. In fact, no predators were picked up in this area of the orchard until the June 27 count, and we believe that these must have arrived aerially. We suspect that *M. occidentalis* may never have been released into this area. In any event, we recommended a treatment of 1 lb Omite 30 WP/acre based on the accumulated SMD and the total lack of predators in this area. In retrospect, this was clearly a local phenomenon and that small area should have been treated alone rather than the whole block.

The sample program picked up the spider mite problem in cluster 4 early; yet, insignificant SMD accumulated in this site to justify treatment.

Therefore, we are adding another requirement to the guidelines: namely, that at least 20 ERM SMD (or 10 Tetranychus SMD) in May must be accumulated to justify a treatment. Thus, we wish to avoid treating too early (when less than 10 SMD have accumulated over a month). This would have delayed the treatment from May 31 to June 15, when it was clearly needed, as no predators had been found for 6 weeks.

Summary and Discussion

The preliminary mite management guidelines functioned well in 1983. Because they were designed originally for use with *Tetranychus* spp., our guidelines had to be modified for application to European red mite during the 1983 field season because ERM was the principal mite species present in most of our blocks. In six of the seven almond orchards we sampled all spider mite populations were under biological control by hullsplit and remained so for the rest of the season. The exception, Sumner-Peck Ranch, was due to the fact that the guidelines were not followed.

Early season adjustment of the prey:predator ratio minimizes spider mite feeding damage and increases acaricide efficiency if acaricides are required. These guidelines thus represent an evolution from our early work, which was based on waiting as long as possible for the predators to catch up and suppress spider mite populations.

In previous years, it was not uncommon for blocks to become partially defoliated by mid-late season because the predatory mites did not overtake spider mite populations fast enough. Thus, we realized that complete reliance on biological control might not be possible in all almond orchards and we began to experiment with lower-than-label rates of acaricides late in the season in order to reduce foliage damage and attain a more favorable predator-prey ratio earlier. This led to using the predator:prey ratio as a predictive index to estimate when biological control might be expected. We realized that ratios of 1:20 or 1:10 or 1:5 would all yield biological control - eventually. Coupling this with the spider mite mean/leaf, we began to predict whether biological control could be expected before too much foliage damage had occurred.

Our current strategy of acaricide treatments in May or June was born out of this experience. We found that many of our blocks required one acaricide treatment a season, even with *M. occidentalis* present and well distributed, if less than 120 SMD could be tolerated. By treating much earlier than normal, we found that less acaricide resulted in the same level of control than a higher dosage yielded later in the season due to the accumulation of dust and webbing on the surface of the leaves which impairs coverage. Additionally, feeding damage that we normally would have accumulated while waiting for biological control to develop was avoided.

This season, of the six orchards we managed, five had to be treated. Three of these five were treated with 1 lb Omite 30 WP/acre, which is 20% of the lowest label rate. One block was treated with 0.5 lb Omite 30 WP/acre, which is 10% of the lowest label rate. All of our recommendations were made before June 15. At the Bidart orchard, 0.75 lb Plictran 50 WP/acre (75% of the label rate) was used because the treatment could not be made until a week after our recommendation and by this time a higher rate was required. In all cases, except where 0.5 lb Omite was used, the predator: prey ratio was 1:10, or better, within seven days of treatment. Even when hullsplit sprays were made, no spider mite problems developed during the remainder of the season in any of these blocks.

Several modifications or refinements were made to the guidelines based on our 1983 field season. 1) From data acquired at Sumner-Peck, Wasco, and Livingston we were able to develop SMD numbers for ERM (Panonychus ulmi). 2) Additionally, a single count spider mite day maximum was established to trigger a treatment in May for unusually high, unacceptable ERM situations. 3) Another refinement was to add a spider mite day minimum to eliminate unnecessary acaricide applications due to trivial damage accumulation. (Livingston-IV situation).

Time required in the presence-absence sampling mite sampling scheme will vary depending on the size of the orchard and the number of trees to be sampled. However, if at least four trees located in four different areas of the block are sampled, it will require approximately 45 minutes to one hour to walk the orchard and sample the four trees, based on our experiences during 1983. If the same four sites in the orchard are sampled and leaf samples are brushed and counted, we estimate the entire process will require 1.5-2 hours. This is about twice as labor intensive, but provides additional information as compared to the presence-absence system, which does not function well before mid June and can't be applied to ERM populations. Thus, this more complex sampling scheme in our guidelines is one alternative to mite management. Our program requires facilities to brush and count mites. It can be used by PCAs and farm managers with these facilities.

The Basic computer program designed to compute the data necessary for the mite management program is available for use on an Apple II plus system. It should be adaptable to other microcomputers and can be provided to the Statewide IPM computer system for modification, if desired.

In summary, our guidelines functioned well, even in areas where the principal pest mite was European red mite. In all of our orchards mid-late season treatments for spider mites were eliminated because favorable predator: prey ratios had been attained by following the guidelines. We cannot, of course, guarantee that adherence to these guidelines will always result in control of spider mites by hullsplit. However, it is our feeling that, much more often than not, this will be the result.

DRAFT

MANAGING MITES IN ALMOND ORCHARDS DURING 1983

A PROPOSED MANAGEMENT PROGRAM

Marjorie A.Hoy, Darryl Castro and Dan Cahn

The following guidelines outline the monitoring plans for the almond orchards where pesticide-resistant Metaseiulus occidentalis were released during 1981 or 1982. These guidelines are based on our experiences during the 1981 and 1982 field seasons. We hope that less labor intensive monitoring techniques will be finalized during 1983 so that the work required to monitor spider mites and predators in almond orchards will be reduced in the future.

This system uses four criteria as the basis for decisions regarding the necessity for acaricide applications and the rates to be recommended. To make the decisions, we will monitor the orchards each week from May to midAugust. Samples of 10 leaves per marked tree will be taken from at least four clusters of five trees (a total of 20 trees) for each block. The clusters of five trees will be located within the orchard and the edges will not be sampled. Leaf samples will be taken from around the tree (inside and outside) in the bottom half of the tree unless the orchard has sprinklers with a very high set such that the foliage is washed. The leaves sampled from each tree will be kept separately in a refrigerator or ice chest until they can be brushed with a mite brushing machine and counted under a dissecting microscope. The same marked trees will be counted each week. Counts are made of active stages only of spider mites and M.occidentalis.

Recommendations are based on the following factors: A) mean spider mites and predators per leaf, B) predator to prey ratio, and C) a damage index based on "mite days". In addition, the treatment levels have been adjusted depending on whether the treatment will occur in early, mid or late season.

A) Mean spider mites and predators per leaf: these counts are obtained from brushing 10 leaves/tree and counting active stages only of both predators and spider mites. All spider mite species are combinedfor this index. Means from the five trees in a cluster are combined into a single mean for the cluster.

B) Predator to prey ratio: this compares the mean number of spider mites/leaf with that of the predators/leaf to give an idea of the relative population densities. A single ratio is not always definitive, but the ratios obtained in succeeding weeks allow us to predict if spider mites will continue to increase.

C) Spider mite days: this is a damage index based on the cumulative effect of feeding injury to a given almond leaf. One spider mite on a leaf for one day is one spider mite day (SMD). Various SMD values have been reported by researchers as representing critical damage levels. Our experiences during 1982 suggest that defoliation due to spider mites starts after about 120 SMD. However, fewer SMD should be allowed to accumulate in orchards that are under water stress. SMD is calculated by: [($\frac{1}{2}$ X Number of days since last sample) X (current SM mean/-leaf + the SM mean/leaf at the last sample period)] + (the running total of SMD accumulated over the previous weeks).

We don't know if defoliation represents an economic threshold or not, as spider mite induced yield loss in almonds has not been well studied. (M.Barnes has suggested that yield loss begins at 500 SMD; our timing is thus very conservative.) Because the threat of defoliation typically evokes treatments with acaricides by growers, we use it as a working threshold.

The numbers for A, B, and C are on a per cluster basis and are compared to the following guidelines. When the values for two of the four clusters result in a TREATMENT decision, we will recommend that the growerapply an acaricide to the entire block. Spot treatments have not been included in this plan although we believe that early treatments of "hot spots" may be beneficial; the decision to spot treat thus is left to the grower. We need to know if spot treatments occur, when, where, and using what material.

The values for A, B, and C will be sent each week via the IPM computer terminals to the Farm Advisors' offices AS SOON AS POSSIBLE. A specific recommendation will be made by us based on these guidelines. We hope that you will explain these recommendations to the growers, and communicate back with us as to whether the grower agrees with our suggestions. If there are differences of opinion regarding the wisdom of our recommendations, the reasons for these differences should be made explicit so that we can learn from our experiences. We hope we can be in touch more easily this year via the IPM computer.

MAY : We will sample once a week.

Carbaryl should NOT be used to control peach twig borer or NOW in May.

EACH WEEK, after every sample determine if the following conditions exist:

1) IF 25 spider mite feeding days (SMD) have accumulated, AND the prey: predator ratio is greater than 10:1, THEN

TREAT: a) if NO predators, use 1 lb 30 WP Omite/acre or 6.4 oz 6E/acre

b) if LOW predators, use 0.5 - 1 lb 30 WP Omite/acre or 3.2-6.4 oz 6E/acre

LAST WEEK OF MAY: check for these additional situations:

2) If in the preceding 3 samples the mean number of spider mites/ leaf was higher each week than the previous week AND NO predators were detected during this 3 week interval, AND IF during the 3 week period, more than 10 SMD total accumulated,

TREAT: use 1 lb Omite/acre or 6.4 oz 6E/acre

JUNE: We will sample once a week.

After every sample period check to determine if one of the 4 conditions listed below exist. Acaricide treatments may be required at any time. If a hullsplit spray is being planned for NOW, and if an acaricide spray decision is made during the last week of June, delay the acaricide spray until the hullsplit spray is applied and they can be combined.

1) IF at any time for 4 succeeding weeks during May or June the mean number of spider mites/leaf are higher than in the previous week, AND predators are present but the ratio of predators:prey is worse than 1:10,

TREAT: use 1-2 lb 30WP Omite/acre or 6.4-12.8 oz 6E/acre

2) IF conditions described in 1) exist but the predator:prey ratio is in the range of 1:5 to 1:10, then

TREAT: use 0.5-1 lb 30 WP Omite/acre or 3.2 - 6.4 oz 6E/acre

3) IF after any 2 counts in June, the mean number of spider mites/ leaf is higher than in the previous week, AND NO predators are present, then

TREAT: use 1 lb Omite/acre or 6.4 oz 6E/acre

4) IF 20+ SMD accumulate in a single week interval, and

a) IF predator:prey ratio is better than 1:10,

TREAT: use 1 lb Omite/acre or 6.4 oz 6E/acre

b) IF predator:prey ratio is worse than 1:10,

TREAT: use 2 lb Omite/acre or 12.8 oz 6E/acre

JULY: We will sample each week.

IF SEVIN is applied, add 1-2 lb 30 WP Omite unless *M.occidentalis* has already brought the spider mite population under control (ratio less than 1:5).

Permethrin should not be used for NOW control, as it kills *M.occidentalis* and often causes spider mite outbreaks.

Guthion, diazinon or Imidan can be safely used for NOW according to label recommendations without killing *M.occidentalis*. Use acaricides as directed by BEFORE HULLSPLIT guidelines.

If NO NOW sprays are being used, then acaricide applications can be made at any time during July, according to the following guidelines.

BEFORE HULLSPLIT, check to see if conditions 1-3 apply.

1) a) If 50+ SMD have accumulated AND the predator ratio is worse than 1:10, then

TREAT: use 2 lb 30 WP Omite/acre or 12.8 oz 6E/acre

b) IF 1 a) is true BUT the predator to prey ratio is in the range of 1:5 to 1:10, then

TREAT: use 1 lb Omite/acre or 6.4 oz 6E/acre

c) IF 1 a) is true BUT the predator to prey ratio is better than 1:5,then DON'T TREAT.

2) a) IF in the first week of July less than 50 SMD have accumulated, AND the predator:prey ratio is worse than 1:10, then

TREAT: use 1 lb 30 WP Omite/acre

b) If a) above is true but the predator: prey ratio is better than 1:10, then DON'T TREAT

3) IF in the first week of July less than 50 SMD have accumulated and NO hullsplit sprays will be made, DON'T TREAT.

AFTER HULLSPLIT

1) If more than 20 SMD have accumulated in a single week, then

TREAT: use 1 lb Omite 30 WP/acre or 0.25 lb. Plictran 50 WP/acre

2) IF at any time for 4 weeks in a row the mean number of spider mites/leaf is higher than the previous week's value AND the predator to prey ratio is worse than 1:10,

TREAT: use 1 lb Omite/ 0.25 lb Plictran/acre

AUGUS: Sample the first two weeks.

The pre-harvest interval for OMITE is 28 days. For PLICTRAN, it is 7 days.

1) IF total SMD approaches 110-130 AND/OR will pass this value within the next week or two,

TREAT: use 0.5 lb. Plictran/acre by air

2) If SMD are below 100-120 AND/OR not expected to go beyond 120 (100 in water-stressed blocks), DON'T TREAT.

FINAL

MITE MANAGEMENT WITH PESTICIDE-RESISTANT M.OCCIDENTALIS

These guidelines are a revised and updated version of draft guidelines prepared for evaluation during the 1983 season. They have been simplified and expanded to include the European red mite (ERM). The system was designed for almond orchards where pesticide-resistant Metaseiulus occidentalis have been established.

Decisions are based on leaf counts made each week. Mean Tetranychus species, ERM and M.occidentalis per leaf are computed. From these means, predator: spider mite ratios and spider mite feeding days (SMD) are computed. We sampled 4 clusters of trees in each orchard up to 160 acres in size. Each cluster was located approximately 10 rows and 10 trees from a corner and consisted of 5 trees, making a total of 20 trees/orchard. Ten leaves are sampled from each tree. Fifty leaves are brushed with a mite brushing machine and the active stages only are counted under a dissecting microscope. By keeping the 4 counts for each orchard separate, the data can be evaluated separately or can be pooled for the whole orchard. Thus, portions of the orchard can be spot treated, reducing miticide costs by 1/4 or 1/2.

The means, ratios and SMD are computed as follows:

1) Mean mites per leaf. The 50 leaves from each cluster of 5 trees are brushed in a mite brushing machine onto one plate. The active spider mites and predators are each counted and divided by 50 to arrive at mean mites per leaf for each cluster. ERM and Tetranychus species (Pacific and two-spotted mites) are counted separately.

2) Predator:spider mite ratio: This consists of the mean number of Tetranychus species per leaf + mean number of ERM per leaf divided by the mean number of predators per leaf.

3) Spider mite days. SMD corresponds to the area under a plot of the mean mites/leaf vs. time. It gives an approximate measure of the accumulated damage done to foliage by spider mites. Because ERM feeding is less serious, ERM-days are divided by 2. Thus, for each count: SMD = (($\frac{1}{2}$ X number of days since last sample date) X (current SM mean/leaf + the SM mean/leaf at the last sample period)) + (running total of SMD accumulated over the previous weeks). Tetranychus SMD should be computed separately from ERM-days. ERM-days should be divided by 2 and added to Tetranychus SMD to obtain a total figure.

Our threshold for total SMD accumulated during the entire season is 110-130 in well-irrigated orchards. This would indicate the beginning of defoliation, but the point at which yield loss begins may be higher. However, most growers prefer to stop mite damage before defoliation begins and we used this as the maximum amount of damage that could be accrued in developing these guidelines.

A recommendation to treat for one sample site (cluster) is sufficient to elicit a treatment for the entire block. However, if the clusters on one side of the orchard are significantly different from the other side, a spot treatment may be made.

MITE MANAGEMENT GUIDELINES

General: orchards should be sampled once per week from May through July and as necessary after that. Foliage should be brushed and counted. If inseason insecticides are planned, Guthion, Diazinon, Imidan and Sevin are acceptable. Use of Sevin for a May spray is not recommended. Permethrin, Supracide and Thiodan should not be used during the growing season. These guidelines assume a Sevin-OP resistant strain of _M. occidentalis_ is established in the orchard.

A. May: Each week determine if one of the following conditions exist

1.) If 25 SMD accumulated* and if the predator:spider mite ratio is worse than 1:10 then

Treat with 1 lb Omite 30 WP/acre

2.) If 10 SMD accumulate in a single week and predator:spider mite ratio is worse than 1:20 then

Treat with 1 lb Omite 30 WP/acre

Last week of May check these situations:

3.) If for 3 succeeding weeks the mean number of spider mites/leaf is higher than the preceding week and no predators were detected in each sample, and if during the period more than 10 SMD accumulated, then

Treat with 1 lb Omite 30 WP/acre

B. June: If hullsplit treatment is planned, mite treatments recommended at the end of the month may be postponed and made with insecticide spray. Each week determine if one of the following conditions exist:

1.) If at any time for 4 succeeding weeks during May or June the mean spider mites/leaf are higher than the preceding week and predators are present but predator:spider mite ratio is worse than 1:5, then

Treat with 1 lb Omite 30 WP/acre, or if ratio is worse than 1:20 use 2 lb Omite.

However, if ratio is 1:5 to 1:10 and fewer than 15 SMD accumulated during the last count period it may be possible to wait until the next count for a decision.

2.) If more than 20 mite days accumulate in a single week and predator:spider mite ratio is better than 1:10, then

Treat with 1 lb Omite 30 WP/acre

Or, if predator:spider mite ratio is worse than 1:10, use 2 lb Omite.

C. July: If Sevin is used for hullsplit spray, 1 lb Omite should almost always be added to combat Sevin's stimulatory effect on mites. Additional Omite should also be added if treatment is indicated below. If hullsplit spray is to be made, and assuming no mite treatments have been made in June, check to see if conditions 1 or 2 apply.

1.) If predator:spider mite ratio is 1:10 or worse, add 1 lb Omite 30 WP/acre

2.) If ratio is better than 1:10 add no additional miticide.

If no insecticide application is planned, miticide may be applied after any sample in July as indicated below:

3.) If more than 20 SMD accumulate in a single week, or if for 4 weeks in a row the mean SM/leaf is higher than the previous week and the predator:spider mite ratio is worse than 1:10, then

Treat with 1 lb Omite 30 WP or 0.25 lb Plictran 50 WP/acre.

D. August: Remember the preharvest interval for Omite is 28 days, 7 days for Plictran, and 14 days for Vendex.

1.) If total SMD approaches 110-130 and/or will surpass this value within the month, then

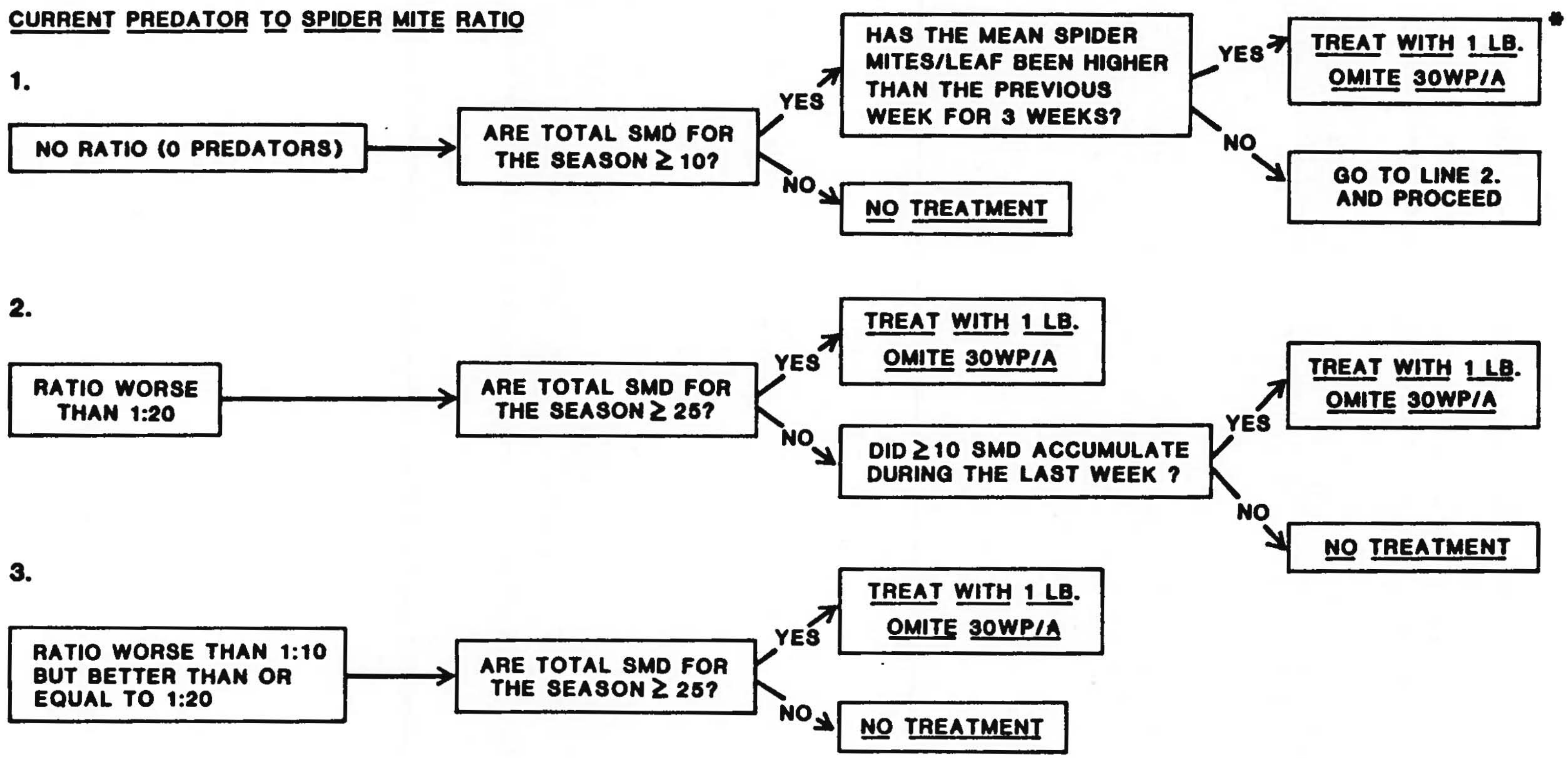
Treat with 0.25-0.50 lb Plictran 50 WP/acre, or 4-8 oz 4 L Vendex/acre, or 1-2 lb 30 WP Omite/acre.

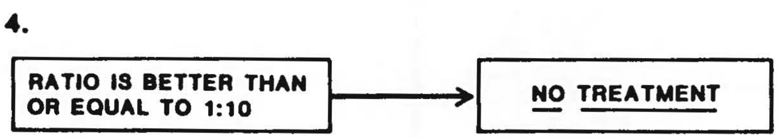
* The formula for spider mite days (SMD) is: SMD = ((½ x number of days since last sample date) x (current SM mean/leaf + the SM mean/leaf at the last sample period)) + (the running total of SMD accumulated over the previous weeks).

77-TY

MAY GUIDELINES

DETERMINE MEAN SPIDER MITES PER LEAF, TOTAL SMD FOR THE SEASON THUS FAR, SMD FOR THIS WEEK, AND THE PREDATOR TO SPIDER MITE RATIO. PICK THE CORRECT DECISION TREE BASED ON YOUR CURRENT PREDATOR TO SPIDER MITE RATIO.

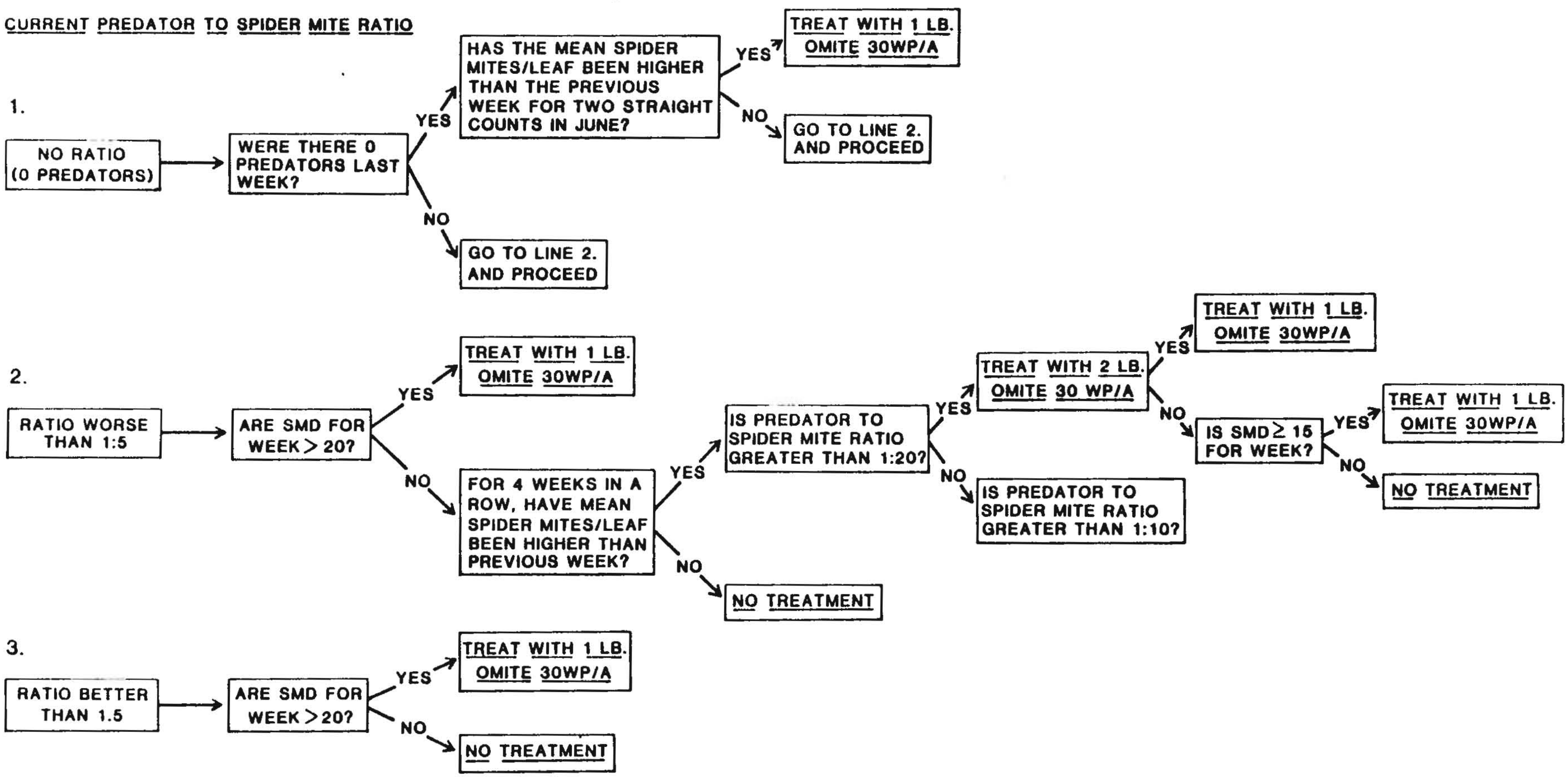




* PLICTRAN (0.25 LB. 50WP/A) OR VENDEX (4 OZ. 4L/A) COULD BE SUBSTITUTED , BUT WE DO NOT HAVE EXPERIENCE WITH THESE MATERIALS EARLY IN THE SEASON AT LOW RATES.

JUNE GUIDELINES

DETERMINE MEAN SPIDER MITES PER LEAF , TOTAL SMD FOR THE SEASON THUS FAR, SMD FOR THIS WEEK, AND THE PREDATOR TO SPIDER MITE RATIO. PICK THE CORRECT DECISION TREE BASED ON YOUR CURRENT PREDATOR TO PREY RATIO. IF A HULLSPLIT SPRAY IS PLANNED FOR NOW, AND IF A DECISION TO APPLY AN ACARICIDE IS MADE IN THE LAST WEEK OF JUNE, CONSIDER COMBINING THE ACARICIDE WITH THE HULLSPLIT SPRAY.



JULY GUIDELINES

DETERMINE MEAN SPIDER MITES PER LEAF, TOTAL SMD FOR THE SEASON, SMD FOR THIS WEEK, AND THE PREDATOR TO SPIDER MITE RATIO. IF SEVIN IS USED FOR HULLSPLIT SPRAY, 1 LB. OMITE 30WP/A SHOULD ALMOST ALWAYS BE ADDED.

IF HULLSPLIT SPRAY IS SCHEDULED:

1.

IF PREDATOR TO SPIDER MITE RATIO IS 1:10 OR WORSE

- YES → ADD 1 LB. OMITE 30WP/A TO INSECTICIDE (2 LBS.IF SEVIN IS USED)
- NO → NO ACARICIDE IS NEEDED UNLESS SEVIN IS USED ((USE 1 LB. OMITE 30WP/A)

IF NO HULLSPLIT SPRAY IS SCHEDULED

1.

ARE SMD FOR WEEK ≥ 20?

- YES → TREAT WITH 1 LB. OMITE 30WP/A
- NO → NO TREATMENT

2.

FOR 4 WEEKS IN A ROW, HAVE MEAN SPIDER MITES / LEAF BEEN HIGHER THAN PREVIOUS WEEK AND IS PREDATOR TO SPIDER MITE RATIO WORSE THAN 1:10?

- YES → TREAT WITH 1 LB. OMITE 30WP/A
- NO → NO TREATMENT

AUGUST GUIDELINES

REMEMBER PRE-HARVEST INTERVAL FOR OMITE IS 28 DAYS, 7 DAYS FOR PLICTRAN AND 14 DAYS FOR VENDEX.

1.

IF TOTAL SMD APPROACH 110-130 OR WILL SURPASS THIS VALUE WITHIN THE MONTH → TREAT WITH 0.25 - 0.50 LB. PLICTRAN 50WP/ACRE OR 1 - 2 LB. OMITE 30WP/ACRE OR 4 - 8 OZ. VENDEX 4L/ACRE

XII. Presence/Absence Sampling During 1983

The presence/absence sampling guidelines and tables provided by Frank Zalom were used in all almond orchards monitored during 1983 in addition to our regular foliage brushing and counting. The counts are summarized for each orchard in Tables I-VII.

Basically, the presence/absence sampling method was only relevant in one orchard during 1983, Bidart's Bakersfield orchard, because that orchard was the only one with *Tetranychus* species present as the predominant species. In all other orchards, European red mite (ERM) predominated, and because this species has a much different dispersion pattern than do *Tetranychus* species, the guidelines can't be applied. ERM was found on nearly every leaf early in the season despite low average leaf densities; thus, a simple substitution of ERM for *Tetranychus* species in the sampling scheme would have resulted in a "Treat" situation in every orchard in the first week sampled.

Sampling the Bidart orchard using both sampling methods yielded similar results (Table IV). The presence/absence scheme would have recommended a spray one week LATER than our guidelines would have. This is not a serious problem if the spray had been made at label rates (5-10 lbs 30WP Omite/acre). The week's difference would have been important if low rates had been recommended and the low rates would not have been as effective if applied one week later than recommended. The grower actually applied 0.75 lb. Plictran/acre the week the presence/absence guidelines would have recommended. On June 20, July 5, and 26, single trees sampled by the presence/absence sampling scheme would have required a treatment; however, when they were lumped with the other 3 trees sampled, the conclusion was "No treat." The four trees sampled were from widely separated areas, one each in the four "clusters" sampled with foliage counts.

This raises another issue--that of the size of the treatment area. The guidelines as written are vague. If the grower wishes to treat the "worse case" situation, then a single tree sampled could result in an acaricide treatment for the entire orchard. More seriously, if a sampler monitored only one tree with a "no treat" conclusion but failed to look over the entire orchard, failure to treat when necessary could occur. If the grower wants to treat the orchard on the basis of "average" conditions, then more than one area/tree should be sampled. We believe that the orchard (or subunit of the orchard that is amenable to separate treatments) should be sampled in several sites, perhaps a minimum of four trees/sites spread out over the orchard.

The presence/absence sampling should be tested again in 1984 in orchards where *Tetranychus* species are dominant, since one orchard is an insufficient test of the method. In addition, it is clear that a sampling program for European red mite is needed, as ERM is: 1) a pest in almonds in that ERM can cause early season defoliation, and 2) distributed differently in almond trees than are *Tetranychus* species.

Table XII-1 Presence/absence sampling in the Sumner/Peck almond orchard-1983.[1/]

Sample date	No. trees counted	No. leaves $\bar{w}$ WEBSP. mites (all stages) /total	No. leaves $\bar{w}$ ERM (all stages) /total	Recomm. treat?[2/]
2 May	25	16/375	115/375	no
9	4	7/60	27/60	(1 lb Omite recomm.) no
16	4	0/60	33/60	no
24	4	0/60	39/60	no
1 June	4	1/60	33/60	(Defoliation starts) no
7	4	1/60	51/60	(1 1/2 lb.Plictran applied) no
14 June	4	0/60	11/60	no
21	4	3/60	16/60	no
28	4	0/60	0/60	(Guthion+Omite applied) no
5 July	4	0/60	0/60	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

2/ The line in June indicates when the Presence/absence scheme should begin to be used with Tetranychus species. Only in the Bakersfield (Bidart) orchard were Tetranychus spp. the dominant spider mites. In all the rest, ERM predominated.

Table XII-2 Presence/absence sampling in the Livingston-I almond orchard-1983.[1/]

Sample date	No. trees counted	No. leaves w̄ WEBSP. mites (all stages) /total	No. leaves w̄ ERM (all stages) /total	Recomm. treat?[2/]
2 May	6	2/90	-	no
10	4	2/60	2/60	no
17	4	5/60	1/60	no
23	4	3/60	9/60	no
31	4	8/60	12/60	no
6 June	4	12/60	24/60	(1/2 lb. Omite applied) no
20 June	4	11/60	26/60	no
27	4	6/60	37/60	no
6 July	4	1/60	31/60	no
11	4	1/60	20/60	no
26	4	3/60	5/60	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

2/ The line in June indicates when the Presence/absence scheme should begin to be used with *Tetranychus* species. Only in the Bakersfield (Bidart) orchard were *Tetranychus* spp. the dominant spider mites. IN all the rest, ERM predominated.

Table XII-3 Presence/absence in the Wasco almond orchard-1983.[1/]

Sample date	No. trees counted	No.leaves $\bar{w}$ WEBSP.mites (all stages) /total	No.leaves $\bar{w}$ ERM (all stages) /total	Recomm. treat?[2/]
2 May	25	2/375	91/375	no
9	4	0/60	34/60	no
16	4	0/60	43/60	no
24	4	0/60	53/60	(1 lb.Omite applied) no
1 June	4	0/60	28/60	no
7	4	2/60	35/60	no
14 June	4	0/60	35/60	no
21	4	7/60	41/60	no
28	4	4/60	15/60	no
5 July	4	9/60	19/60	(Guthion 4 lb.50WP) no
11	4	3/60	22/60	no
19	4	2/60	22/60	no
26	4	0/60	3/60	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

2/ The line in June indicates when the Presence/absence scheme should begin to be used with Tetranychus species. Only in the Bakersfield (Bidart) orchard were Tetranychus spp. the dominant spider mites. In all the rest, ERM predominated.

Table XII-4 Presence/absence sampling in the Bidart (Bakersfield) orchard-1983.[1/]

Sample date	No. trees counted	No. leaves w̄ WEBSP. mites (all stages) /total	No. leaves w̄ ERM (all stages) /total	Recomm. treat? *Tetranychus* spp.
2 May	25	9/375	0/375	no
9	4	1/60	0/60	no
16	4	2/60	0/60	no
24	4	3/60	0/60	no
31	4	0/60	0/60	no
7 June	4	6/60	0/60	no
14 June	4	7/60	0/60	no
20	4	19/60	2/60	(1-2 lb.Omite reçomm.) no*
28	4	33/60	0/60	(.75 lb.Plictran applied) yes
5 July	4	32/60	0/60	no*
11	4	17/60	0/60	no
19	5	20/75	0/75	no
26	4	11/60	0/60	no*

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

* Single trees in these counts had treat results - when lumped total was NO-TR.

Table XII-5 Presence/absence sampling in the Livingston-V almond orchard-1983.[1/]

Sample date	No. trees counted	No. leaves $\bar{w}$ WEBSP. mites (all stages) /total	No. leaves $\bar{w}$ ERM (all stages) /total	Recomm. treat?[2/]
2 May	25	14/375	-/375	no
10	4	1/60	3/60	no
17	4	2/60	7/60	no
23	4	0/60	5/60	no
31	4	0/60	14/60	no
6 June	4	1/60	23/60	no
15 June	4	0/60	43/60	no
20	4	8/60	37/60	(1 lb. Omite applied)
				no
6 July	4	1/60	8/60	no
11	4	0/60	6/60	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

2/ The line in June indicates when the Presence/absence scheme should begin to be used with *Tetranychus* species. Only in the Bakersfield (Bidart) orchard were *Tetranychus* spp. the dominant spider mites. In all the rest, ERM predominated.

Table XII-6 Presence/absence sampling in the Livingston II & III orchards combined-1983. 1/

Sample date	No. trees counted	No. leaves $\bar{w}$ WEBSP. mites (all stages) /total	No. leaves $\bar{w}$ ERM (all stages) /total	Recomm. treat? 2/
2 May	6	1/90	19/90	no
10	4	1/60	13/60	no
17	6	5/90	29/90	no
31	6	1/90	42/90	no
6 June	6	7/90	68/90	(1 lb. Omite applied) no
15 June	6	5/90	49/90	no
20	6	8/90	43/90	no
27	6	6/90	67/90	no
6 July	6	2/90	47/90	no
11	6	16/90	78/90	no
26	6	4/90	5/90	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present,"

2/ The line in June indicates when the Presence/absence scheme should begin to be used with *Tetranychus* species. Only in the Bakersfield (Bidart) orchard were *Tetranychus* spp. the dominant spider mites. In all the rest, ERM predominated.

Table XII-7 Presence/absence sampling in the Livingston IV almond orchard-1983.[1/]

Sample date	No. trees counted	No.leaves $\bar{w}$ WEBSP.mites (all stages) /total	No.leaves $\bar{w}$ ERM (all stages) /total	Recomm. treat?[2/]
2 May	2	0/30	-	no
10	2	1/30	0/30	no
17	2	8/30	6/30	no
23	2	0/30	2/30	no
31	2	0/30	5/30	no
6 June	2	7/30	10/30	no
15 June	2	6/30	10/30	no
20	2	7/30	4/30	no
27	2	0/30	23/30	no
6 July	2	3/30	11/30	no
11	3	7/45	23/45	no
26	2	2/30	2/30	no

1/ Fifteen leaves/tree were sampled in each tree. The decision table used was the one that had "predators present."

2/ The line in June indicates when the Presence/absence scheme should begin to be used with *Tetranychus* species. Only in the Bakersfield (Bidart) orchard were *Tetranychus* spp. the dominant spider mites. In all the rest, ERM predominated.

XIII. PUBLICATIONS

Hoy, M. A., P. H. Westigard, and S. C. Hoyt. 1983. Release and evaluation of a laboratory-selected, pyrethroid-resistant strain of the predaceous mite *Metaseiulus occidentalis* (Acari: Phytoseiidae) in southern Oregon pear orchards and a Washington apple orchard. J. Econ. Entomol. 76:383-388.

Hoy, M. A. 1982. Aerial dispersal and field efficacy of a genetically improved strain of the spider mite predator *Metaseiulus occidentalis*. Ent. Exp. Appl. 32:205-212.

Hoy, M. A. 1982. Genetic improvement of *Metaseiulus occidentalis*: Implementing pesticide resistant strains--progress and problems. p. 18-28 Proc. Australisian Workshop on Devl. & Implem. IPM., P. J. Cameron, C. H. Wearing and W. M. Kain, Eds., Auckland, N.Z., Govt. Printers, 231 pp.

Hoy, M. A. 1982. Genetics and genetic improvement of the Phytoseiidae, pp. 72-89, in: *Recent Advances in Knowledge of the Phytoseiidae*, M. A. Hoy, Ed, Div. Agric. Sci. Publ. 3284, U.C., Berkeley, 92 pp.

Hoy, M. A. (In press) Genetic improvement of a biological control agent: multiple pesticide resistances and nondiapause in *Metaseiulus occidentalis* (Nesbitt) (Phytoseiidae). Proc. VI Intern. Congr. Acarology, Edinburgh, August 1982.

Hoy, M. A. (In press) Genetic improvement of a biological control agent: Selection for pesticide resistance in Metaseiulus occidentalis, a phytoseiid predator of spider mites. Proc. N.A.S. - C. A. S. Symposium on Biological Control, Beijing, China, September 1982.