Annual Report to Almond Board of California

Project No.: 05-FZ-01 Insect and Mite Research

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Objectives:

1. Purchase pheromone traps, navel orangeworm (NOW) bait traps, and lures for UC Cooperative Extension Farm Advisors for their ongoing monitoring and extension efforts. Evaluate candidate NOW pheromones that result from current research.

2. San Jose scale - evaluate amount of SJS damage that results from different levels of scale infestation, and determine if and how long tree recovery may take.

3. Peach Twig Borer - evaluate efficacy and timing for registered and candidate insecticides.

4. Spider mites – evaluate efficacy and treatment timing for registered and candidate miticides, and determine acute and sublethal effects of several new miticides against predatory mites.

Results:

Objective 1, Monitoring supplies and regional trapping. Each year through this project, trapping supplies are purchased for use by UC Cooperative Extension Farm Advisors to help them to monitor the phenological activity of almond insect pests in their counties. The Advisors use the data gathered from these traps to update pest status for local growers and PCA's. Trapping records are solicited from the Advisors at the end of each season, and become part of a historical database. For the 2005 season, supplies purchased and distributed included 700 wing traps and trap liners, 500 San Jose scale (SJS) traps, 50 navel orangeworm (NOW) egg traps, 1125 pheromone lures, and 6 lbs of NOW bait.

As in the previous 3 years, funding was provided to Rich Coviello for trapping NOW, peach twig borer (PTB), oriental fruit moth and SJS in Fresno Co., and providing regular updates on this monitoring to growers and PCAs who request them via email or fax. Two almond orchards were monitored as part of this subobjective during 2005. One orchard, "Laton", is located in the historical almond growing area of south-central Fresno County, and the other "Panoche" is an orchard located near the intersection of Interstate 5 and Panoche Road in the center of a relatively new region where almond production is expanding. PTB and SJS flights were relatively high at the Laton location (Figures 1 and 2). A dormant treatment was not applied at this location for the past two years. Oriental fruit moth trap counts were relatively high at the Panoche location (Figure 3). Hull-split treatments for PTB and NOW often control oriental fruit moth, however this year the degree-day treatment timing did not coincide the three species. NOW densities were apparently very low at these two locations in 2005 (Figure 4). Only occasionally were a few eggs found on egg traps, and generally on one of the four traps in the

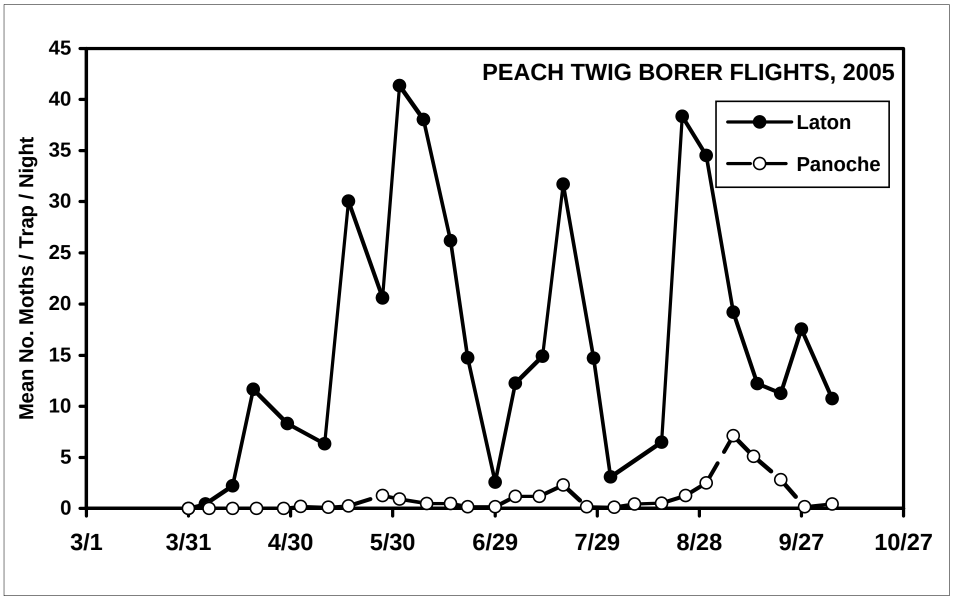

Figure 1. Seasonal pheromone trap captures of peach twig borer male moths at Laton and Panoche, Fresno Co., as reported by Rich Coviello, UC Cooperative Extension, 2005.

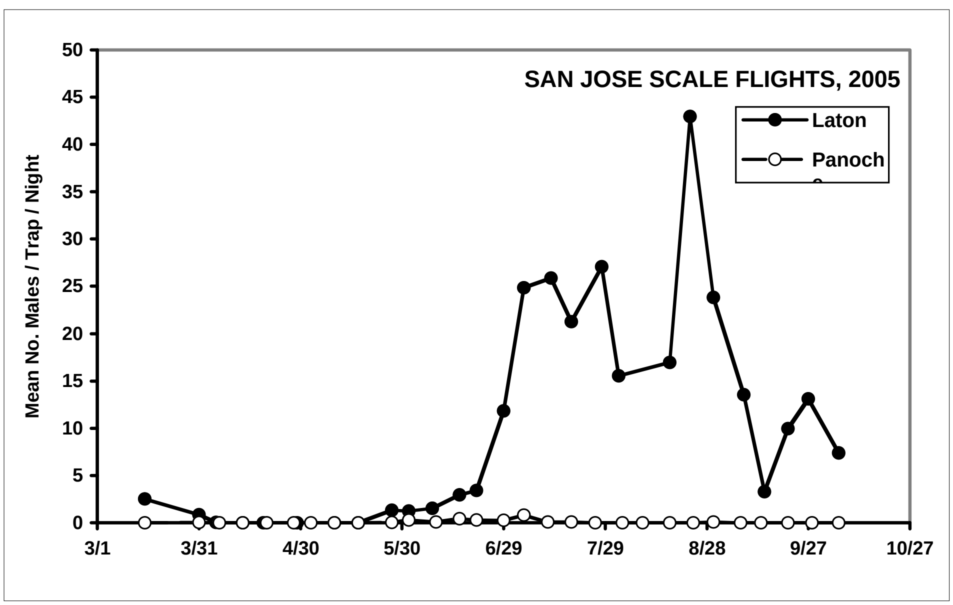

Figure 2. Seasonal pheromone trap captures of San Jose scale males at Laton and Panoche, Fresno Co., as reported by Rich Coviello, UC Cooperative Extension, 2005.

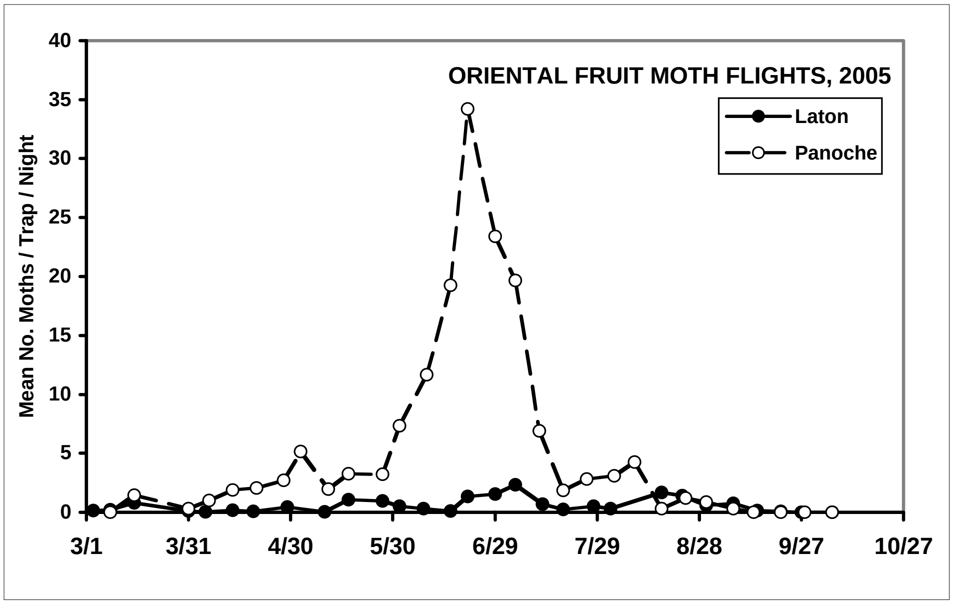

Figure 3. Seasonal pheromone trap captures of oriental fruit moth male moths at Laton and Panoche, Fresno Co., as reported by Rich Coviello, UC Cooperative Extension, 2005.

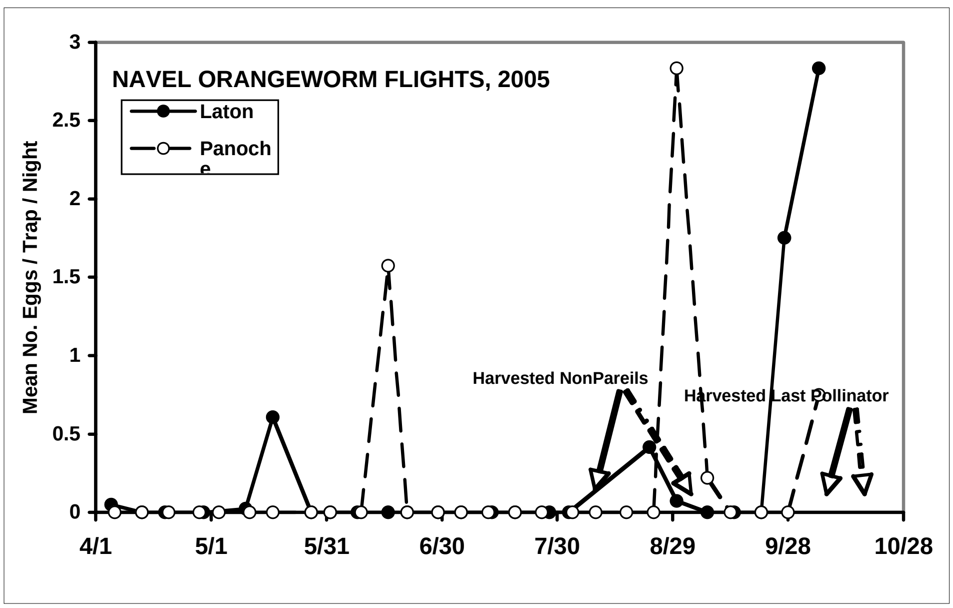

Figure 4. Seasonal egg trap captures of navel orangeworm at Laton and Panoche, Fresno Co., as reported by Rich Coviello, UC Cooperative Extension, 2005.

orchard - an indicator of a low overall population. As might be expected, the number of eggs and the number of traps with eggs increased significantly after the Nonpareils and the last pollinator varieties were harvested. This is related to competition between the nuts and traps in attractiveness to the female moths beginning at hull-split and continuing through harvest. The Panoche orchard is the same one monitored in 2004 when navel orangeworm densities were much higher. The lower densities recorded in 2005 may be related to much improved orchard sanitation in the almonds, and, perhaps more importantly, the sanitation and removal of old fruit from a neighboring pomegranate orchard, which was a source of migrant navel orangeworm moths throughout the previous season.

In 2005, we proposed to evaluate available NOW pheromone(s) by comparing male captures in traps baited with pheromone lures to female egg-laying recorded by black egg traps to establish the relationship between these and implications to their use with the NOW degree-day model and treatment timing. The NOW pheromone was identified in a paper by Leal and colleagues earlier this year (*Naturwissenschaften*, 92: 139-146). Sites were identified in Fresno County and the Sacramento Valley for this study, but unfortunately a commercial source of the pheromone was not available for our use so we could not pursue this study.

Objective 2, San Jose scale. Walt Bentley, together with Mario Viveros, have been leading the effort to develop sampling decision rules and management options for San Jose scale which would allow growers and PCAs to predict the need for a dormant spray application and use reduced-risk control options. The study is being conducted in the Kern Co. Almond Pest Management Alliance Orchard in Wasco. The orchard is 160 acres in size. It is divided into 8 separate plots of 20 acres. This site has an established SJS population. Four plots were treated with conventional organophosphate dormant and in-season sprays (Conventional treatment). Four plots were treated with products considered to be reduced-risk pesticides that include horticultural mineral oil, spinosad and methoxyfenozide (Intrepid). Each of these 8 plots were further divided into 10 acre plots, half of which have not received a dormant spray for 3 years (beginning with the winter of 2002). Because of the severity of the SJS infestation in the untreated sections, it became possible to evaluate orchard recovery from a severe SJS infestation.

In late January, 2005, plots received a delayed dormant spray that included either 6 gallons of Volck Supreme oil, 8 gals of Volck Supreme oil, or no dormant treatment. In 2004, pyriproxifen (Seize 35WP) and 6 gallons of oil were applied across all plots. The conventional treated plots also received a hullsplit application of phosmet (Imidan 70WP) at the rate of 4 lbs per acre in 200 gals of water, and buffered to pH 6. The reduced risk plots were treated in May with methoxyfenozide at the rate of 16 ounces per acre in 200 gallons of water.

San Jose scale traps were deployed in late February, 2005, and monitored through October. Male SJS, *Encarsia perniciosa*, and *Aphytis spp*. were counted every week on these traps. Double-sided sticky tape was wrapped around a secondary scaffold on the tree with the scale trap, as well as on each tree to the north, south, east, and west of the trap tree. The tapes were deployed in March, and monitored through October for crawler abundance. In early October, each of the trees with a sticky tape (five per plot) was evaluated for SJS infestation. Each tree was searched for 3 minutes for live scale on new shoots and for damage due to scale feeding, and assigned a rating from 0 to 3 where no scale found = 0; any live scale = 1; live scale and yellowing leaves =2; live scale and dead or dying limbs=3. These same trees were evaluated in February, 2005, for live scale infesting spurs. Twenty spurs were collected from each of the 5 trees at each trap location. Regression analysis was performed on these data with spur infestation as the independent variable and tree damage as the dependent variable. The 2005 data were pooled with the 2002 ,2003, and 2004 data for the analysis.

A dramatic reduction in SJS infestation from the previous year was shown in 2004. No additional scale were found in 2005. Observations from previous years suggested that plots where no dormant treatment were applied were the most severely infested and damaged by SJS. For example, the seasonal total of crawlers per inch of tape in the Conventional treated blocks with no dormant averaged 957.34, 656.88 and 0.12 in the years 2002, 2003, and 2004 (a dormant treatment was applied in this year). The seasonal total crawlers per inch of tape in the reduced risk plots averaged 90.22, 6.08, and 0.15 for 2002, 2003, and 2004, respectively. In 2005 no crawlers were found in any of the plots, based on counts through June. The remainder of the sticky tapes collected are still being counted.

Damage severity ratings were similarly affected by the 2004 dormant treatment in both the conventional and reduced risk treatments. In 2002, the severity ratings for SJS averaged 0.25, 0.50, 4.25, and 5.50 for the conventional plus dormant oil and organophosphate, reduced risk dormant oil, reduced risk no dormant oil, and conventional no dormant spray treatments, respectively. The conventional no dormant spray treatment had significantly ($P<0.05$, Fisher's protected LSD) more damage than all but the reduced risk and no dormant oil treatment. The reduced risk and no dormant spray treatment was not significantly different $P>0.05$ than the reduced risk dormant spray treatment. There were no live scale found in the October, 2005, ratings in any of the plots.

In 2003, the conventional with no dormant spray treatment was again most severely damaged. The ratings were 0, 0.75, 3.75, and 7.25 for the conventional plus dormant oil and organophosphate, reduced risk plus dormant oil spray, reduced risk with no dormant spray, and conventional with no dormant spray treatments, respectively. The conventional with dormant oil and organophosphate and the reduced risk with dormant oil treatments were not statistically different ($P>0.05$, Fisher's protected LSD). The conventional with no dormant spray had significantly ($P<0.05$, Fisher's protected LSD) more damage than the remaining treatments.

In 2004, after the oil and pyriproxifen treatment was applied, further damage due to live scale was prevented. The damage ratings were 0.03, 0, 0, and 0 for the conventional and no dormant spray, conventional with dormant spray, reduced risk with no dormant spray, and reduced risk with dormant spray treatments, respectively. As previously mentioned, of the 12,000 spurs collected and assessed in January, 2005, none from any of the treatments were infested with any live scale. This indicates the pyriproxifen plus oil treatment promotes scale control for at least a 2 year period.

The relationship between spur infestation and damage rating was pooled over the 4 year period, yielding 64 data points. The results of the pooled regression analysis indicate a significant relationship between spur infestation, and the severity of damage due to live SJS. The relationship between the average number of infested spurs and damage severity was highly significant ($R^2 = 0.615$, $Y= 0 +.031 X$; $P< 0.001$, no intercept model) for the four year period (Figure 5). The relationship between the average number of SJS per plot and damage severity was also highly significant, ($R^2 = 0.398$, $Y= 0 + .002 X$; $P< 0.001$, no intercept model), but less precise, for the four year period.

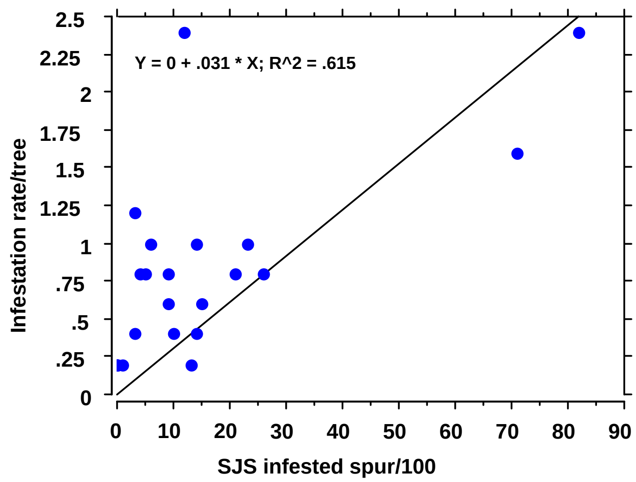

Figure 5. Relationship between San Jose scale infested spurs and infestation rating for the 4 years 2002-05.

Pruning weights were shown to be significantly related to average spur infestation over the previous 4 years (R^2 = 0.771, Y= 0.374 +.246X; P< 0.001, no intercept model), and this study finally provided an accurate method of quantifying damage as reduced pruning weight will have a significant effect on yield. Figure 6 presents the results of this analysis and shows that higher average scale infestation over the previous 4 years will effect the overall new growth of an almond tree. Infestations in excess of 6 San Jose scale infested spurs in 100 samples will result in significant loss of tree growth if left uncontrolled.

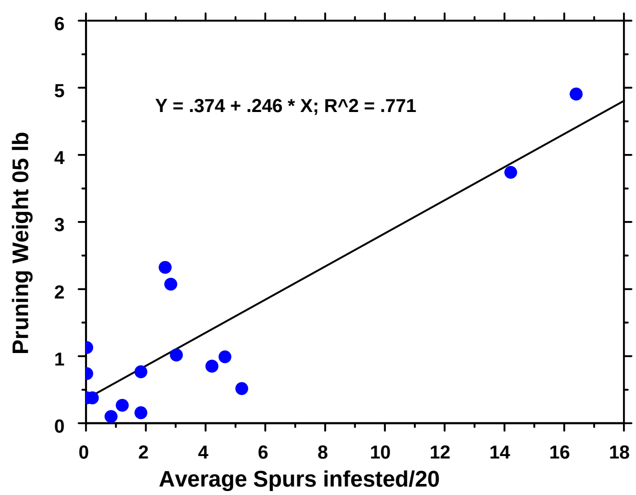

Figure 6. Relationship between average San Jose scale spurs infested observed during the study and pruning weights measured in 2005.

Conclusions from the 4 years of this study are that SJS can be managed for at least two years, even in a heavily infested orchard, by a pyriproxifen and oil application. In cases where horticultural mineral oil has been regularly applied in the dormant season, there is no need to tank mix with additional insecticides in the dormant spray to manage SJS. The most accurate method of predicting the need for a SJS treatment is sampling infested spurs. The number of spurs infested is a more accurate predictor of damage than counting the number of scale found on the spurs. Finally, Infestations in excess of 6 San Jose scale infested spurs in 100 samples will result in significant loss of tree growth if left uncontrolled.

Objective 3, Peach Twig Borer. An experiment was conducted to determine the efficacy of several insecticides applied for PTB control during orchard dormancy. The site of this study was a commercial third leaf almond orchard located in the North Buttes area northwest of Yuba City, Sutter Co., California. The orchard was a standard planting for the area, and was immediately adjacent to a mature almond orchards to the west and south. Dormant treatments were applied on January 24, 2005. Delayed dormant sprays were applied on February 2. Pink bud sprays were applied on February 17. Full bloom sprays were applied on February 22. Each treatment replicate was a single tree, and all treatments were replicated 9 times with two sets of untreated controls. Because each of the 3 rows was planted to a different variety (vars. Padre, Carmel Butte) as is the case with almond orchards which require cross pollination between varieties, the experimental treatments were blocked into the 3 rows. Treatments were applied using a Solo Piston Pump Sprayer at the equivalent volume of 100 gal/acre. All treatments except the 2 methoxyfenozide (Intrepid) and the diflubenzuron (Dimilin) treatments applied at the delayed dormant and pink bud timings also included Volck Supreme Oil at 1.5% vol/vol. The methoxyfenozide treatments were applied with Latron B-1956 spreader at 0.0125% vol/vol. The diflubenzuron treatments at delayed dormant and at pink bud were applied with 0.25 % summer oil vol/vol. Dormant oil is routinely tank mixed with insecticides for the dormant application to kill eggs of several spider mite species resident in California orchards. Dormant oil has not been shown to kill peach twig borers when applied in the absence of another insecticide.

Table 1. Mean (+ SE) peach twig borer strikes in untreated trees among the 3 varieties in the Winter, 2005, peach twig borer insecticide trial.

Row	Variety	Mean (± SE) shoot strikes
1	Padre	27.583 ± 11.236
2	Carmel	10.167 ± 4.750
3	Butte	11.250 ± 9.627

ANOVA statistics, F=7.097, df=2,15, P=0.0068.

A primary target of the dormant treatment is the peach twig borer larva which overwinters in a hibernacula usually located on twig or branch tree forks. The larva emerges from the hibernacula during or immediately after bloom, and crawls to the new shoot tips where they bore into the ends. The resulting 'flagging' of shoot tips are characteristic of peach twig borer feeding. We used the number of flags per tree counted in a 5 minute timed search as an indicator of the number of peach twig borer larvae present on a given tree. Shoot strikes in this experiment were counted on April 13.

ANOVA (Table 1) revealed a significant difference in shoot strikes in untreated trees located among the 3 varieties (F=7.097, df=2,15, P=0.0068). Variety was not included as a factor in the analysis of variance for treatments because all treatment differences were significant from untreated without including variety as a factor.

Table 2. Mean (± SE) peach twig borer shoot strikes per tree, 2005.

Treatment and timing	Rate (product/acre)	N	Mean (± SE) ** shoot strikes
Untreated	NA	18	16.33 ± 11.76
Dimilin dormant [1]	16 oz	9	0.44 ± 1.01
Dimilin delayed dormant [2]	12 oz	8	1.13 ± 2.10
Dimilin pink bud [2]	12 oz	9	0.00 ± 0.00
Success dormant [1]	6 oz	9	0.00 ± 0.00
Intrepid pink bud	10 oz *	9	0.44 ± 0.73
Intrepid delayed dormant	12 oz *	9	0.00 ± 0.00
Intrepid pink bud & full bloom	5 oz *	9	0.00 ± 0.00
Danitol dormant [1]	21.33 oz	9	0.00 ± 0.00
Danitol dormant [1]	10.76 oz	9	0.00 ± 0.00
Diazinon dormant [1]	4 pts	9	0.00 ± 0.00
Ambush dormant [1]	10 oz	9	0.00 ± 0.00
Imidan dormant [1]	5.33 lb	9	0.11 ± 0.33
Warrior dormant [1]	2.56 oz	8	0.13 ± 0.35
Warrior dormant [1]	3.84 oz	9	0.00 ± 0.00
Dibrom dormant [1]	2 pts	9	0.11 ± 0.33
Dibrom dormant [1]	3 pts	9	0.22 ± 0.44
Dibrom + Ambush dormant [1]	2 pts + 10 oz	9	0.00 ± 0.00

1 Applied with 1.5% oil v/v.
2 Applied with 0.25% summer oil v/v.
* Latron B-1956 spreader applied with this treatment @ 0.125% v/v
** Peach twig borer shoot strikes are significantly different from the untreated control by pairwise t-tests at $P<0.05$ in all cases.
Dormant spray application date: January 24, shoot strikes counted April 13.
ANOVA statistics, $F=15.655$, df=17,151, $P<0.0001$.

ANOVA revealed significant differences between treatments (ANOVA statistics, $F=15.655$, df=17,151, $P<0.0001$). All treatments significantly reduced of peach twig borer shoot strikes relative to the untreated check. It is possible that there was a treatment timing effect for the insect growth regulators diflubenzuron and methoxyfenozide, but differences between treatment timings were not statistically significant. From our previous experience, the mean number of peach twig borer shoot strikes found in the untreated checks of our study would be considered relatively high. Treatment at this level would probably be considered necessary for mature almond trees and for fresh or canned soft fruit to avoid direct damage to nut meats and fruit.

Objective 4, Spider Mites. An experiment to evaluate efficacy of several registered and candidate miticides was conducted at the Nickel's Estate near Arbuckle, Colusa County, in collaboration with John Edstrom. The orchard consisted of mature almond trees, planted 75 trees to the acre. Treatments were applied on August 16, 2005. Two-spotted spider mite (*Tetranychus urticae*) densities averaged about 0.40 per leaf at the time of application. The action threshold for webspinning spider mites on almonds is about 4.0 motile mites per leaf. European red mite (*Panonychus ulmi*) densities averaged about 11.5 per leaf at the time of application. The action threshold for European red mites on almonds is not defined but is considered to be much higher than that of webspinning spider mites. Because of wet winter/spring conditions in 2005, mite densities remained very low through much of the summer until irrigation was withheld for harvest. Treatments were applied using a gas-powered hand gun sprayer at the equivalent volume of 400 gal/acre. Each treatment replicate was a single tree, and each treatment was replicated 4 times in a completely randomized design. Products tested included summer oil, rosemary oil and peppermint oil (Ecotrol EC), acequinocyl (Kanemite), bifenezate (Acramite), hexathiozox (Onager), and abamectin (both Agrimek and A8712, a new formulation). Treatments and application rates are provided on the tables.

Mite sampling consisted of removing 10 leaves per tree randomly from around the circumference of each tree, placing the leaves into a plastic bag, and returning the leaves to the Zalom lab for counting. Using a mite brushing machine, the total number of two-spotted spider mites and European red mite motiles was determined. A pretreatment count was made on August 16, 2005, with post-treatment counts taken one, two, three, four, and five weeks later.

Results of this study are presented on Tables 3a, 3b and 4. These tables present means and standard deviations of all treatments with the results of Student's t-test at P=0.05 with treatment means being compared to the untreated control.

The two spotted mite densities were relatively low at the time of the application, but increased in the control plots to reach the control action threshold by 4 weeks after application. European red mite densities remained at pretreatment levels for 2 weeks after the application, but then began to decline. Significant differences were not always observed for the weekly samples, but this is not surprising since there was so much variability among the untreated control plots. In general, differences between treatments were most apparent when densities were highest, beginning the second week after application for the two spotted spider mite and for the first 3 weeks after application for European red mite.

Observed side effects of five new miticides on the longevity, fecundity, fertility and progeny development of newly emerged adult females of the predator mite, *Galendromus occidentalis*, exposed to a “worse case” situation where complete exposure of the female predators occurs by both spray contact and leaf residues of less than 24 hr. The miticides tested were etoxazole (Zeal®, Valent U.S.A. Corp.), spiromesifen (Oberon®, Bayer Inc.), fenpyroximate (Fujimite®, Nichino America Inc.), bifenazate (Acramite®, Chemtura Corp.) and acequinocyl (Kanemite®, Arysta Corp.) (Table 5. Egg laying and survival of the exposed predator females were recorded daily, as was egg hatch. There were twenty replicates of all acaricide treatments and the untreated control. To determine the effects on the development of progeny of treated females, 50 eggs produced by females exposed to each treatment were placed individually on leaf discs treated earlier the same day and allowed to dry. Mortality and developmental time for each life stage were determined. Longevity, fecundity, and fertility were analysed by ANOVA with means separated by LSD at $P < 0.05$.

Table 3a. Mean (± SD) motile two spotted spider mites per leaf, Nickels Estate, Arbuckle, California, 2005.

		Mean ± SD 2-spot motiles/leaf			
Treatments	Rate (Form/Acre)	Pretreat 8/15/2005	8/23/05	8/30/05	9/6/05
Untreated	NA	0.13 ± 0.19	0.13 ± 0.10	1.43 ± 0.93	1.35 ± 0.89
Summer oil	1%	0.68 ± 0.79	0.45 ± 0.70	1.58 ± 2.18	1.68 ± 1.73
Ecotrol EC	4 pts	0.23 ± 0.45	0.38 ± 0.45	1.53 ± 2.18	0.93 ± 0.83
Kanemite	21 oz	0.13 ± 0.25	0.08 ± 0.10	0.03 ± 0.05	0.43 ± 0.46*
Kanemite	26 oz	0.05 ± 0.06	0.03 ± 0.05	0.00 ± 0.00	0.13 ± 0.10*
Kanemite	31 oz	2.48 ± 2.55*	0.00 ± 0.00	0.48 ± 0.56	0.20 ± 0.11*
Acramite 50	1 lb	0.00 ± 0.00	0.03 ± 0.05	0.08 ± 0.10	0.10 ± 0.00*
Onager	20 oz	0.03 ± 0.05	0.00 ± 0.00	0.03 ± 0.05	0.33 ± 0.17*
Agrimek+ Oil	15.6 oz + 0.25%	0.00 ± 0.00	0.15 ± 0.19	0.15 ± 0.13	0.38 ± 0.22*
A8712 + Oil	15.6 oz + 0.25%	0.28 ± 0.55	0.00 ± 0.00	0.28 ± 0.43	0.15 ± 0.17*

*Means significantly different from untreated control at *P*<0.05 by Student's t-test.

Table 3b. Mean (± SD) motile two spotted spider mites per leaf, Nickels Estate, Arbuckle, California, 2005.

		Mean ± SD 2-spot motiles/leaf	
Treatments	Rate (Form/Acre)	9/14/05	9/21/05
Untreated	NA	5.13 ± 5.18	4.38 ± 5.94
Summer oil	1%	14.15 ± 21.05	10.49 ± 8.67*
Ecotrol EC	4 pts	5.03 ± 9.05	3.73 ± 4.75
Kanemite	21 oz	2.25 ± 3.07	2.08 ± 2.55
Kanemite	26 oz	0.55 ± 0.62	1.40 ± 1.26
Kanemite	31 oz	0.90 ± 0.47	1.15 ± 1.27
Acramite 50	1 lb	0.23 ± 0.22	0.83 ± 1.05
Onager	20 oz	0.38 ± 0.22	0.65 ± 0.59
Agrimek+ Oil	15.6 oz + 0.25%	0.42 ± 0.72	0.31 ± 0.10
A8712 + Oil	15.6 oz + 0.25%	0.25 ± 0.19	0.60 ± 0.29

*Means significantly different from untreated control at *P*<0.05 by Student's t-test.

Effects of the five acaricides evaluated on longevity, fecundity, fertility and progeny development of *G. occidentalis* are presented on Table 6. There was a significant difference in female longevity between treatments (F=23.29; df=5; P<0.001). There was also a significant difference in fecundity between treatments (F=33.99; df=5; P<0.001). Fertility was not recorded for eggs produced by females treated with either Zeal or Oberon. Fertility occurred but was reduced considerably by both the Acramite and Kanemite treatments. We are doing more detailed studies of sublethal effects to include more realistic exposure than the worst case exposure presented in this report. This study will include the effect of residues on females of up to 37 days after treatment so that it can be determined after what period it would be safe to release *G. occidentalis* following an application of one of the products. The complete results of this study were submitted and just published in the journal *Experimental and Applied Acarology*.

Table 4. Mean (± SD) motile European red mites per leaf, Nickels Estate, Arbuckle, California, 2005.

		Mean ± SD European red mites/leaf														
Treatment	Rate (Form)	Pretreatment 8/15/2005			8/23/05			8/30/05			9/6/05			9/14/05		
UTC	NA	7.65	±	4.17	17.55	±	18.42	7.40	±	6.84	4.68	±	3.69	1.60	±	0.91
Summer Oil	1%	10.45	±	7.98	7.65	±	6.32	2.95	±	1.68	6.13	±	5.25	7.08	±	8.77
Ecotrol	4 pts	15.55	±	12.48	15.68	±	10.42	26.80	±	19.00*	9.25	±	4.09*	5.68	±	5.22
Kanemite	21 oz	9.88	±	8.45	2.70	±	3.46	0.63	±	0.51*	1.70	±	2.60*	3.04	±	2.90
Kanemite	26 oz	9.35	±	9.89	7.73	±	11.07	0.88	±	0.62*	0.45	±	0.37*	1.28	±	1.19
Kanemite	31 oz	9.03	±	11.27	0.53	±	0.79	0.53	±	0.73*	1.25	±	1.45*	0.80	±	0.56
Acramite 50	1 lb	15.35	±	12.72	15.58	±	9.28	4.28	±	5.29	1.03	±	0.71*	2.05	±	2.30
Onager	20 oz	10.25	±	5.21	5.45	±	9.57	1.40	±	1.19*	2.64	±	3.47	1.58	±	2.18
Agrimek + Oil	15.6 oz + 0.25%	13.65	±	6.34	11.70	±	6.73	11.95	±	8.00	6.50	±	3.39	2.13	±	2.10
A8712 + Oil	15.6 oz + 0.25%	13.83	±	15.33	3.98	±	4.08	1.25	±	1.39*	0.98	±	0.36*	1.05	±	1.21

*Means significantly different from untreated control at $P<0.05$ by Student's t-test.

Table 5. Acaricides and rates evaluated for sublethal effects on *Galendromus occidentalis*.

Active ingredient	Trade name	% a.i. and formulation	Concentration used (ppm)
Fenpyroximate	Fujimite	5 SC	0.21
Etoxazole	Zeal	72 WP	24.12
Acequinocyl	Kanemite	15 SC	158.0
Bifenazate	Acramite	50 WS	112.75
Spiromesifen	Oberon	23 SC	76.20

Table 6. Longevity, fecundity, fertility, and progeny development for *G. occidentalis* females treated within <12 h of adult eclosion with label rates of five different acaricides.

Acaricide	Longevity (days) [1]	Total eggs/female [1]	Fertility (% hatch)	Immature development (days)	Immature mortality
Control	6.53±0.49a	18.4±1.84a	88	5	0%
Zeal	6.27±0.71a	10.5±1.89b	0	-	-
Oberon	4.15±0.32b	1.8±0.56d	0	-	-
Fujimite	< 1c	0	0	-	-
Acramite	5.65±0.53a	5.5±1.05c	28	**	100%
Kanemite	3.90±0.35b	3.1±0.61cd	31	**	100%

[1] Means followed by the same letter are significantly different at $p<0.05$ by LSD.
** All larvae died after eclosion from the egg.

Figure 7 shows the mean eggs laid per female during on each day following treatment. Untreated *G. occidentalis* females had a preoviposition period of 24 h and reached the oviposition peak 72 h following treatment and maintained an average fecundity of around 2.5 eggs/day until day seven following treatment. Treated females never produce as many eggs at the oviposition peak as did untreated females. For all acaricides with the exception of Zeal, the oviposition peak occurred 72 h following treatment, but peak egg production was only about 1 egg. Egg production by females treated with Zeal peaked on day 5 following treatment, but eggs per day was ≥1 for days 2 to 8 following treatment.

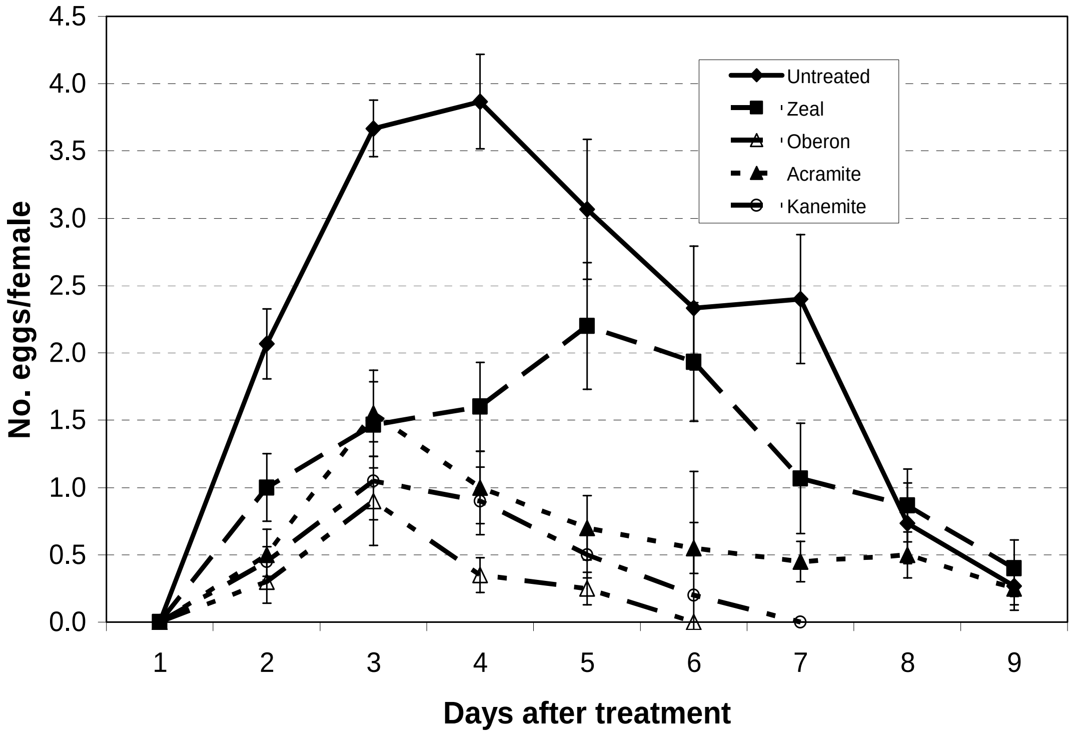

Figure 7. Number of eggs laid per female per day, by female *G. occidentalis* sprayed within 12 h of adult eclosure with labelled rates of five different acaricides. First day following treatment is the preovipositional period.