Annual Report to
Almond Board of California
May 1, 2000
Correct Project Number: 99-FZ-o0
Project No.: 99-FZ-00 Insect and Mite Research

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Project Participants: UC Farm Advisors in 10 counties for Objective 1; Walt Bentley (UCIPM, Kerney Agricultural Center) for Objective 2; Joe Connell (UCCE, Butte Co.), Bill Krueger (UCCE, Glenn Co.), Carolyn Pickel (UCIPM, Sutter-Yuba Co.), Walt Bentley (UCIPM, KAC), Robert Sanders (Crop Consultant, Butte/ Glenn Co.), Christine Tobia (Entomology, UC Davis), Dave Limburg (Entomology, UC Davis) and Barat Bisabri (DowElanco) for Objective 3.

Objectives:

1. Purchase pheromone traps and lures, and other monitoring supplies for UC Cooperative Extension Farm Advisors as part of their ongoing monitoring efforts.

2. San Jose Scale - Continue to monitor specific orchards in Kern Co. to determine the possible influence of different pest management practices on San Jose scale and parasite population dynamics. Attempt to improve monitoring of San Jose scales by correlating male abundance in pheromone traps to scale crawlers. Conduct field trials to test the effect of several registered materials materials as dormant sprays for control of San Jose scale.

3. Peach Twig Borer - Continue to monitor peach twig borer populations in the San Joaquin and Sacramento Valleys to identify whether differences in susceptibility to organophosphate or pyrethroid insecticides occurs in different orchards. Determine relative trap catches and longevity of commercial lures for peach twig borer.

Summary of Results:
Objective 1, Monitoring supplies. Each year through this project, trapping supplies for use by participating UC Cooperative Extension Farm Advisors to help them to monitor the phenological activity of specific insects in their counties. The advisors use the data gathered from these traps to update local growers and PCA's in the status of various almond insect pests in their counties. Traps and lures have also been purchased for use by Farm Advisors who cooperate in BIOS demonstrations, and in their applied research programs. The trapping records are assembled at UC Davis at the end of each season, and have served as a database for validation of phenology

models. In winter, 1999, over 3000 traps and 2800 lures were purchased and distributed to 11 Farm Advisors to monitor navel orangeworm, peach twig borer, San Jose scale, and oriental fruit moth in almond orchards. The total cost of these supplies for 1999 was $7996. The number and type of traps purchased are given on Table 1.

Table 1. Trapping supplies purchased for monitoring insect pests in almonds, 1999.

Name	Location	Wing Traps	Trap Liners	NOW Traps	SJS Traps	PTB Lures	OFM Lures	SJS Lures	NOW Bait (lb)
J. Connell	Butte Co.	6	24	0	0	25	0	0	0
R. Duncan	Stanislaus	6	20	5	0	50	33	0	1
R. Coviello	Fresno Co.	175	300	0	0	150	75	75	1
L. Hendricks	Merced Co.	100	200	0	200	225	0	250	10
J. Edstrom	Colusa Co.	6	18	4	4	20	10	0	1
R. Buchner	Tehama Co.	8	64	4	4	32	32	12	1
M. Bartels	Kern Co.	0	0	0	600	0	0	600	0
W. Bentley	UC KAC	200	200	50	300	200	0	150	0
W. Krueger	Glenn Co.	4	12	4	0	20	0	0	1
W. Reil	Yolo Co.	0	100	0	0	75	0	0	0
M. Freeman	Fresno Co.	0	100	0	75	150	0	75	0
F. Zalom	UC Davis	100	200	0	0	391	50	50	0
Total	All Sites	605	1238	67	1183	1338	200	2800	16

Since starting this effort in 1981, we have used lures purchased from Trece® Inc. for standard population monitoring in most of the orchards. We started using their lures because Trece (then Zoecon) was the industry standard at the time this monitoring study began. Since that time, several companies have begun manufacturing and selling lures, some utilizing the same red rubber septa dispensers and others utilizing other technologies for regulating pheromone release. Some of these lures (including ones from Trece and Scenturion) are advertised as 'long life' lures because they are intended to last longer between changes. We continue to use the Trece lures in most of the orchards being monitored in order to maintain consistency by reducing the potential for variability due to lures between the years of this study. However, we have purchased lures from other companies from time to time for specific monitoring programs by Farm Advisors that are not part of the core monitoring effort, and we continue to be asked by Farm Advisors and PCAs about the properties of the different available commercial lures.

In 1990, we conducted a study to compare the different properties of the lures that were available at the time. The results of this study showed that different lures had somewhat different responses to conditions early season versus later season, and continued to maintain the size of trap catch relative to new lures for different periods of time. Because the properties of the lures differed seasonally probably due to their emissions of the pheromones under different environmental conditions, it was impossible to be judgmental about the 'quality' of the lures. These results were reported in the following publication: Zalom, F. G. 1995. Traps and lures for monitoring peach twig borer (*Anarsia lineatella*) and oriental fruit moth (*Grapholitha molesta*). Acta Horticulturae 373:269-276.

Since the availability of lures are different from the 1990 study, we compared standard lures manufactured by Consep Membranes (Biolure), IPM Technologies, Scenturion, and Trece aged for different periods of time within four separate untreated orchard blocks in 1999. Wing style traps baited with a lure of each experimental type were placed in a complete block design at a spacing of at least 4 trees or tree rows between traps, and replicated 4 times. "Aged" lures were compared to "new" lures of the same type, and to a "new" Trece lures which served as a standard for reference. The "aged lures were taken from their foil packets at weekly intervals before the start of the trial and placed into a trap out of doors on the Davis campus for aging. The "new" lures were removed from their foil packets the day before they were placed into the field for the trial. The traps with the different lure treatments were rotated through a grid in each block twice each week to reduce variability between lure treatments due to location in each orchard, and moth counts were taken at this interval. The results of this study indicated that peak moth capture per night with "new" lures were not significantly different for any of the lure types (Figures 1a-d). Moth captures by "aged" lures did not consistently fall below that of a new lure for 3 weeks for the IPM Technologies and Scenturion lures, 3.5 weeks for the Trece lures, and 5 weeks for the Biolures.

Objective 2, San Jose scale. San Jose Scale has become an increasing problem for almond growers in the southern San Joaquin Valley. This work was begun in 1997 by James Brazzle and Walt Bentley, and was continued through this year, primarily in Kern County, with the goals of developing sampling information on the scales using pheromone traps and sticky tapes in orchards under differing insecticide programs, monitoring parasitoid populations on the sticky traps in these orchards, and evaluating the influence of various nitrogen rates applied to almonds on San Jose scale abundance. Additionally, the seasonal development of scale was used to provide information to farmers and pest control advisers in Kern County. Nine orchards have been monitored for scales, and these are listed on Table 2. History of pesticides used in these orchards has also been determined.Each of the orchards was monitored with four San Jose Scale pheromone traps placed on February 25, 1999. Trece Inc. San Jose scale rubber septa lures were used and replaced every four weeks during the study. The San Jose scale sticky traps were replaced at each visit. San Jose scale, *Encarsia perniciosi*, and *Aphytis spp* were monitored each week through November.

Additionally, four of the orchards were monitored for adult male scale to try to determine the relationship of pheromone trap catches to scale crawlers. In each of these orchards, 6 tent traps baited with Pherocon® SJS pheromone lures were monitored. In two trees within the row, one on each side of the tree with the trap, a single limb, selected at head height, was selected for monitoring crawlers. A one inch wide band of double sided sticky tape was placed around the limb and sampled weekly to determine crawler density. The comparison of traps to sticky bands will continue in 2000 as a MS student project under my direction at UC Davis.

Table 2. Locations of orchards being monitored in Kern County San Jose Scale study.

Orchard number	Name	Location
1	Rosedale	Stockdale Ranch, Bellevue Rd.
2	Shafter #1	Riverside St.
3	Shafter #2	Rosales, Palm Ave.

4	Wasco #1	Amcal, McCombs Rd.
5	Delano	Billings Rd.
6	Peterson	Peterson Rd., McFarland
7	Buttonwillow	Tracy Ave., Buttonwillow
8	Wasco #2	Tut Bros., Schofield Ave.
9	Randall	Zerker Ave., Shafter

Each of the four orchards used an organophosphate plus oil dormant spray. One orchard also used two organophosphate sprays during the growing season applied to control other insect pests. The first spray was made in May (Lorsban) and the second spray in late July (Guthion). Table 3 presents the seasonal pheromone trap catches for male SJS, *Encarsia perniciosi,* and *Aphytis spp.* in these orchards. This is the second year that these orchards have been monitored in detail, so conclusions regarding the influence of May and July sprays on the abundance of *Encarsia* would be premature. However, there does appear to be some trend toward reduced *Encarsia* abundance in the orchard where spring and summer sprays were applied. Interestingly, there appears to be little impact on the parasitoid, *Aphytis*. Data on crawler abundance will also be evaluated from two of these orchards after trapping concludes for this year.

Table 3. Seasonal pheromone trap catches of male San Jose scale, *Encarsia*, and *Aphytis*, Kern County, 1999.

Orchard	Dormant OP + Oil	May OP	July OP	Total SJS/Year	Total *Encarsia*/ Year	Total *Aphytis*/ Year
1	Yes	No	No	1630	674	54
2	Yes	No	No	2596	1641	41
3	Yes	No	No	2208	3789	44
4	Yes	Yes	Yes	1948	51	83

The biofix dates and generations for San Jose scale were determined for each of the orchards from the trap captures and degree-days calculated for associated weather data taken from the UCIPM Website (Table 4). The generations determined will be used to differentiate peaks for each generation as well as total moth and crawler capture for each generation for the regression analysis.

Table 4. San Jose scale biofix dates for each generation. Weather data for calculation of degree-days were obtained from the UCIPM Website for Shafter (Vetsch, Randall and Peterson orchards) and Lost Hills (Buttonwillow orchard).

	Date of beginning of each generation				
Orchard	1st	2nd	3rd	4th	5th
Vetsch	03/22/99	06/01/99	07/11/99	08/15/99	09/26/99
Buttonwillow	03/09/99	06/14/99	07/23/99	09/04/99	10/20/99
Randall	03/23/99	06/01/99	07/11/99	08/16/99	09/27/99

Peterson	03/23/99	06/01/99	07/11/99	08/16/99	09/27/99

Data for trap captures and associated sticky tape captures for the orchards are presented on Figures 2-5. In the Vetsch orchard, San Jose scale abundance was lower in the dormant treated plots than in the plots that did not receive a dormant treatment (Figures 2a-d). Parasitism was also higher in the untreated plots, but it this could be the result of higher scale populations as well. Following this orchard into the next season it will be interesting to see if the greater numbers of parasites will translate into better control of the scales. San Jose scale crawler numbers are always lower on sticky tape samples than are male scales on pheromone traps. It is assumed that since sticky tapes capture crawlers present on a given area of bark, these counts should be more accurate as long as there is sufficient replication so as to reduce variability. Figures 2-5 show paired samples of scale abundance in pheromone traps and on sticky bands. In general, orchards (and parts of orchards) with higher scale densities also appear to have higher numbers of crawlers captured on the sticky bands, and the patterns in the first and second generations seem to follow one another. The exception to this is the Randall orchard. The relationship between traps and sticky tapes is not as clear in later generations. Increased replication from orchards that are being monitored in 2000 will provide sufficient data to test our hypothesis concerning the relationship between sampling methods in the first and second generations.

We had planned to repeat control trials for San Jose scale with James Brazzle in 1999, but this proved impossible since he resigned his Kern County CE position. A trial comparing the registered pesticides diazinon, spinosad (Success), esfenvalerate (Asana), dormant oil alone against an untreated check for control of San Jose scale and impacts upon scale parasites was, however, conducted by UC Advisors Walt Bentley and Lonnie Hendricks near Livingston in Merced County, and supported by this project. Figure 6 shows the total number of San Jose scale males captured in pheromone traps during the season from each treatment, and the total number of *Encarsia* sp. Parasites captured in the same traps. The results show that a dormant application of the pyrethroid Asana resulted in lower parasite densities than did the otherr treatments. The implications of this are significant if the scale popualtions are disrupted as a result of these applications. Figure 7 shows the densities of San Jose scales more clearly. All treatments resulted in lower San Jose scale populations when compared to the untreated comtrol.

Unfortunately, due to cooperator error, nitrogen fertilization was applied uniformly over the 1999 test plot where we had hoped to determine the influence of nitrogen on San Jose scale crawler abundance. In 1998, two treatments were investigated, 0 units of nitrogen and 170 units of nitrogen, each replicated five times. Individual plots were one acre in size and two San Jose scale sticky traps were placed in each plot. Seasonal male flight abundance from March 3 through September 23 was evaluated, but no significant difference was observed. The number of males trapped in the 0 nitrogen treatment averaged 1758.6 while in the 170 unit nitrogen treatment averaged 1226.6. We do not intend to pursue this aspect of the scale study any further, but will instead concentrate on a study of spray volumes as it impacts coverage and efficacy.

Objective 3, Peach Twig Borer. The susceptibility of peach twig borers to diazinon and esfenvalerate (Asana) was studied in 7 orchards in 1997. Because of low population densities at many of the sites in 1998 and 1999, we could not obtain sufficient numbers of larvae to perform bioassays in as many sites as in 1997. Peach twig borer larvae were removed from the shoot strikes which were gathered from each field site, and placed into individual capped containers containing a standard bean diet. A drop of one of 5 sequential dosage rates of diazinon or esfenvalerate mixed in acetone was applied topically to each larva. The larvae were held at 68°C in an environmental chamber for 48 hours before assessing mortality. LD50 and LD90 values and slopes of the dose mortality lines were calculated for each of the sites (Figures 8 and 9).

All of the peach twig borer populations sampled were susceptible to diazinon, but there was some variability in the range of susceptibility, with LD50 values ranging from less than 200 ppm (Arbuckle and Williams) to around 500 ppm of the Kern Co. orchards.

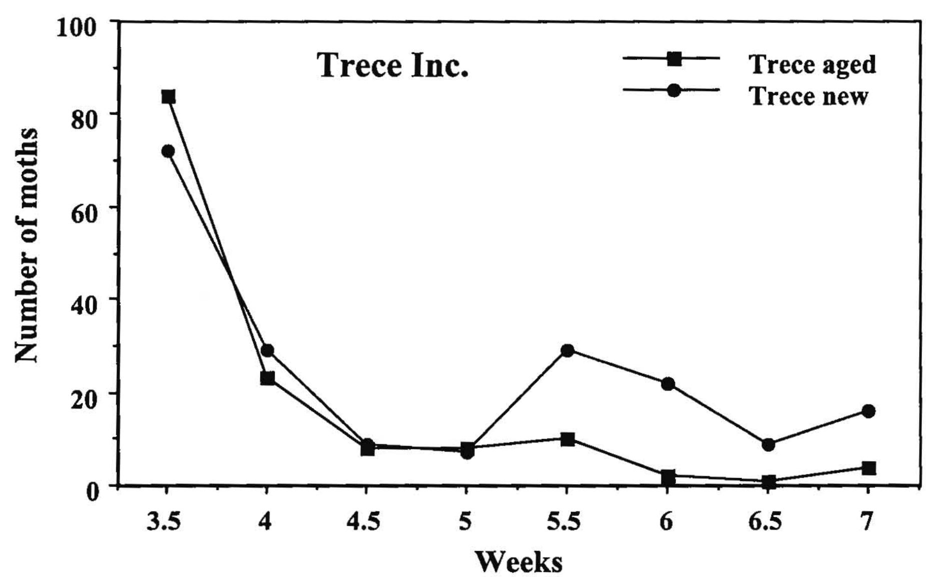
Most of the peach twig borer populations sampled were susceptible to esfenvalerate in 1997 and 1998, with virtually all of the orchards in the range of LD50 values of about 0.5 to 1.5 ppm. However, our Sacramento Valley sites near the Sacramento River in each of the 3 years, and one site each in Kern County and Stanislaus County site had LD50 values much higher than those observed at the other sites and in previous years (Table 5). The suspect Sacramento Valley site have a history of pyrethroid use dating back 6 years. Growers who have been using pyrethroids without interruption as dormant or in season sprays for several years should carefully monitor peach twig borer twig strikes in their orchards to detect unexpected increases in populations, and consider using *Bacillus thuringiensis* bloom sprays or spinosad dormant or bloom sprays instead of the dormant spray for peach twig borer control.

Table 5. Susceptibility of overwintered peach twig borer larval populations collected from almond twigs to esfenvalerate (Asana).

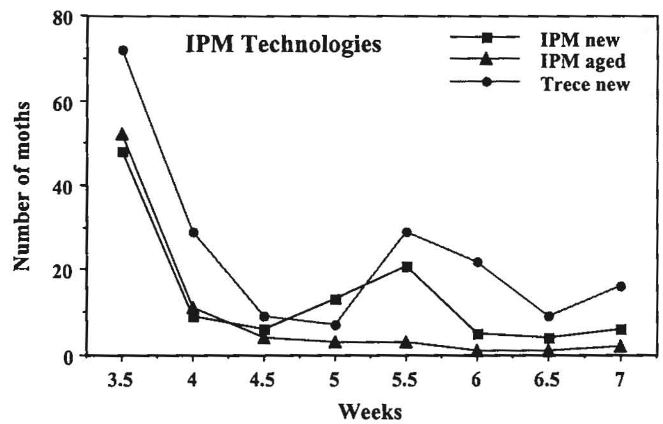
Year	Location	LD50 (ppm)	LD90 (ppm)	Slope
1997	Livingston	1.66	22.98	35.07
1997	Denair	1.49	18.69	36.38
1997	Dixon	0.65	17.72	27.81
1997	Arbuckle	1.53	20.33	37.47
1997	Williams	0.84	14.47	29.02
1997	N. Kern	0.48	11.46	32.44
1997	Kern	3.93	25.06	49.69
1997	Chico	9.01	23.48	96.11
1998	Shafter	0.74	7.55	39.71
1998	Chico	3.31	38.84	37.39
1998	Orland	0.15	0.92	51.57
1999	Kern	3.04	3.91	367.93
1999	Modesto	3.63	4.54	414.15
1999	Hamilton City	12.43	292.01	29.19

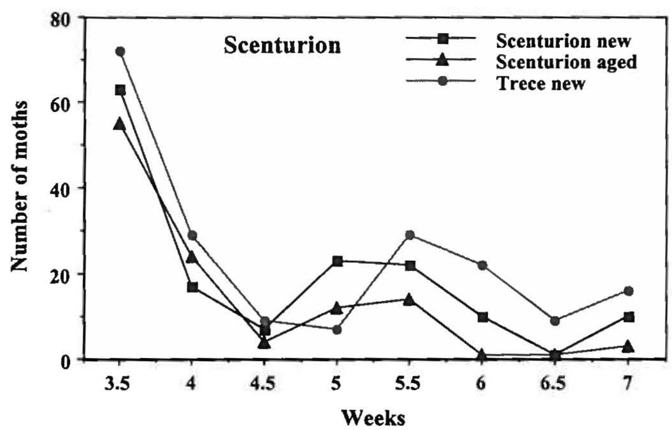
Figures:

Figure 1a. Comparison of new and 3 week aged peach twig borer red rubber septa lures produced by Trece Inc.



Figures 1b-d. Comparison of new and 3 week aged peach twig borer red rubber septa lures produced by IPM Technologies, Scenturion Inc. and Consep Membranes (Biolure) in comparision to each other and to a new Trece Inc. red rubber septa.





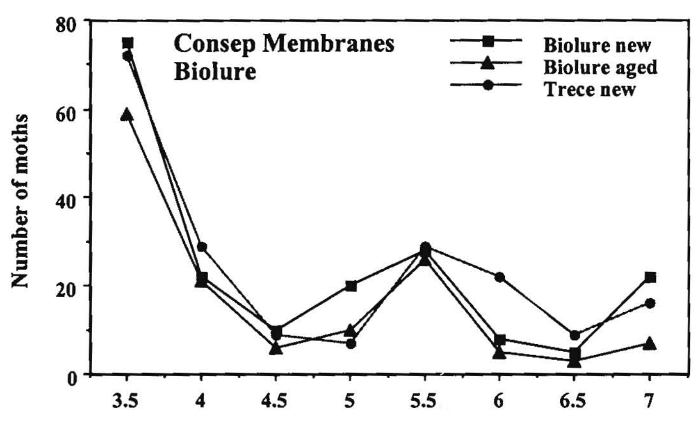


Figure 2a. Average number of SJS scale males per trap in the treated plots in the Vetsch orchard.

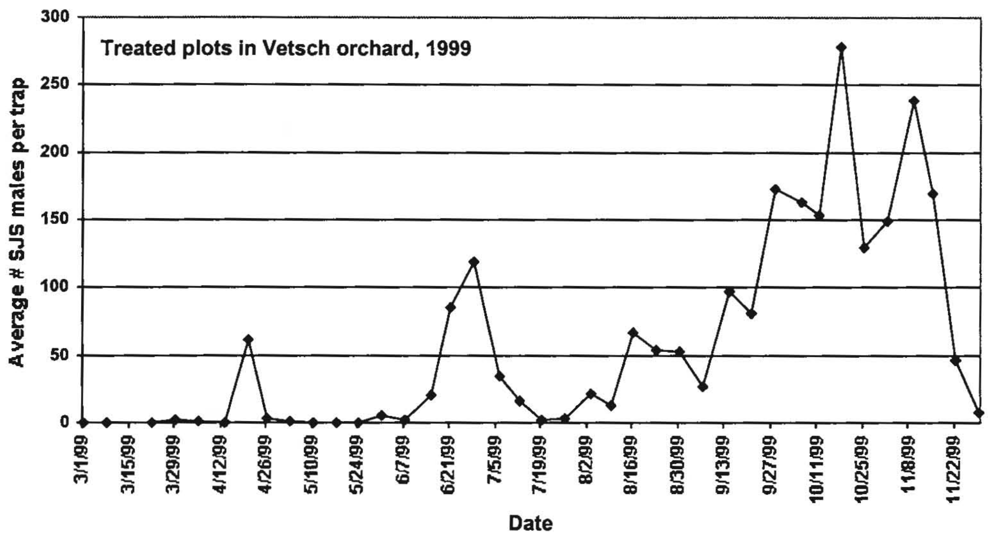


Figure 2b. Average number of SJS scale males per trap in the untreated plots in the Vetsch orchard.

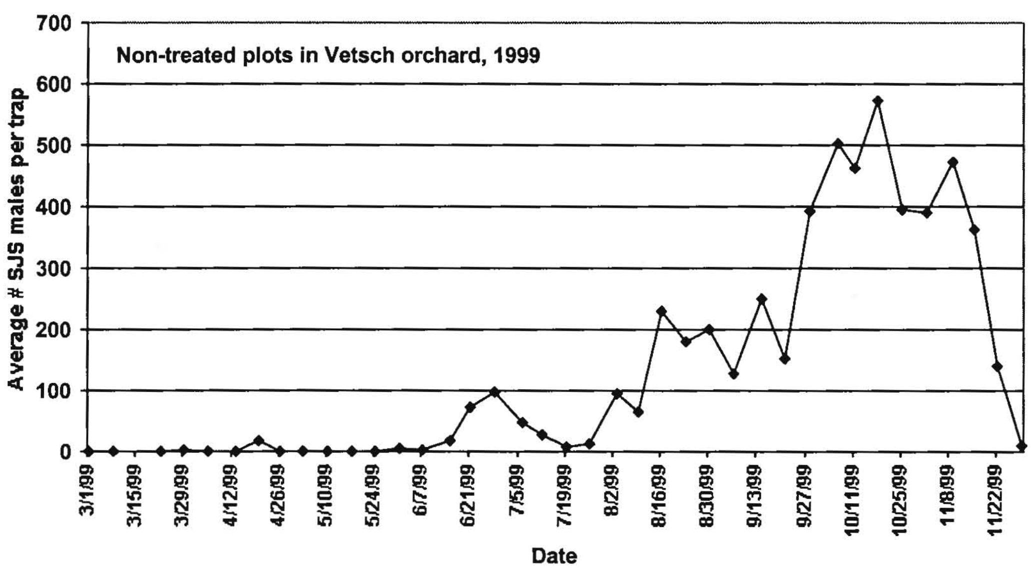


Figure 2c. Average number of SJS scale crawlers per sticky tape in the treated plots in the Vetsch orchard.

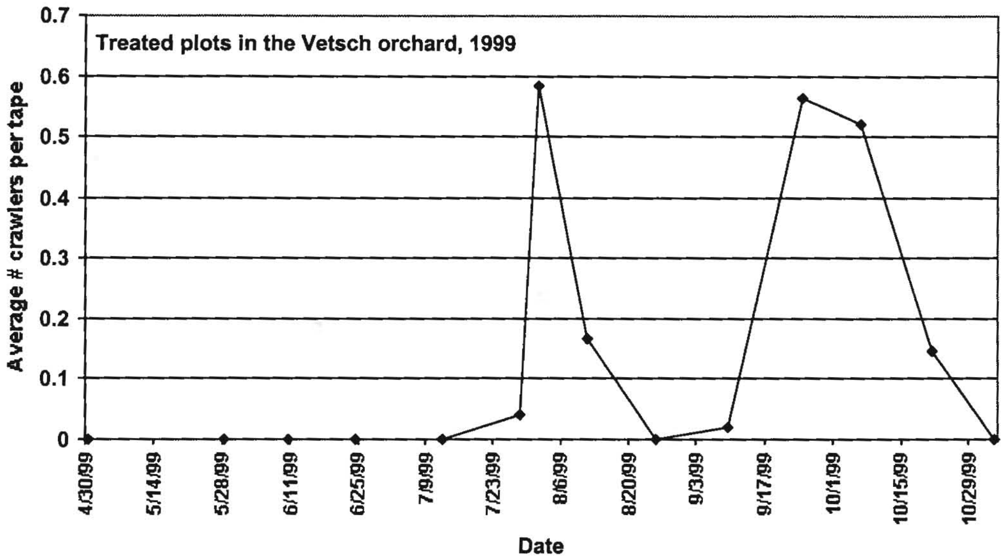


Figure 2d. Average number of SJS scale crawlers per sticky tape in the untreated plots in the Vetsch orchard.

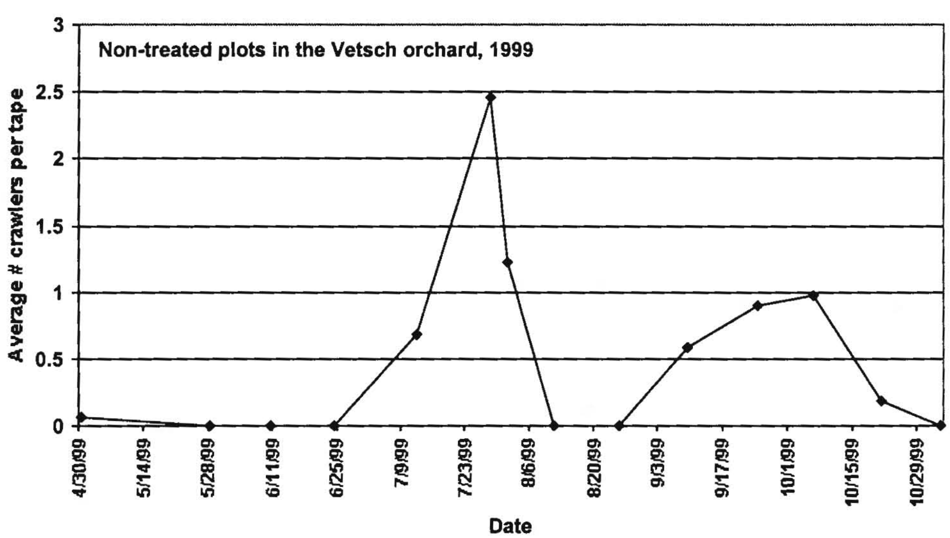


Figure3a. Average number of SJS scale males per trap in the Peterson orchard.

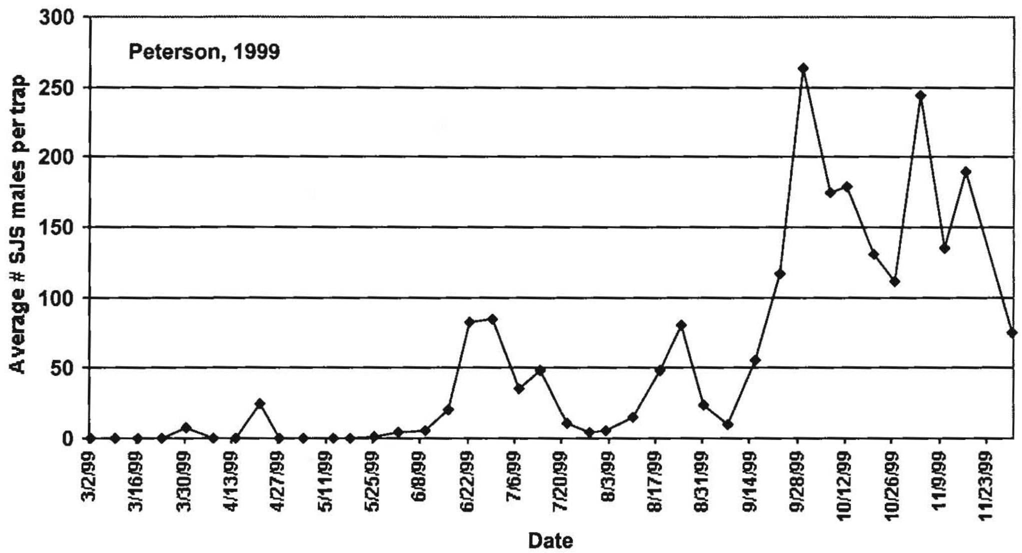


Figure 3b. Average number of SJS scale crawlers per sticky tape in the Peterson orchard.

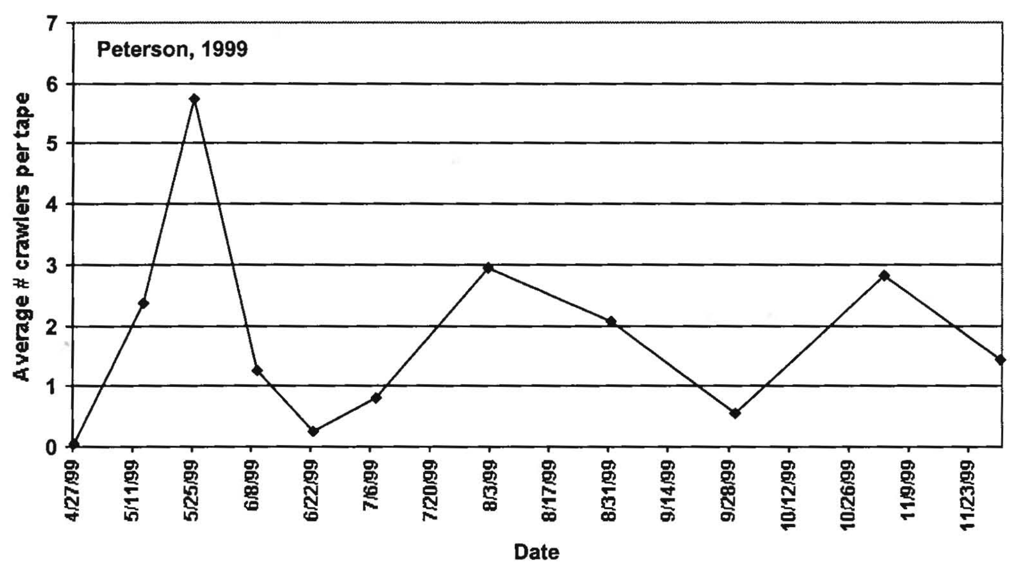


Figure 4a. Average number of SJS scale males per trap in the Randall orchard.

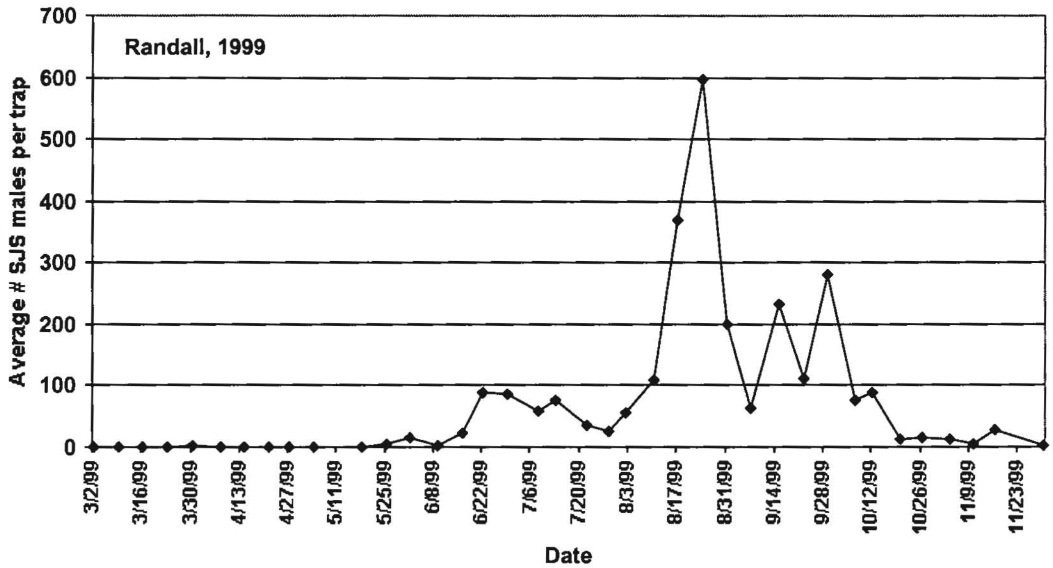


Figure 4b. Average number of SJS scale crawlers per sticky tape in the Randall orchard.

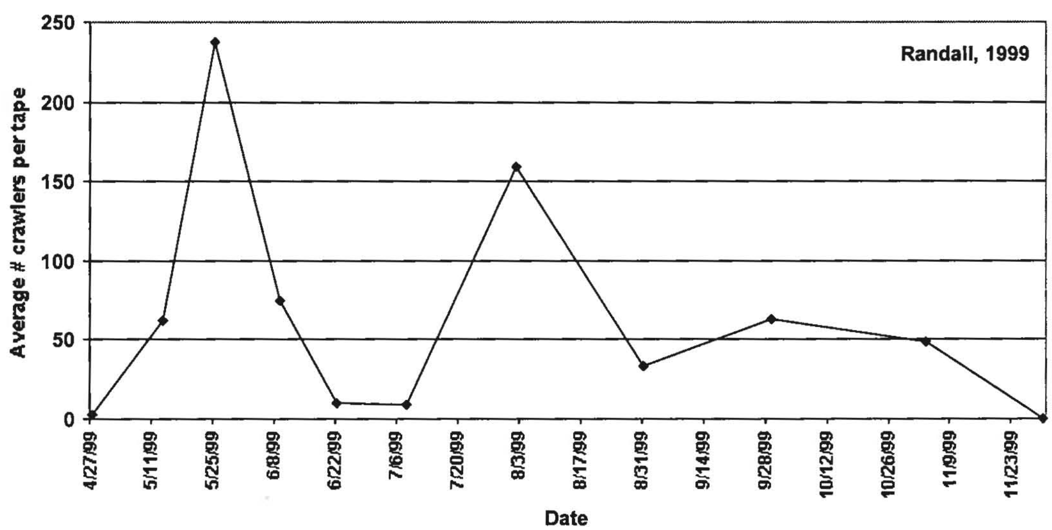


Figure 5a. Average number of SJS scale males per trap in the Buttonwillow orchard.

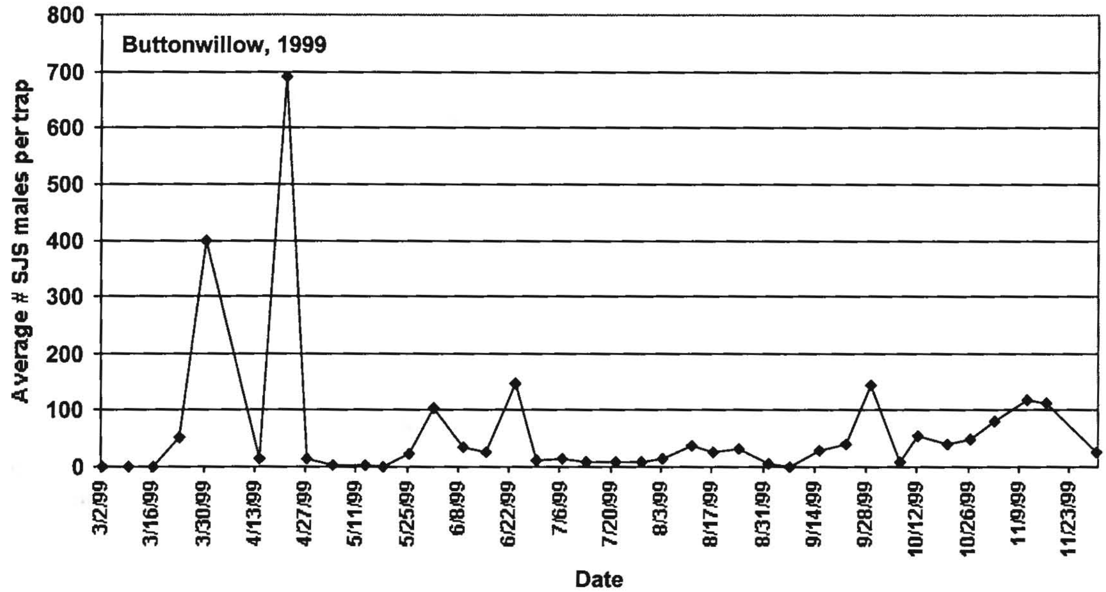


Figure 5b. Average number of SJS scale crawlers per sticky tape in the Buttonwillow orchard.

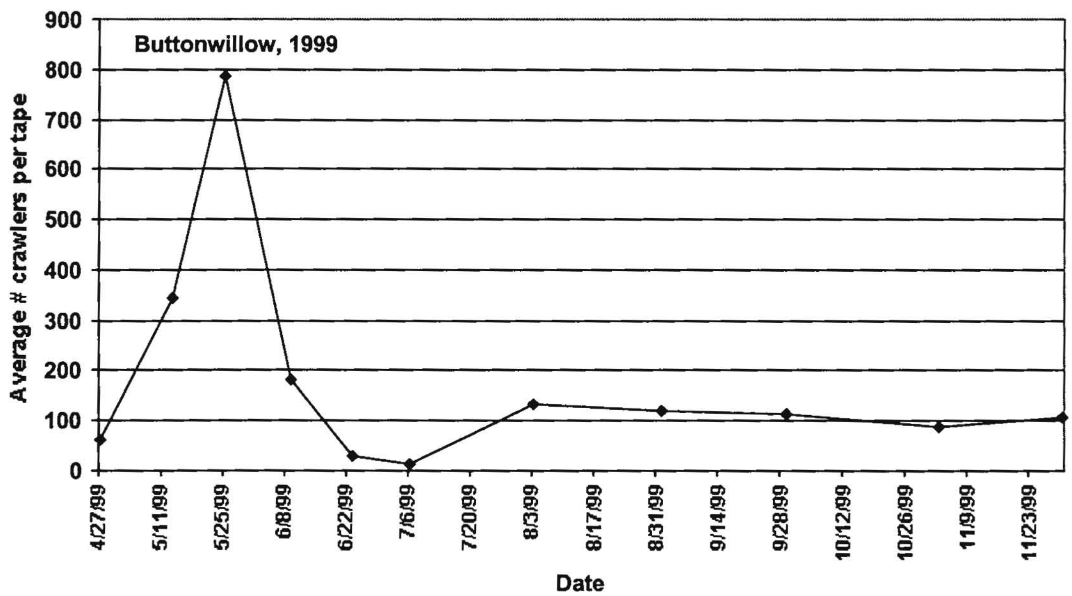


Figure 6. Total San Jose scale males and Encarsia sp. Parasites on San Jose scale pheromone traps in plots treated with label rates of diazinon, Success, Asana and oil in the Arakelian Farms orchard, Merced Co., 1999.

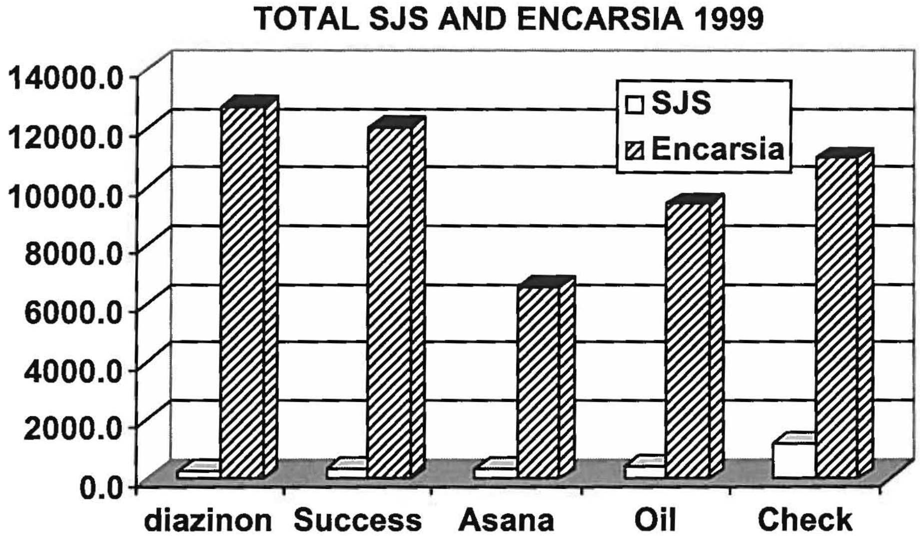
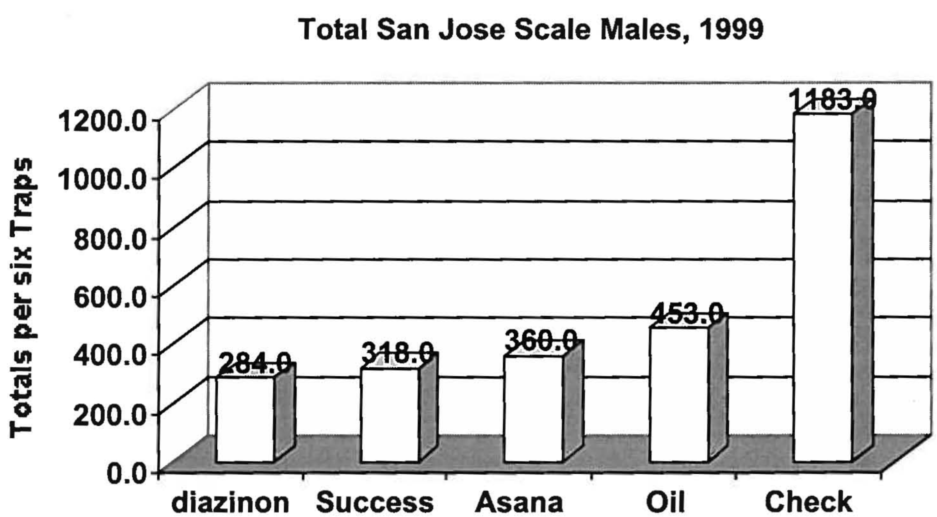


Figure 7. Total San Jose scale males captured on six pheromone traps in plots treated with label



rates of diazinon, Success, Asana and oil in the Arakelian Farms orchard, Merced Co., 1999.

Figure 8. Probit lines for peach twig borer susceptibility to esfenvalerate (Asana) in several almond growing areas of California, 1997-99.

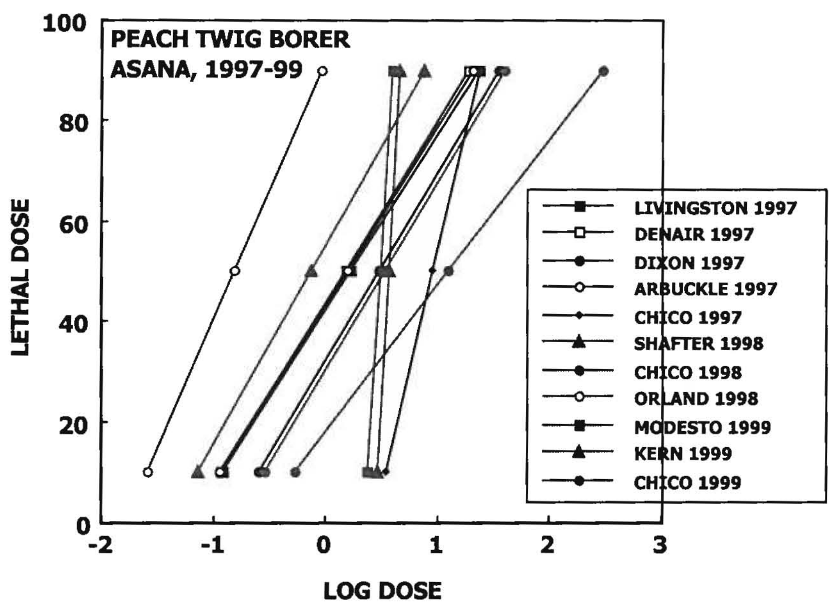
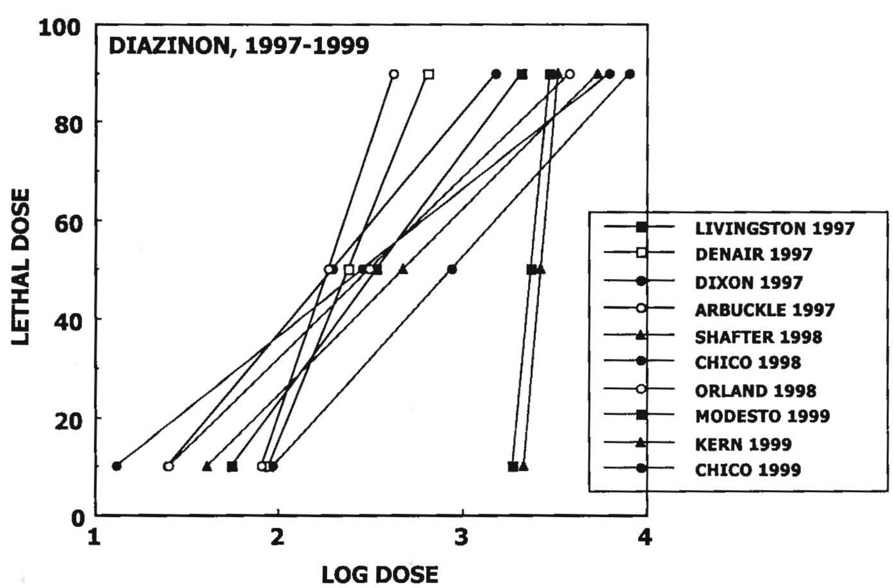


Figure 9. Probit lines for peach twig borer susceptibility to diazinon in several almond growing areas of California, 1997-99.



Publications related to project, 1999:

Zalom, F. G., and M. Oliver. 1999. Dormant treatment options. Nut Grower Magazine. 8(1): 16-24.

Zalom, F. G., M. Oliver and D. Hinton. 1999. Dormant treatment options. Pacific nut producer. 5(2): 22-24.

Zalom, F. G., M. Oliver and D. Hinton. 1999. Dormant treatment options. Almond Board of California Dormant Spray News. Summer, 1999. 5 pp.

Zalom, F. G. and M. Oliver. 1999. Dormant spray calculator. UCIPM World Wide Web Site. http://www.ipm.ucdavis.edu.

Roltch, W. J., F. G. Zalom, A. J. Strawn, J. F. Strand and M. Pitcairn. 1999. Evaluation of several degree-day estimation methods in California climates. Intl. J. Biometeorol. 42:169-176.