Pest Management Alliance Program
April 2011 Final Progress Report

Project Title: Developing Biologically Integrated Orchard Systems (BIOS) and Corresponding Market Certification Rewards for Canning Peaches in the San Joaquin Valley

Principal Investigator: Marshall W. Johnson

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1) Statement of Project Objectives

1. Reduce the perceived need and use of PQPA Priority I materials (organophosphates and carbamates) in California canning peaches by 20% through demonstration and outreach to increase adoption of reduced risk practices and materials for key pests;

2. Increase and hasten grower transition to more integrated pest management methods through applied on-farm research on pest population dynamics and conservation of key beneficial species.

3. Evaluate costs to growers of adopting reduced-risk production practices and grower perception toward adopting environmentally-responsible product certification.

2) Participants currently involved in the project

Principle Investigators

- Dr. Marshall W. Johnson, CE Specialist & Entomologist, University of California, Riverside
- Dr. Hannah Nadel, University of California, Riverside, Research Specialist
- Walter Bentley, IPM Entomologist and UC Cooperative Extension (UCCE) Area IPM Advisor, University of California Statewide IPM

Field and Lab Assistants

- Andrew Molinar (SRA I), Dept of Entomology, University of California, Riverside
- Steven Weir (Lab Asst I), Dept of Entomology, University of California, Riverside
- Kyle Schlegel (Lab Helper I), Dept of Entomology, University of California, Riverside
- Martha Gerik (Lab Asst II), Dept of Entomology, University of California, Riverside

UCCE Farm Advisors

- Maxwell Norton, Merced County
- Roger Duncan, Stanislaus County

Cooperators

- Dr. Robert Bugg, Senior Analyst in Agricultural Ecology at UC Davis
- Dr. Kent Daane, Cooperative Extension Specialist**,** Department of Environmental Science, Policy, and Management, UC Berkeley
- Dr. Patrick Weddle, Pacific Biocontrol Corporation, Placerville, CA
- Dr. Steve Balling, Del Monte Foods
- James P. (Pat) McCaa, Agricultural Systems Manager of Del Monte Foods
- David Visher, California Program Manager of Food Alliance

Growers:

- Glenn Arnold and Craig Arnold. Glenn Arnold, Tel: (209) 761-0963, Email: arnoldgs@pacbell.bet.
- Darrell DiGiovanni, Farm Management Inc., 11016 N Ballico Ave., Ballico, CA, 95303. Tel: (209) 667-1011. Fax: (209) 667-1013.
- Harvinder Kullar, 12246 Newport Rd., Ballico, CA, 95305. Tel: (209) 324-2750.
- Sid Long and Scott Long, Superior Fruit Ranch, 4801 E. Whitmore Ave., Ceres, CA 95307. Tel: (209) 538-1166.
- José Perez, 14510 Bradbury Rd., Delhi, CA, 95315. Tel: (209) 678-0879
- Blaine Yagi, Yagi Brothers Produce, Inc., 5614 Lincoln Blvd., Livingston, CA, 95334. Tel: (209) 761-3561.

Pest Control Advisors

- Lonnie Slaton, J. R. Simplot Co., 10985 Ballico Ave., Ballico, CA 95303. Tel: (209) 667-6013.
- John Johnston, Mid Valley Ag. Services, 11019 Eucalyptus Ave., Livingston, CA 95334. Tel: (209) 394-7981.
- Garrett Nydam, Mid Valley Ag. Services, 2106 Santa Fe Ave, Hughson, CA 95326. Tel: (209) 883-4900.
- Don de Boer, Mid Valley Ag Services, 11019 Eucalyptus Ave., Livingston, CA 95334. Tel: (209) 394-7981.

- Bill Thompson, Four Seasons Ag Consulting, Inc., 12230 Livingston Cressey Road, Livingston, CA. 95334. Tel: (209) 988-6388.

3) Outreach meetings held

December 4, 2008. *North San Joaquin Valley Cling Peach Seminar*, Modesto, CA. 57 attendees. Presented "Control Strategies and New Materials for Insect Control in Peaches". Walt Bentley, IPM Entomologist and UCCE Area IPM Advisor, University of California Statewide IPM.

January 7, 2009. *14th Annual Sacramento Valley Cling Peach Day*, 142A Garden Highway, Yuba City CA 95991, 57 attendees. Presented "Insect Control Strategies in Peaches" and Video – "Managing oriental fruit moth using sunflower plantings to augment *Macrocentrus ancylivorus*." Hannah Nadel, Associate Entomology Specialist, UC Riverside, and Marshall Johnson, Extension Entomologist, UC Riverside

May 6, 2009. *2009 Tree and Vine Update Breakfast*. 29 attendees. Modesto (Stanislaus County), CA. Hannah Nadel and Walt Bentley discussed aspects of the Cling Peach PMA Project and reported on progress to date in setting up cooperators and initiation of sampling programs.

June 19, 2009. *Peach IPM In-Field Day*. 18 attendees. Superior Fruit Ranch, Ceres (Stanislaus County), CA. Various topics covered including: a) Biology, monitoring and management of OFM; PTB and leaf rollers in peach orchards; b) Use of mating disruption for OFM management; c) Monitoring orchards under mating disruption with bait buckets and shoot strikes; d) Hands-on training for counting shoot strikes and identifying pests; and e) Demonstration of release of *M. ancylivorus* parasitic wasps onto sunflowers for biological control of OFM. Speakers included: Walt Bentley, UC Cooperative Extension IPM Advisor, Kearney Ag Center; Marshall Johnson; UC Extension Entomologist, UC Riverside; Hannah Nadel; Associate Entomology Specialist, UC Riverside; Roger Duncan, UC Cooperative Extension Pomology Advisor, Stanislaus County; and Maxwell Norton, UC Cooperative Extension Advisor, Merced County.

June 19, 2009. *Peach IPM Field Day*. 16 attendees. Harvindar Kular Ranch, Ballico (Merced County), CA. Topics presented included: a) Trapping, day-degree models; b) Overview of the Peach Pest Management Alliance Project; c) Biology, monitoring and management of OFM, PTB and leaf rollers in peach orchards; d) Sprayable pheromone and pheromone dispenser strategies for Oriental Fruit Moth mating disruption in peach orchards; e) Monitoring orchards under mating disruption with bait buckets and shoot strikes; and f) Release of *M. ancylivorus* parasitic wasps for biological control of OFM. Speakers included: Walt Bentley, UC Cooperative Extension IPM Advisor, Kearney Ag Center; Marshall Johnson; UC Extension Entomologist, UC Riverside; Hannah Nadel; Associate Entomology Specialist, UC Riverside; and Maxwell Norton, UC Cooperative Extension Advisor, Merced County.

November 6, 2009. A summer "wrap-up" meeting was held at the UC Cooperative Extension Office at Merced to review the results of the summer activities with the participating growers and PCAs. Project personnel attending the meeting were Marshall Johnson, Hannah Nadel, Walt Bentley, Steven Weir, and cooperators Roger Duncan and Maxwell Norton.

November 12, 2009. Reported progress to meeting of the Pest Management Alliance Committee and California Dept of Pesticide Regulation in Sacramento, CA. Presentation by Johnson, M. W., H. Nadel, and Walter Bentley given on "Developing Biologically Integrated Orchard Systems & Corresponding Market Certification Reward for Canning Peaches in the San Joaquin Valley."

December 3, 2009. Northern San Joaquin Valley Cling Peach Seminar, Modesto, 3 December 2009. Presented the following presentations: "Oriental Fruit Moth Parasite Video" and "Alternative Strategies for Managing OFM and Other Peach Pests," by Marshall Johnson and Walt Bentley, respectively.

October 13, 2010. A review of the Peach Pest Management Alliance was provided ["Managing Oriental fruit moth in canning peach orchards in the San Joaquin Valley of California."] by Marshall Johnson to an *Introduction to Environmental Sciences* class [Andrea Joyce, Instructor] at UC Merced, CA.

November 2, 2010. Lunch meeting held in Turlock, CA, with PMA-Participating Growers and Consultants. Hour-long review of the results of the 2010 summer program. The review focused on infestations of Oriental fruit moth and peach twig borer. Most of the cooperating growers and consultants attended the meeting. Project personnel attending the meeting were Marshall Johnson, Walt Bentley, Andrew Molinar, Steven Weir, and cooperators Roger Duncan and Maxwell Norton.

November 9, 2010. 2010 Cling Peach and Pear Combined Workgroup Meeting held in Davis, CA. An update on the Peach Pest Management Alliance was provided by Walt Bentley to the attending workgroup members. Project personnel attending the meeting were Walt Bentley and cooperators Roger Duncan and Maxwell Norton.

November 18, 2010. Reported progress to meeting of the Pest Management Alliance Committee, California Dept of Pesticide Regulation, Sacramento, CA. Presentation Walter Bentley and Marshall Johnson given on "Developing Biologically Integrated Orchard Systems for Canning Peaches in the San Joaquin Valley."

December 15, 2010. An update on the project was provided at the North San Joaquin Valley Cling Peach Day, Modesto. Walt Bentley gave a presentation called "Peach IPM Project, PTB, OFM, Other Pests". Project personnel attending the meeting were Walt Bentley and cooperators Roger Duncan and Maxwell Norton.

March 8, 2011. An update on the Peach Pest Management Alliance was provided ["Recent Stone Fruit Entomology Research in the San Joaquin Valley."] by Marshall Johnson to the Merced College Spring Semester Pest Management Course, Merced, CA.

4) Activities and progress

Objective	Tasks, Milestones or Deliverables/Outcomes (related to each objective)	Begin Date	End Date
Administration	**Project planning meeting** • The initial project planning meeting was held on 5 December 2008 at UC Davis. • A meeting with most of the non-grower participants and the grant manager (Mark Robertson) was held on 6 January 2009 at Modesto. • Another meeting was held on 27 February 2009 with non-grower participants in Modesto.	**Sept-08**	**Sept-08**
Demonstration and Outreach	**Establish plots in growers' orchards** • Two plots each were established in each of six growers (5 in Merced County and 1 in Stanislaus County). In three of the orchards, one treatment plot was used for mating disruption (of Oriental fruit moth) trials and compared to a conventional management treatment (no mating disruption). In the remaining three orchards, two plots at each orchard were established in which mating disruption of Oriental fruit moth was conducted. In one of these plots, the parasitoid *M. ancylivorus* was released and conserved by planting sunflowers to produce sunflower moth larvae on which the parasitoid would overwinter. Of these orchards, the one in Stanislaus county also included a conventional management orchard to compare with the mating disruption and *Macrocentrus* conservation plots.	**Oct-08**	**Feb-09**
Demonstration and Outreach	**Continually monitor, support, and re-establish plots** **2009** • Plots established in February 2009 were continuously monitored from March until fruit were harvested in late summer 2009.	**Feb-09**	**Nov-10**

- Arthropod species monitored included oriental fruit moth (OFM), peach twig borer, omnivorous leaf roller (OLR), oblique banded leafroller (OBLR), and San Jose scale, *Grapholita molesta*, with pheromone traps (and bait bucket traps for OFM). Spider mites and associated predators were monitored using leaf samples. Spider mite infestations were rated and predator mites were counted. Also monitored were male San Jose scale populations and associated parasitoids (*Aphytis mytilaspidis* and *Encarsia perniciosi*).

2010

- All blocks and plots that were monitored in the 2009-2010 season were again followed except for the one near in Livingston. That block was taken out of production, and we initiated monitoring in a new block (37º 24' 24” N 120º 43' 06” S) that was near the original block. However, around August 2010, we found out that the conventional plot that we were following had been treated identical to the Mating Disruption plots and we lost one of our replicates for conventional treatments.
- Spurs were checked for the presence of San Jose scale on 15 January 2010. Infestation percentages ranged from 0 to 59% through the six blocks
- Monitoring for San Jose scale using pheromone traps was initiated in all plots on 22 February 2010. Counts were taken weekly until 27 September 2010.
- Pheromone traps for Oriental fruit moth and omnivorous leafroller were placed in blocks in early March 2010. Pheromone traps for peach twig borer and oblique-banded leafroller were placed in blocks in mid to late March 2010.
- Monitoring for spider mites was initiated on 24 June 2010 and continued until 27 September 2010. This included visual observations in the field and counts of mites on the leaves under a microscope.

Demonstration and Outreach	**Host introductory grower meeting/workshops for Fresno and Stanislaus Counties** • Note that instead of working in Fresno County, we choose to work in Merced County because of the numbers of canning peach growers there • Northern San Joaquin Valley Cling Peach Seminar in Modesto (Stanislaus Co.) on 4 December 2008 • 14th Annual Sacramento Valley Cling Peach Day, 142A Garden Highway, Yuba City, CA, on 7 January 2009 • Peach IPM In-Field Day. Superior Fruit Ranch, Ceres (Stanislaus County), CA, on 19 June 2009	**Feb-09**	**Mar-09**
Demonstration and Outreach	**Hold three seasonal informal training sessions for participating growers and PCAs on monitoring for pests and reduced-risk practices** • **December 4, 2008.** *North San Joaquin Valley Cling Peach Seminar*, Modesto, CA. • **January 7, 2009.** *14th Annual Sacramento Valley Cling Peach Day*, 142A Garden Highway, Yuba City CA 95991. • **6 November 2009.** A lunch time meeting was held for participating growers and PCAs to review the major achievements of the project. Merced, CA	**Nov-08**	**Jan-09**
Demonstration and Outreach	**OFM mating disruption research and demonstration** **2009** • Mating disruption tactics were initiated in orchards of cooperating growers during the period of ca. 27 February to 9 March 2009. Mating disruption continued throughout most of the season based on pheromone trap catches. A relatively recent technology for delivering OFM mating-disruption pheromone was used, which minimizes application time and lasts longer than other mating-disruption devices. The Isomate TT OFM ("TT" is short for "twin tube') consists of two plastic tubes joined at both ends, that store and release female sex pheromone.	**Feb-09**	**Aug-09**

<table>
<tr><td></td><td>All participating growers were provided with Isomate TT OFM dispensers for Oriental fruit moth mating disruption. Dispensers were hung in orchard blocks during February 2009.</td><td></td><td></td></tr>
<tr><td>Research and Demonstrate</td><td>Mite action threshold research

2009
No action on this task because mite populations extremely low. Mites and their predators were monitoring throughout the season. Spider mite densities did not begin to dramatically increase until the beginning of harvest or after harvest in the blocks monitored. However, based on grower / PCA decisions, most blocks were treated with miticides although early season mite densities were very low.
2010
Spider mite densities were very low in most of the 2010 blocks. It is unlikely that mite densities reached damaging levels in any blocks prior to harvest. As in 2009, most cooperators treated for mites before densities became severe to avoid high late season densities.</td><td>Mar-09</td><td>Oct-10</td></tr>
<tr><td>Research and Demonstrate</td><td>Monitor and compare beneficial insects and mites in IPM vs. conventional blocks

2009
Monitoring of key beneficial insects was initiated on 20 March 2009 and continued until harvest in Fall 2009. Species surveyed included OFM egg parasitoids and San Jose scale parasitoids (A. mytilaspidis and E. perniciosi). There were no significant differences in the levels of beneficial insects and predacious mites observed in the IPM vs. the conventional blocks.
2010
The 3-minute counts of natural enemies on the foliage that were employed in the 2009 season were discontinued in 2010.
Numbers of green lacewings in bucket traps,</td><td>Mar-09</td><td>Nov-10</td></tr>
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	parasitoids of San Jose scale on pheromone traps, and predators of spider mites on foliage samples were recorded during the 2010 summer season and were examined relative to potential differences in the IPM and conventional blocks.		
Demonstration and Outreach	**Host field days in Merced, Fresno, and Stanislaus Counties at demonstration farms and other venues for surrounding agricultural communities** • **May 6, 2009.** *2009 Tree and Vine Update Breakfast*. Modesto (Stanislaus County), CA. • **June 19, 2009.** *Peach IPM In-Field Day*. Superior Fruit Ranch, Ceres (Stanislaus County), CA.. • **June 19, 2009**. *Peach IPM Field Day*. Harvindar Kular Ranch, Ballico (Merced County), CA. • **November 6, 2009.** A summer "wrap-up" meeting was held at the UC Cooperative Extension Office at Merced, CA	**May-09**	**June-09**
Demonstration and Outreach	**Website on canning peach IPM available** • The establishment of a website was delayed because of the time required to initiate the project and accumulate results to post on the website. • At the end of summer 2009, we realized that we did not have much information to post on peach IPM that was not already covered at the UC IPM website. Our plans to provide new information on a) conservation of the OFM natural enemy, *M.s ancylivorus,* by using sunflower plantings; b) spider mite impacts on peach yields; c) the economic benefits of using mating disruption and reduced-risk pesticides; and d) the impacts of conventional pesticides on natural enemies were disrupted. No new information was available because a) OFM densities were so low that we could not find *Macrocentrus*-parasitized larvae in the study sites; b) most growers applied miticides that lowered spider mite populations to near-zero levels prior to harvest; c) some grower	**May-09**	**July-09**

	cooperators did not follow plans to use reduced-risk pesticides in mating disruption blocks (despite frequent communication on UC IPM recommendations), and d) no differences in natural enemy densities were found between the mating disruption and conventional pesticide blocks.		
Economic Evaluation	**Economic data collection from demonstration farms** • We met with growers and cooperators on 6 November 2009 in Merced, CA. Significant findings were discussed with the growers. Material and labor costs were collected via e-mail, Fax, or phone calls.	**Sep-09**	**Oct-09**
Research and Demonstrate	**Preliminary report and recommendations from research** • A preliminary report was submitted to Mark Robertson as part of the annual report due in September 2009. Highlights of the report follow. o IPM with mating disruption for OFM was demonstrated in six orchards in 2009 on a total of 90 acres, and extended to an additional 103 acres of peaches by one grower. Total peach acreage of participating growers, which is most likely to be impacted, exceeds 600 acres. o Organophosphates (OP) and pyrethroids were targeted for elimination from IPM demonstration blocks within demonstration orchards, to be replaced by mating disruption and biological control for OFM and by reduced-risk pesticides for OFM and other pests, if needed, as part of an overall IPM strategy. The OP phosmet (i.e., Imidan) was eliminated from 123 acres of canning peaches in the Ceres orchard and replaced by mating disruption and reduced-risk pesticides. o The other participating growers used pyrethroids, but no OPs in 2008. In 2009, reduction in synthetic pyrethroids was mixed; in some cases they were reduced, while in	**Oct-09**	**Jan-10**

	others they remained the same. The following are cases where they were reduced: a) the pyrethroids Asana and Warrior were eliminated from both IPM and conventional plots (20 acres) in the Livingston orchard, a 100% reduction (14 lb total) compared with 2008; b) in the Ballico-E orchard, the pyrethroids Asana and Warrior were reduced by 52% (6.9 lbs total) in the mating disruption block (10 acres) compared with the conventional block during the demonstration; and c) no pyrethroid was applied in blocks under mating disruption (20 acres) in Ceres during the demonstration, compared with 1.0 lb (total) of the pyrethroid Silencer in the 5.0 acre conventional block. o Reduced-risk products for insects and mites that replaced OPs and pyrethroids included the mating disruption device Isomate TT-OFM, which emits OFM female sex pheromone and confuses the males, thereby preventing or delaying mating. The product is effective for about 6 months. They also included specific growth regulators, ovicides, and spinosad, which were alternated to avoid build up of insecticide resistance in pest populations. o Fruit damage due to OFM was minimal or absent at all monitored blocks during 2009 regardless of pest control practice. This suggests that mating disruption was equal to conventional practices with respect to effective OFM management. o Challenges encountered during the project included general resistance by growers using FQPA Priority I products to try mating disruption, which led us to engage cooperating growers that were already using some reduced-risk practices rather than those preferring the Priority I products. A problem occurred in the Ballico West orchard, where the pest management plan for the demonstration orchards was not adhered to, leading to a May application of pyrethroids in the block under IPM and mating disruption. Later in 2010, we realized that pesticide		

	application regimes had not changed in some of the mating disruption plots and that we did not have as many plots that could be described as mating disruption + reduced risk pesticides. In some plots, it was mating disruption and conventional pesticides or more commonly mating disruption, conventional pesticides (i.e., pyrethroids), and some reduced risk pesticides. o Given the above, the relative cost of conventional and IPM materials varied among orchards at four sites. IPM materials were substantially more costly than conventional materials at the Ballico East and Ballico West sites (about 1.6 to 1.8-fold) with much of the difference being related to the cost of the pheromone emitters and the labor to place them in the orchard. At Livingston and Ceres, costs were similar in the IPM orchard versus the conventional orchards. o We recommended continuation of the use of sunflower strips to reduce OFM infestations. Additional information is needed on the specific impact of *Macrocentrus* on the OFM population.		
Demonstration and Outreach	**Hold three seasonal informal training sessions for growers and PCAs on monitoring for pests and reduced-risk practices** • No training sessions were held during this time period because we wanted to wait and present an overall assessment of our results after the 2010 production season had ended. • During 2009 and 2010, video recordings were made of various subjects in order to produce informational videos on a variety of subjects of interest to peach growers and associated consultants.	**Feb-10**	**Aug-10**
Demonstration and Outreach	**Present at grower meeting in Stanislaus, Fresno Counties** • **November 12, 2009.** Reported progress to meeting of the Pest Management Alliance Committee, California Dept of Pesticide	**Feb-10**	**Mar-10**

	Regulation, Sacramento, CA. • **December 3, 2009.** *Northern San Joaquin Valley Cling Peach Seminar*, Modesto, 3 December 2009. • **October 13, 2010.** A review of the Peach Pest Management Alliance to an *Introduction to Environmental Sciences* class [Andrea Joyce, Instructor] at UC Merced, CA. • **November 2, 2010.** Lunch meeting held in Turlock, CA, with PMA-Participating Growers and Consultants. • **November 9, 2010.** *2010 Cling Peach and Pear Combined Workgroup Meeting* held in Davis, CA. • **November 18, 2010.** Reported progress to meeting of the Pest Management Alliance Committee, California Dept of Pesticide Regulation, Sacramento, CA. • **December 15, 2010.** An update on the project was provided at the *North San Joaquin Valley Cling Peach Day*, Modesto. • **March 8, 2011.** An update on the Peach Pest Management Alliance was provided ["Recent Stone Fruit Entomology Research in the San Joaquin Valley."] by Marshall Johnson to the Merced College Spring Semester Pest Management Course, Merced, CA.		
Research and Demonstrate	**Sunflower and enhanced biological control research & demonstration** **2009** • Blooming sunflowers planted within or adjacent to three orchards (Ceres, Winton, & Turlock) were used as a breeding resource by the sunflower moth, *Homoeosoma electellum*, which is an alternative host for the biological control agent *M. ancylivorus*. • Abundance of sunflower moth was variable and was probably influenced by the proximity to wild sunflowers and history of sunflower plantings in the orchard. The highest abundance was in the Ceres orchard, at which sunflower plantings were began in 2008, suggesting that sunflower moth abundance may increase with time in all	**Apr-10**	**Jan-11**

	sunflower plantings in 2010. • About 4,000 *Macrocentrus* individuals were released in each IPM peach block adjacent to sunflowers between May and July 2009. • Although sunflower moth established in the sunflower heads, use of sunflower moth as a breeding resource by *Macrocentrus* was variable in 2009 and not correlated with moth abundance. • Efficacy of enhanced biological control using sunflowers and *Macrocentrus* could not be determined because larvae of OFM and peach twig borer were uncommon in peach trees under IPM and therefore could not be collected and reared to determine if they were parasitized. • At the Stanislaus site in 2009, questions arose about damage on mature fruit in the block planted with sunflowers. We were unable to tell whether it was injury from western flower thrips or oblique-banded leafroller (OBLR). **2010** • We again maintained plantings of sunflowers adjacent to three orchard plots. Strips of sunflowers were replanted at the two Merced sites in late April 2010. Natural re-growth of the sunflowers at the Stanislaus site alleviated the need to replant. • To resolve the question in 2010 about thrips coming from sunflower plantings, we sampled thrips on weeds and blooms on trees from mid-February to mid-March thrips. Branches with blooms were bagged to either keep thrips out or in. Two introductions of thrips were made plus a control in a randomized trial design. To date, no thrips damage has been observed on any of this fruit to date. Thus, we now believe that we were seeing damage from OBLR. In support of this conclusion is the fact that OBLR pheromone trap catches were high at the affected site during the bloom period in 2009. • Sunflowers at the Merced sites were thinned in early June to facilitate better plant growth. • We found sunflower moth and *Macrocentrus* at all three locations. However, given near zero levels of shoot strikes and no OFM damaged fruit		

	in all monitored orchards (due to the high effectiveness of mating disruption), we were unable to demonstrate any impact of *Macrocentrus* on Oriental fruit moth. • We did discover that plantings of sunflowers to facilitate overwintering of *Macrocentrus* on the sunflower moth should take place in mid to late July so that sunflower heads will be in the right stage for sunflower moth infestation before fall temperatures drop to low levels. • At one location, the second sunflower planting in August was unsuccessful in producing a good stand of sunflowers because the grower turned off the irrigation source in mid-September, thereby killing or stunting surviving sunflower plants. • It was discovered that *Macrocentrus* was commonly parasitizing sunflower moth larvae in wild sunflowers growing near peach orchards. Research is needed to determine the value of populations of *Macrocentrus* overwintering on sunflower moth in wild sunflowers.		
Research and Demonstrate	**OFM mating disruption research and demonstration, second year** • All participating growers, PCAs, and Farm Advisors were contacted to reinitiate the experimental blocks. All growers committed to continuing the program. One Merced site was changed because the orchard was removed from production (see below for explanation). • All participating growers were provided with Isomate TT OFM dispensers for Oriental fruit moth mating disruption. • Twin-Tube Isomate pheromone dispensers were placed in orchard blocks from 26 February to 26 March 2010. • In mid-February 2010, pheromone traps for Oriental fruit moth (OFM), omnivorus leaf roller (OLR) and San Jose Scale were placed in growers' blocks. Bait buckets for OFM were also placed in orchards. • Bait buckets were placed in most blocks by mid-March 2010 and were routinely checked for Oriental fruit moth adults and green lacewing	**Mar-10**	**Nov-10**

	adults until 27 September 2010. • Blocks were monitored for Oriental fruit moth starting on 1 March 2010. Monitoring was terminated in all blocks by 27 September 2010. • Spur samples taken at 5 of 6 orchards on 15 January 2010 for San Jose Scale (SJS). Scales were counted and parasitism was noted at 2 of the 5 orchards sampled. Total percent of spurs infested from each field ranged from 0% to 59% with a highest average of 2.6 SJS per spur at one site. According to IPM guidelines treatment with oil and/or IGR was advised at 3 sites. • Weekly email updates were sent to all cooperators with trap counts of all moth pests. Degree days and spray timing estimates provided by Kelley Morrow from IPM2go. Maxwell Norton used the information for some of his non-participating growers. • Use of mating disruption was highly successful in suppressing Oriental fruit moth densities (as verified by bait bucket counts) and damage and was equally as good as use of conventional insecticides for Oriental fruit moth control.		
Demonstration and Outreach	**Host field days in Merced, Fresno, and Stanislaus Counties at demonstration farms and other venues for surrounding agricultural communities** **2009** • Field days were hosted in Merced County (Harvindar Kular Ranch, Ballico) and Stanislaus County (Superior Fruit Ranch, Ceres) on 19 June 2009. At each location, various topics were covered including: Biology, monitoring and management of OFM; PTB and leaf rollers in peach orchards; Use of mating disruption for OFM management; Monitoring orchards under mating disruption with bait buckets and shoot strikes; and Demonstration of release of *M. ancylivorus* parasitic wasps onto sunflowers for biological control of OFM. • Questionnaires were provided to attendees at both locations.. Results suggest that attendees in Merced County were less familiar with use of mating disruption for Oriental fruit moth (OFM) than those in Stanislaus County. Those attendees	**May-09**	**Jun-10**

	in Stanislaus County indicated that they typically have to treat for OFM in late summer, whereas the Merced County attendees did not. Both groups of attendees were highly interested in planting sunflowers to help manage OFM via the parasitoid *Macrocentrus*. **2010** • No training sessions were held during this time period because we wanted to wait and present an overall assessment of our results after the 2010 production season had ended.		
Research and Demonstrate	**Evaluate fruit damage in study blocks at the nine participating IPM and conventional orchards and train growers to identify damage at harvests** • Fruit damage was evaluated in all plots that we monitored. • Insect damage was insignificant in most plots. No plot had any Oriental fruit moth damage to the fruit. Only one plot had peach twig borer damage, which was 1.8% of the 1,000 fruit examined. • All other damage recorded was probably caused by disease, mechanical, or physiological factors. • Video recordings were made of damage to the fruit for use in the production of training videos for grower education.	**Jun-10**	**Sep-10**
Economic Evaluation	**Economic data analysis for Years 1 and 2** • In 2009, total pest management costs (materials and labor) varied from \$180 to \$379 and averaged \$316 ± 26 in the mating disruption + reduced risk pesticide treatments to \$264 ± 58 in the conventional treatments. • In 2010, total pest management costs (materials and labor) varied from \$90 to \$366 and averaged \$308 ± 15 in the mating disruption + reduced risk pesticide treatments to \$184 ± 56 in the conventional treatments. • Reduced-risk products were generally more expensive (Average costs - 2009: \$46; 2010: \$27) than conventional pyrethroid compounds	**Sep-10**	**Nov-10**

	(Average costs - 2009: $8; 2010: $6).		
Research and demonstrate	**Second report and recommendations from research** • In 2010, it was discovered that all grower / PCA cooperators on the project were not following established protocol guides which included UC IPM recommendation • Given the above, the study was reorganized to examine the costs and effectiveness of the following management protocols: a) OFM mating disruption + reduced-risk pesticides (MD+RRP); conventional pesticides (mainly pyrethroids (CON); and OFM mating disruption + conventional pesticides (MD+CON) • Each protocol was replicated at 3 different sites using the same grower / PCA cooperators as before • Major findings were: o OFM could be controlled by mating disruption and resulting damage to fruit was not significantly different than using conventional controls o When mating disruption is used, OFM adults continue to fly in peach orchards (based on bait bucket catches), but adults are not attracted to pheromone traps o No other pests appeared to be impacted by the management protocols employed o Costs of mating disruption increased management costs from 33 to 59% over use of conventional products o Although costs of reduced-risk products were significantly higher than pyrethroid insecticides, all cooperators were using these products to control at least one pest problem (e.g., spider mites) o Attempts to verify the effectiveness of the parasitoid *M. ancylivorus* failed because OFM shoot strikes were too few to provide larvae to rear out the parasitoid	**Oct-10**	**Jan-11**

Demonstration and Outreach	**Final interview of nine participating growers about perception of reduced-risk practices, associated material and labor costs, and harvest parameters** • We met with growers and cooperators on 2 November 2010 in Turlock, CA. Significant findings were discussed with the growers. Material and labor costs were collected via e-mail, Fax, or phone calls. • There was near-zero injury by all pest species monitored to the peach crops that we monitored in 2010. One site had 1.5% injury from PTB.	**Oct-10**	**Nov-10**
Economic Evaluation	Economic report completed	**Nov-10**	**Dec-10**
Research and Demonstrate	Final report and recommendations from research	**Jan-11**	**May-11**

5) Changes or projected changes in personnel, timeline, experimental/demonstration plan, or outreach events.

The following changes were made to the project:

- About mid-way through the 2010 season, it came to our attention that some of our cooperators were not maintaining the treatment blocks that we had agreed upon. We also realized that the suppression of Oriental fruit moth was so complete that we did not have any shoot strikes from which we could collect Oriental fruit moth larvae to determine if they were parasitized by *Macrocentrus*. Given this, we abandoned our original experimental layout of 1) a comparison of conventional compounds vs. mating disruption in combination with low risk compounds with three paired replications; and 2) a comparison of mating disruption (with low risk compounds) vs. mating disruption (with low risk compounds) + conservation of *Macrocentrus* via sunflower plantings with 3 paired replications. Our revised experimental design was the comparison of conventional compounds vs. mating disruption in combination with low risk compounds for Oriental fruit moth control with three un-paired replications. We also added a third treatment to this comparison and that was conventional compounds used in addition to mating disruption. This allowed us to see what was happening to peach twig borer populations in these treatments and we will also see if there is any impact on spider mite and San Jose scale densities.

Project Title: Developing Biologically Integrated Orchard Systems (BIOS) and Corresponding Market Certification Rewards for Canning Peaches in the San Joaquin Valley

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Executive Summary

Oriental Fruit Moth (OFM), *Grapholita molesta* (Busck), and Peach Twig Borer (PTB), *Anarsia lineatella* Zeller, are primary pests of both fresh market (i.e., freestone) peaches and canning (i.e., cling) peaches in California. Although both insect species can complete development on the vegetative parts of the tree (e.g., shoots), they will attack developing fruit when available. Their impacts on fruit differ in that OFM larvae will burrow deeply into fruit to feed near the peach pit whereas PTB larvae tend to feed just under the skin of the fruit. Currently, bearing cling peaches used for canning purposes in California are planted on about 26,300 acres (the majority in the northern San Joaquin Valley) while bearing freestone peaches used for the fresh market are grown on about 36,000 acres, totaling about 62,300 bearing peach acres potentially impacted.

Given the effectiveness of mating disruption programs for OFM in fresh market peaches, on-farm demonstrations of IPM (i.e., mating disruption and reduced-risk pesticides) and biological control against OFM were initiated in northern San Joaquin Valley canning peaches in the 2009 and 2010 production seasons. In both years, mating disruption was demonstrated in six orchards on a total of 90 acres, and extended to an additional 103 acres of peaches by one grower. Total peach acreage of participating growers, most likely to be impacted, exceeds 600 acres. Potential impact may be extended to all peach acreage in California, excluding acreage already under reduced-risk practices.

Organophosphates (OP) and pyrethroids were targeted for elimination from IPM demonstration blocks within demonstration orchards, to be replaced by mating disruption and biological control for OFM and by reduced-risk pesticides for other pests, if needed, as part of an overall IPM strategy.

A project management team was formed composed of the two principle investigators (Marshall Johnson and Hannah Nadel), two scientific advisors (Walter Bentley and Robert Bugg), and two Farm Advisors (Maxwell Norton and Roger Duncan). Six growers and five pest control advisors (PCA) were engaged as project cooperators (one of the PCAs worked in two of the orchards) in the northern part of the San Joaquin Valley. An industry collaborator, Pacific Biocontrol Corporation (Vancouver, WA), donated mating disruption product for an entire 123 acre orchard and worked closely with the PIs to promote successful implementation of the technique in all sites. The project purchased mating disruption product for the other cooperating growers. The project management team, cooperators, and two industry collaborators (DelMonte, Inc. and Pacific Biocontrol Corporation) formed a Canning Peach PMA for northern San Joaquin Valley.

During the 2009 season, H. Nadel oversaw the day-to-day operation of the Canning Peach PMA. However, she relocated to Massachusetts in December 2009 and Andrew Molinar was hired to oversee the daily PMA activities for the 2010 growing season.

Our original plan was to 1) demonstrate the effectiveness of OFM mating disruption combined with reduced-risk pesticides; and 2) evaluate our abilities to conserve overwintering populations of the wasp *M. ancylivorus*, a highly effective parasitoid of OFM. Conservation of *M. ancylivorus* was to be achieved by providing larvae of the sunflower moth, *Homoeosoma electellum* Hulst, for the parasitoid to overwinter upon. Natural populations of the sunflower moth were established adjacent to peach orchards by planting commercial sunflowers. *M. ancylivorus* females would search the sunflower heads and parasitize the sunflower moth larvae infesting the heads.

To demonstrate to growers the effectiveness of OFM mating disruption, we worked in three blocks (20 acres each) that were in commercial production. Each block was divided into two sections of 10 acres each. The sections were to be treated with either: a) conventional pesticide or b) mating disruption + reduced-risk pesticides. The original plan was that 1) OFM pheromone would be dispersed into the three mating disruption (MD) sections to control OFM, and reduced-risk, natural enemy compatible pesticides would be used for other pest infestations (see Appendix I); and 2) growers would use conventional pesticides for control of OFM and other pests in the remaining three sections.

To evaluate the effectiveness of using sunflower plantings to conserve *M. ancylivorus*, three growers with additional blocks of canning peaches were selected to participate in the program. A 20 acre block for each grower was selected and MD methods were employed for OFM control across the entire block. Then, we divided all the blocks into two 10 acre sections and sunflower plantings were established next to half of the treated sections. Thus, we had a MD + *Macrocentrus* treatment versus MD alone. Growers were requested to use low risk, natural enemy compatible pesticides throughout the entire block.

The results of Year 1 (2009) of the project revealed that the new OFM pheromone dispensers (Isomate TT-OFM, Pacific Biocontrol Corp., Vancouver, WA) that we employed continued to dispense pheromones as long as 6 months, which we did not anticipate. The result was that OFM larval populations (i.e., infested shoots) were practically non-existent in the orchards that we worked in. No effective traps exist for monitoring *M. ancylivorus*. Because of this, OFM larvae must be collected from infested shoots strikes (i.e., shoot strikes) and the parasitoid reared out of the parasitized OFM larvae. Given the low OFM populations, we were unable to collect enough OFM larvae to check for parasitization by *M. ancylivorus* within the peach orchards, thereby crippling our ability to directly document any beneficial effects of using sunflowers to conserve the overwintering populations of the parasitoid. OFM populations were even lower in 2010 also, thus all our efforts to demonstrate the benefits of sunflower stands were ineffective.

During the 2010 season, we also verified another significant factor that dramatically altered our plans for analyzing the data that we were collecting on use of reduced risk pesticides in the MD sections. We had assumed that our cooperating farmers / pest control advisors (PCAs) were applying reduced-risk pesticides in the MD sections as we had requested. However, conversations with one of the PCAs suggested that some cooperators were not following the protocols that we had agreed upon. Basically, in some of the MD sections, the only difference between control practices in the MD section and the conventional pesticide section was the use of Isomate TT-OFM dispensers in the MD section. Otherwise, it was “business as usual” in the

MD sector. We did not truly realize this until late in the 2010 season. Additionally, examination of the results from 2009 season indicated the same practice was carried out that year.

Fortunately, we had 13 orchard sections that we monitored each year. One of these was an extra conventional block that was on a farm with MD and MD + *Macrocentrus* treatments. Out of these 13 sections, we found enough sections to give us three MD + reduced-risk pesticide (MD+RRP) sections (Sites A, B & C), three conventional treated (CON) sections (Sites D, E & F), and three MD + conventional (MD+CON) treatments (Sites G, H & I). This design allowed us to answer the following questions: a) how effective was OFM mating disruption + reduced-risk pesticides; b) how expensive was MD if one also chose to manage other pests using conventional pesticides; and c) were there any pest species that our MD + reduced-risk pesticide protocol missed compared to the conventional treatments.

Year 2009

Oriental Fruit Moth. OFM trap catches in 2009 were variable in the pheromone trap and bait bucket catches among the various sites (**Figs. 1, 2, 3**). In the mating disruption + reduced risk pesticide (MD+RRP) sites (**Fig. 1**) and the mating disruption + conventional pesticide (MD+CON) sites (**Fig. 3**), pheromone trap catches were zero most of the monitoring period. However, bait bucket catches indicated that female and male moths were flying at these sites, and even surpassed the treatment threshold (i.e., 50 individuals per bucket) at Site G around 25 May 2009. In contrast, OFM pheromone trap catches in the conventional pesticide (CON) sites (**Fig. 2**) varied from 0 to > 90 males per week. Counts at Sites D and E were quite high. Bait bucket counts in these sites were also high (up to > 120 individuals per week at Site E). Examination of the proportion mated females collected from the bait buckets did not show that there were more unmated females in the MD+RRP sections compared to the CON sections as once might expect. Additionally, bait bucket counts did not show a specific time interval(s) during the summer when OFM adults would be captured. Shoot strikes were below 1 per tree in all sites except Sites E and G where they were around 2.5 strikes per tree. These high numbers were somewhat reflected in the bait bucket counts during late May.

Peach Twig Borer. Pheromone trap catches in 2009 showed that PTB counts were generally low during the season until late August (**Fig. 4**). Counts in the CON and the MD+CON sites were very low prior to August (< 10 adults/trap/week) compared to the counts in the MD+RRP sites, which hovered between 5 and 25 adults/trap/week. There is no obvious explanation for this observation. PTB shoot strike counts were very low (< 1 strike per tree).

Obliquebanded Leafroller. Examination of the pheromone trap catch data suggests that OBLR adults are active in May and then again in August (**Fig. 5**). There were no obvious effects of the treatments employed.

Omnivorous Leafroller. Adults of OLR appear to be active from mid-April to past harvest in August and September (**Fig. 6**). However, the various treatments did not appear to impact this species. There was no consistent trend in the moth flight. Given this, it is very important to use Day Degrees to time applications for this pest.

Spider Mites. Populations of two spotted spider mite, *Tetranychus urticae*, and Pacific spider mite, *Tetranychus pacificus*, were followed using foliage samples (30 leaves total from among 10 sampled trees). Given the similar appearance of these two species, they were lumped together in counts. In 2009, a rating system was used for spider mite counts instead of actual numbers of individuals per leaf. Numbers of mites per leaf were based on a 0 to 5 rating system where 0 =

no spider mites; 1 = 1 to 10 mites (and no eggs); 2 = 1 to 10 mites (with eggs); 3 = 11 to 50 mites with eggs; 4 = 51 to 100 mites with eggs (definite webbing); and 5 = > 100 mites with eggs (lots of webbing).

Miticides were applied between May 27 (Site I) and August 19 (Site D) to all sites except C. Sites B, E, G, and I had zero spider mites or only the occasional presence of mites (less than 1 adult leaf per week) in 2009. At the other sites, spider mites did not appear in significant numbers until around mid-season (July)(**Fig. 7**). Among these sites, none ever had an average spider mite rating that reached a rating of 4 (i.e., > 51 spider mites with eggs and webbing). Sites with spider mite ratings between 2 and 3 were Sites A (July 1 miticide treatment), C, F (July 30 miticide treatment), and H (July 30 miticide treatment). Spider mite ratings peaked and then declined at Sites C, D, F, and H. Natural enemies of spider mites were recorded in all sections. Sites with spider mites were harvested by the end of August.

San Jose Scale. This pest (*Quadraspidiotus perniciosus*) was monitored using pheromone traps that attract the winged male San Jose scales and the scale's major parasitoids, *A. mytilaspidis* and *E. perniciosi*. (**Figs. 8, 9, & 10**). There were no obvious population trends relative to the various management protocols. San Jose scale male densities varied dramatically among the sites with seasonal peaks ranging from an average of less than 1 to ca. 140 males per trap per week [see **Figs. 8** (Site A) and **9** (Site E), respectively]. Both parasitoids were trapped at all sites and their numbers were also highly variable. The highest weekly average peaks of *Aphytis* and *Encarsia* were 160 (**Fig. 8**, Site C) and 100 (**Fig. 9**, Site D) wasps, respectively. *Aphytis* was the most prominent parasitoid species at 7 of the nine sites monitored. In general, when parasitoid counts were high, male scale counts were low or zero.

Natural Enemy Counts. Biological control agents observed in peach orchards included the following predators: green lacewings, ladybugs, hover flies (i.e., syrphid flies), assassin bugs, minute pirate bugs (*Orius* sp.), spiders, and the California gray ant. Additionally, various parasitic wasps and flies (tachinids) were observed. Based on 3-minute observations, there was no significant difference in the presence of natural enemies within orchards maintained under the various management protocols. However, these types of observations are limited in their usefulness because the presence of biological control agents are affected by the prey or host species present. General predators such as green lacewings and California gray field ant may attack many different prey so that two orchards could have similar densities of each predator, but their targeted prey may be dramatically different between the orchards (e.g., scales in one orchard and aphids in another).

<u>Macrocentrus</u> in Sunflower Plantings. Commercial sunflowers were planted at study sites near Winton (location of Site B), Turlock (location of Site I), and Ceres (location of Sites A & D). About 4,000 adult *M. ancylivorus* parasitoids received from the Colorado State Insectary at Grand Junction, CO, were released at the sites between May and July 2009. Sunflower heads were collected in July and August 2009 and emerging sunflower moth larvae were held for adult emergence of either adult sunflower moths or adult *M. ancylivorus* parasitoids. All sunflower heads were infested by the sunflower moth and 9, 9, and 17 percent of the sunflower moth larvae from Winton, Ceres, and Turlock, respectively, were parasitized by *M. ancylivorus* (**Fig. 15**). This finding supports the idea that sunflower plantings could provide sunflower moths that could potentially be used as overwintering hosts for *M. ancylivorus*.

Cost of Management Protocols. Management costs (total of materials & labor) varied greatly in 2009 from a low of $195.97 (CON: Site E) to a high of $379.42 (CON: Site D) (**Table 1**). Average costs per management protocol were $263.62, $298.07, and $315.79 for the CON, MD+CON, and MD+RRP protocols, respectively (**Table 3**). While labor costs were quite similar for these protocols, the costs of reduced-risk pesticides (not counting OFM pheromone) increased the control costs for pesticide sprays. Mean costs for reduced-risk products used at the various sites was $46.00 per application. Pyrethroid insecticides made up about 99% of the conventional products used. Their average cost was $8.29 per application. Cost of the Isomate TT pheromone product varied between $110 and $132 depending on how many dispensers were placed in the orchards.

Fruit Damage. No significant damage was attributed to OFM in 2009. Most observed damage was attributed to thrips or OBLR (appearance is similar). Thus, all of the management protocols examined provided equal levels of protection from OFM, and there were no obvious non-target effects (e.g., elimination of natural enemies; increase in pest numbers) from their implementation.

Year 2010

Oriental Fruit Moth. As in 2009, OFM trap catches in 2010 were variable in the pheromone trap and bait bucket catches among the various sites (**Figs. 1, 2, 3**). Many bait bucket captures were lower in 2010 than in 2009 (i.e., Sites C, E, F, G, H & I). In the mating disruption + reduced risk pesticide (MD+RRP) sites (**Fig. 1**) and the mating disruption + conventional pesticide (MD+CON) sites (**Fig. 3**), pheromone trap catches were again zero most of the monitoring period. However, bait bucket catches indicated that female and male moths were flying at these sites, but they never surpassed the treatment threshold (i.e., 50 individuals per bucket). OFM pheromone trap catches in the conventional pesticide (CON) sites (**Fig. 2**) were low and below 10 males per week. Bait bucket counts in these sites were also low with the highest recorded peak being ca. 14 moths per week at Site D (**Fig. 2**). As in 2009, examination of the proportion mated females collected from the bait buckets did not show that there were more unmated females in the MD+RRP sections compared to the CON sections. Consistent with 2009, bait bucket counts did not show a specific time interval(s) during the summer when OFM adults would be captured. OFM shoot strike counts were taken on June 17, July 20, and September 9. The mean numbers of shoot strikes were extremely low (< 0.2 strikes per tree) at all sites throughout the season.

Peach Twig Borer. Pheromone trap catches in 2010 showed that PTB counts were generally higher in late August compared to findings in 2009 (**Fig. 4**). As in 2009, the 2010 counts in the CON and the MD+CON sites were low prior to August (< 20 adults/trap/week) compared to the counts in the MD+RRP sites, which hovered between 5 and 45 adults/trap/week. There was no obvious explanation for this observation. PTB shoot strike counts were extremely low (< 0.2 strikes per tree).

Obliquebanded Leafroller. As in 2009, pheromone trap catch data indicate that OBLR adults are active in May and then again in August (**Fig. 5**). There were no obvious effects of the treatments employed.

Omnivorous Leafroller. Adults of OLR were similarly active as in 2009 (**Fig. 6**). Trap counts were lower at some sites and higher in others. The various treatments did not appear to impact this species. There was no consistent trend in the moth flight.

Spider Mites. Using the same sampling protocol as in 2009, populations of two spotted spider mite and Pacific spider mite were followed using foliage samples (30 leaves total from among 10 sampled trees). Given the similar appearance of these two species, they were lumped together in counts. However, instead of using a rating system as in 2009, the actual numbers of spider mites and their eggs were counted. The presence of natural enemies was also recorded.

As in 2009, miticides were applied to all sites except C. Sites A, D, F, H, and I had zero spider mites or only the occasional presence of mites (less than 1 adult leaf per week) in 2010 (**Fig. 11**). At the other sites (B, C, E & G), spider mites did not appear in significant numbers until around late season (early September) after the fruit had been harvested. Among these sites, the highest mite mean density recorded was ca. 12 mites per leaf at Site C about 3 weeks post harvest. Sites B, E, and G had high mean densities ≤ 5 mites per leaf at this time. The numbers of spider mite eggs were higher than the spider mite densities in late season as would be expected for increasing populations. Natural enemies (mostly green lacewings) of spider mites were recorded at all sites.

San Jose Scale. Based on pheromone trap catches (**Figs. 12, 13, & 14**) of male San Jose scales, *A. mytilaspidis*, and *E. perniciosi*, there were no obvious population trends relative to the various management protocols. As in 2009, male San Jose scale densities varied dramatically among the sites with seasonal peaks ranging from an average of ca. 2.5 to ca. 2,400 males per trap per week [see **Figs. 13** (Site F) and **12** (Site B), respectively]. Both parasitoids were trapped at all sites and their numbers were also highly variable. The highest weekly average peaks of *Aphytis* and *Encarsia* were 235 (**Fig. 13**, Site F) and 300 (**Fig. 12**, Site A) wasps, respectively. *Aphytis* was the most prominent parasitoid species at seven of the nine sites monitored. Both in 2009 and 2010, *Encarsia* was most common at Sites A and D As observed in 2009, when parasitoid counts were high in 2010, male scale counts were low or zero.

<u>Macrocentrus</u> in Sunflower Plantings. Sunflower plantings at the three sites used in 2009 were maintained in 2010. Five releases of *M. ancylivorus* individuals were made over the summer and totaled to 8,600 wasps released per orchard site. Percentages of sunflower moth larvae parasitized were lower in 2010 than 2009 with less than 1% of the larvae at the various sites producing *M. ancylivorus* individuals. We hypothesize that the low parasitization counts resulted from high numbers of larval predators (e.g., Orius sp.) inhabiting the sunflower heads, which fed upon sunflower moth larvae present in the heads.

Estimated Costs of Sunflower Plantings. To produce ca. 210 sunflower plants adjacent to a peach orchard, the costs would be ca. $150 of which about $65 would be for drip tape (for irrigation) and $80 for labor. Sunflower seed was less than $1.20. Water would also have to be supplied to support the plants all through the growing season and on into the fall.

Cost of management protocols. Management costs (total of materials & labor) again varied greatly in 2010 from a low of $90.53 (CON: Site E) to a high of $325.32 (CON: Site C)(**Table 2**). Average costs per management protocol were lower in 2010 with $183.73, $252.68, and $307.57 for the CON, MD+CON, and MD+RRP protocols, respectively (**Table 3**). Again, the labor costs were quite similar for these protocols, but the costs of reduced-risk pesticides (not counting OFM pheromone) increased the control costs for pesticide sprays. Mean costs for reduced-risk products used at the various sites was $26.82 per application. Pyrethroid insecticide average cost was $5.80 per application. Cost of the Isomate TT pheromone product varied between $120 and $144 depending on how many dispensers were placed in the orchards.

Fruit Damage. As in 2009, no significant damage was attributed to OFM in 2010. The highest level of "worm" damage (1.8%) was from PTB at Site C, and this was attributed to a lack of PTB control treatment applied during the early season. Thus, all of the management protocols examined in 2010 provided equal levels of protection from OFM, and there were no obvious non-target effects (e.g., elimination of natural enemies; increase in pest numbers) from their implementation.

Conclusions

IPM using mating disruption for OFM was demonstrated in late-harvested cling peach varieties at six sites (MD+RRP: A, B, C; MD+CON: G, H, I) in comparison with the growers' conventional pest management practices at three sites (CON: D, E, F). In all conventionally treated blocks, more OFM adults were recorded in the pheromone traps as compared to the mating disruption blocks. Bait buckets were useful because they permitted the tracking of OFM adults when pheromone traps were inoperable in the mating disruption sections. However, examination of female OFM reproductive organs did not validate that the majority of females captured in bait bucket traps in MD+RRP sites were unmated or that OFM females captured in CON sites were mated.

IPM with mating disruption successfully prevented OFM damage in all blocks in which it was applied. A noteworthy success occurred in 2009 at the Ceres orchard (Site A) that adopted mating disruption over most of its entire peach acreage (130 acres of canning varieties) after suffering heavy OFM damage in 2008 with repeated OP (phosmet) treatments. The UCCE Farm Advisor for Stanislaus County, Roger Duncan, worked closely with the Ceres grower and PCA to encourage adoption. No OPs were used in 2009 and 2010.

Pyrethroids continued to be used at most of the sites (7 out of 9) we studied. However, of promise is the fact that reduced-risk products (e.g., miticides) were used at every site in 2009 and 2010. OFM damage to fruit was negligible at all sites studied during the project. Fruit damage from other pests did not impact fruit grade at harvest.

Challenges encountered during the project included general resistance by growers and pest control advisors (PCAs) using FQPA Priority I products to try mating disruption, which led us to engage cooperating growers that were already using some reduced-risk practices rather than those preferring the Priority I products. However, as stated above, we had to change our study plans because too many of our mating disruption sites were treated with conventional pesticides.

Outcomes

Blooming sunflowers planted within or adjacent to the orchards were used as a breeding resource by the sunflower moth, which is an alternative host for the biological control agent *M. ancylivorus*. Abundance of sunflower moth was variable and was probably influenced by the proximity to wild sunflowers and history of sunflower plantings in the orchard. The highest abundance was in the Ceres orchard (Sites A & D), at which sunflower plantings were established in 2008, suggesting that sunflower moth abundance may increase with time in all sunflower plantings in 2010. Use of sunflower moth larvae as a breeding resource by *Macrocentrus* was variable both years and not well correlated with larval abundance. Efficacy of enhanced biological control using sunflowers and *M. ancylivorus* could not be determined because larvae of OFM and peach twig borer were rare in peach trees under IPM and therefore could not be collected and reared to determine if they were parasitized.

Reduced-risk products as well as mating disruption materials were substantially more costly than conventional materials with much of the difference being related to the cost of the pheromone emitters and the labor to place them in the orchard. Mating disruption costs constituted between 33.9 and 59.4 percent of the management costs at all sites where mating disruption was employed. In this study, the average cost for a reduced-risk product used in the field was 5.5 and 4.6-fold higher than that of the pyrethroids used in 2009 and 2010, respectively. However, all growers participating in this study used some reduced-risk product at least once each year of this study.

Training and outreach were provided on use of IPM with mating disruption for OFM control in informal on-farm sessions for cooperating PCAs and growers, and for a broader audience at field days and seminars.

Outreach / Outputs and Deliverables

Outreach included informal meetings with growers and their PCAs as part of the orchard selection process. Summary IPM management plans (**Appendix I**) were distributed to cooperating growers and PCAs. The PCAs and one grower were shown how to properly apply Isomate TT mating disruption devices, and they in turn demonstrated the procedure to work crews. In-field meetings were held with the three growers that were willing to try enhanced biological control. At these meetings, we discussed how to situate, plant, and irrigate sunflowers within or adjacent to their orchards. Informal on-farm training was provided to familiarize individuals with the biology of *M. ancylivorus* parasitoid and to expose them to live specimens. Seminars were presented to growers, PCAs, and other stakeholders on the IPM management plan for canning peaches which including monitoring and managing OFM infestations in peaches using mating disruption during the following activities:

- *Northern San Joaquin Valley Cling Peach Seminar*, Modesto, 4 December 2008
- *Sacramento Valley Cling Peach Day*, Yuba City, 7 January 2009
- *2009 Tree and Vine Update Breakfast*, Modesto, 6 May 2009
- *Peach IPM Field Day*, Ceres, 19 June 2009
- *Peach IPM Field Day*, Ballico, 19 June 2009
- *Cling Peach PMA Cooperator Lunch*, Merced, 6 November 2009
- Pest Management Alliance Committee, California Dept of Pesticide Regulation, Sacramento, CA, 9 November 2010
- *Northern San Joaquin Valley Cling Peach Seminar*, Modesto, 3 December 2009
- *Introduction to Environmental Sciences* class, UC Merced, 13 October 2010
- Hour-long review of 2010 PMA summer program at Turlock, CA, 2 November 2010
- 2010 Cling Peach & Pear Combined Workgroup Meeting, Davis, CA, 9 November 2010
- Pest Management Alliance Committee, California Dept of Pesticide Regulation, Sacramento, CA, 18 November 2010
- Merced College Spring Semester Pest Management Course, Merced, CA, 8 March 2011

A 17-minute video on using *M. ancylivorus* for enhanced biological control of OFM in peaches was completed and draft versions were shown at five cling peach events. Future outputs will include more seminars and published information on the results of this project.

New Technologies

A relatively recent technology for delivering OFM mating-disruption pheromone was used, which minimizes application time and lasts longer than other mating-disruption devices. The Isomate TT OFM ("TT" is short for "twin tube') consists of two plastic tubes joined at both ends, that store and release female sex pheromone.

Transferable Technologies

Isomate TT is transferable to other commodities that may use the mating-disruption technique to control pests.

Habitat enhancement to promote biological control of peach pests can be extended to the Sacramento Valley and other peach-growing areas in North America, and may be useful to all peach and nectarine varieties.

Efficacy of Biopesticides / Reduced Risk Alternatives

Mating disruption for OFM control was as efficacious as conventional pesticides and in one case was more efficacious than conventional pesticides. In the latter case, the participating grower in Ceres suffered heavy crop losses due to OFM in 2008 despite four in-season applications of the OP phosmet, but after adopting mating disruption and reduced-risk materials in 2009 he had no detectable OFM damage in his orchard (Site A) and received full price for his fruit by the processor. Some evidence for better OFM control through mating disruption was found near Ballico, where significantly higher shoot strikes (damaged branch tips due to OFM larvae) occurred in the CON section (Site E) than in the MD+CON section (Site G). However, fruit damage was negligible in both blocks at harvest. Fruit damage due to OFM was minimal or absent at all monitored blocks during 2009 and 2010 regardless of pest control practice.

Enhanced biological control of OFM using sunflower plantings and *M. ancylivorus* wasps was implemented in three orchards, but its efficacy could not be determined during the project. To assess efficacy, OFM and PTB larvae must be collected from infested peach branch tips and reared on artificial diet to determine the proportion of larvae parasitized and killed by *M. ancylivorus*, but OFM and PTB larvae were either absent in monitored blocks or had already exited the shoot tips before they were collected. However, we were able to assess two steps in the enhanced biological control system as indicators for potential efficacy of the whole system: a) colonization of sunflower blooms by sunflower moth larvae, and b) parasitization of sunflower moth larvae by *M. ancylivorus*. Although their abundances were highly variable among sites, sunflower moths laid eggs and their larvae fed on blooms at all three sites, and *M. ancylivorus* wasps parasitized the sunflower moth larvae at the sites. These positive results suggest that sunflower plantings may be able to play a role in conserving *M. ancylivorus* wasps that suppress OFM and PTB providing a control that is complementary with other management practices.

Preliminary studies that we initiated in wild sunflowers showed that *M. ancylivorus* does parasitize sunflower moth larvae in these flower heads. The role of sunflower moth infested wild sunflowers in helping *M. ancylivorus* to overwinter needs to be evaluated.

New Practices Implemented By Growers

For their first time, four cooperating growers used mating disruption for OFM combined with lower-risk pesticides on at least 10 acres of their orchards. Another grower transitioned from a less effective sprayable mating disruption product to the season-long Isomate TT product, and the sixth grower continued using Isomate TT and eliminated an OP application. The UCCE Farm Advisor for the Ceres grower, who adopted mating disruption for OFM after suffering heavy losses in 2008 with OP applications, encouraged adoption by engaging an industry collaborator to donate mating disruption product for the entire orchard and by working closely with the grower and PCA to ensure success. Outreach on the prior demonstrated success of using IPM with OFM mating disruption in fresh market peaches, combined with the donation of Isomate TT by the project and industry, and on-farm support by the PMA project team, likely provided a strong impetus for adoption by growers.

Two cooperating growers planted sunflowers adjacent to their orchards to enhance habitat for a biological control agent of OFM, while another continued this practice that he began in 2008. Extension and outreach on a successful trial conducted at the University of California Kearney Agricultural Center by Walter Bentley, with donations of the biological control agent *M. ancylivorus* by the Colorado State rearing facility at Grand Junction, CO,, and pilot trials in Merced and Stanislaus Co. conducted on-farm by UCCE Farm Advisors Maxwell Norton and Roger Duncan, provided impetus for grower adoption.

Potential Change in Growers Behavior as a Result of this Project

On 19 June 2009, in-field workshops were held in Stanislaus and Merced Counties and attendees were provided surveys to complete. The results of these surveys can be found in **Appendix II** & **III** for Stanislaus and Merced Counties. Interestingly, in Stanislaus County, most respondents were very familiar with the concept of mating disruption (80%) compared to those in Merced County (54%). Of those respondents in both counties who had used mating disruption, most had used the sprayable form of the pheromone compared to the pheromone emitters. Prior to the workshop, only 50% of the Stanislaus respondents were familiar with the use of *Macrocentrus* for OFM suppression compared to 63% in Merced County. Few (≤ 25%) in either county had tried to conserve *Macrocentrus* populations by planting sunflowers within or near their peach orchards. However, following our discussion of using sunflowers to conserve *Macrocentrus* populations, 80 and 90% of the respondents from Stanislaus and Merced Counties, respectively, said they would consider planting and maintaining sunflowers to help *Macrocentrus* overwinter for better OFM control.

Table 1. Comparison of insect and mite pest management costs in Mating Disruption + Reduced-Risk Pesticides (MD+RRP), Conventional (CON), and Mating Disruption + Conventional (MD+CON) sites, 2009.

			Cost per acre ($)				
Pest management protocol	Location	Materials applied/acre	Material	Labor/ equip	Total material	Total labor/equip	Total
MD+RRP	**Site A** (Superior)	Isomate TT @ 180 tubes	132.30	10.11			
		Dimilin 2L @ 6.4 oz	12.55				
		Pro 90 @ 4.8 oz	0.53	20.00			
		Altacor @ 4 oz	49.76				
		Apollo 42% @ 8 oz	120.68				
		Pro 90 @ 6.4 oz	0.70	20.00	316.52	50.11	**366.63**
	Site B (Arnold)	Isomate TT @ 150 tubes	110.00	12.80			
		Gavicide Super 90 oil 4 gal	20.96				
		Asana XL @ 10.24 oz*	6.40	20.00			
		Intrepid 2f 10.11oz	21.85	20.00			
		Belt SC 4 oz	31.48				
		Envidor 2 SC 1.12 pts	37.00	20.00	227.69	72.80	**300.49**
	Site C (Yagi)	Dimilin @ 14 oz	27.45				
		Superior oil @ 5 gal	45.00	20.00			
		Isomate TT @ 150 tubes	110.00	12.80			
		Superior oil @ 1 gal	45.00	20.00	227.45	52.80	**280.25**
CON	**Site D** (Superior)	Dimilin 2L @ 6.4 oz	12.55				
		Pro 90 @ 4.8 oz	0.53				
		Intrepid 2F @ 1 pt	39.50				
		Bupher @ 6.4 oz	0.42	20.00			
		Silencer @ 3.2 oz	4.74				
		Pro90 @ 6.4 oz	0.70	20.00			
		Altacor @ 4.0 oz	49.76				
		Apollo 42% @ 8.0 oz	120.68				
		Pro 90 @ 6.4 oz	0.70	20.00			
		Acramite @ 16 oz	54.75				
		Buffer @ 1.2 pt	1.27				
		Spray oil @ 2 ga	11.82	22.00	297.42	82.00	**379.42**

Continued next page

Table 1. Continued.

Pest management protocol	Location	Materials applied/acre	Cost per acre ($) Material	Labor/ equip	Total material	Total labor/equip	Total
CON	**Site E** (Kullar)	Asana XL @ 12 oz*	12.00	20.00			
		Warrior @ 3 oz	10.80	20.00			
		Asana XL @ 8 oz*	8.00				
		Apollo @ 2 oz	30.17	20.00			
		Acramite @ 16 oz	55.00	20.00	115.97	80.00	**195.97**
	Site F (Perez)	Asana XL @ 10 oz*	10.00				
		IAP 440 oil @ 30.3 lb	20.00	20.00			
		Asana XL @ 10 oz*	10.00	20.00			
		Baythroid XL 2.5 oz	5.47	20.00			
		Acramite @ 16 oz	55.00				
		IAP 440 oil @ 6.9 lb	5.00	20.00			
		IAP Organic 440 oil @ 14.1 lb	10.00	20.00	115.47	100.00	**215.47**
MD + CON	**Site G** (Kullar)	Asana XL @ 12 oz*	12.00	20.00			
		Isomate TT @ 150 tubes	110.00	12.80			
		Intrepid 2F @ 12.8 oz	31.62	20.00			
		Apollo @ 2 oz	30.17				
		Belt SC @ 3 oz	30.00	20.00			
		Acramite @ 16 oz	55.00	20.00	268.79	92.80	**361.59**
	Site H (Perez)	Asana XL @ 10 oz *	10.00				
		IAP 440 oil @ 30.3 lb	20.00	20.00			
		Isomate TT @ 150 tubes	110.00	12.80			
		Asana XL @ 10 oz*	10.00	20.00			
		Baythroid XL 2.5 oz	5.47	20.00			
		Acramite @ 16 oz/ac (5 aconly)	55.00				
		IAP Organic 440 oil @ 14.1 lb	5.00	20.00	215.47	102.80	**318.27**
	Site I (Digiovanni)	IAP 440 All Purpose oil 4 gal	20.96				
		Asana XL 9.81 oz*	6.13	20.00			
		Isomate TT @ 150 tubes	110.00	12.80			
		AsanaXL 8.17 oz*	5.11				
		Apollo 42% 3.13 oz	19.36	20.00	161.56	52.80	**214.36**

Table 2. Comparison of insect and mite pest management costs in Mating Disruption + Reduced-Risk Pesticides (MD+RRP), Conventional (CON), and Mating Disruption + Conventional (MD+CON) sites, 2010.

			Cost per acre ($)				
Pest management protocol	Location	Materials applied/acre	Material	Labor/ equip	Total material	Total labor/equip	Total
MD+RRP	**Site A** (Superior)	Isomate TT @ 180 tubes	144.00	12.8			
		Dimilin 2L 12.8oz	24.42				
		Gavicide Super 3gal	15.72	20.00			
		Success 4.8oz	31.11				
		MSO 4.8 oz	0.53	20.00			
		Agrimek .15ec 12.8oz	25.87				
		Buffer 4 oz	0.27				
		spray oil 1gal	5.24	20.00	247.16	72.80	**319.96**
	Site B (Arnold)	Isomate TT 150 tubes	120.00	12.80			
		Gavicide Super 90 oil 4 gal	20.96				
		Asana XL 10 oz	6.25	20.00			
		Belt 4 oz	31.48	20.00			
		Intrepid 2f, 12 oz	25.93	20.00	204.62	72.80	**277.42**
	Site C (Yagi)	Spray oil	20.96	20.00			
		Isomate TT @ 150 tubes	120.00	12.80			
		Intrepid 2f 12.8oz	24.42				
		Agrimek 0.15 ec 10oz	20.21	20.00			
		Baythroid XL 2.8oz	6.13	20.00			
		Altacor 4 oz	40.8	20.00	232.52	92.80	**325.32**
CON	**Site D** (Superior)	Diazinon Ag 500 2qts	21.45				
		Gavicide Super 2 gal	10.48	20.00			
		Dimilin 2L 12.8oz	24.42				
		Gavicide Super 3gal	15.72	20.00			
		Success 4.8oz	31.11				
		MSO 4.8 oz	0.53	20.00			
		Altacor 4.0 oz	40.80				
		SI 100 3 oz	2.13				
		Buffer 4 oz	0.27				

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		Agrimek .15ec 12.8 oz	25.87				
		Spray oil 1gal	5.24	20.00			
		Lambda Star 1cs 4oz	5.42				
		Pro 90 4 oz	0.52	20.00	183.96	100.00	**283.96**
	Site E (Kullar)	Asana XL 10oz	6.25	20.00			
		Warrior 3oz	6.91	20.00			
		Asana XL 8oz	5.00				
		Apollo 42% 2oz	12.37	20.00	30.53	60.00	**90.53**
	Site F (Perez)	Asana XL @ 10 oz*	6.25				
		Gavicide 90 4 gal	20.96	20.00			
		Success 6oz	38.89	20.00			
		Baythroid XL 2.25 oz	4.92	40.00			
		Baythroid XL 2.5 oz	5.47				
		Agrimek 0.15 ec 10oz	20.21	20.00	96.70	80.00	**176.70**
MD + CON	**Site G** (Kullar)	Asana XL 10oz	6.25	20.00			
		Isomate TT 150 tubes	120.00	12.80			
		Warrior 3 oz	6.91	20.00			
		Asana XL 8oz	5.00				
		Apollo 42% 2oz	12.37	20.00	150.53	72.8	**223.33**
	Site H (Perez)	Asana XL @ 10 oz *	6.25				
		Gavicide 90 4 gal	20.96	20.00			
		Success 6 oz	38.89	20.00			
		Isomate 150 tubes (1.84 oz)	120.00	12.80			
		Baythroid XL 2.25 oz	4.92	40.00			
		Baythroid XL 2.5 oz	5.47				
		Agrimek 0.15 ec 10oz	20.21	20.00	216.70	92.80	**309.50**
	Site I (Digiovanni)	Asana XL 10 oz	6.25				
		Gavicide Super 90 oil 4gal	20.96	20.00			
		Isomate TT 150 tubes	120.00	12.80			
		Asana XL 8 oz	5.00				
		Agrimek 0.15ec 10 oz	20.21	20.00	172.42	52.80	**225.22**

*Pyrethroid

Table 3. Comparison of mean (and standard deviation) of pest management costs[1] in canning peach orchard sites (n = 3) where the following management protocols were followed in 2009 and 2010: Mating Disruption + Reduced-Risk Pesticides (MD+RRP), Conventional (CON), and Mating Disruption + Conventional (MD+CON) sites

Year	Management protocol	Mean (± SEM) cost ($) of materials	Mean (± SEM) cost ($) of labor	Mean (± SEM) overall cost ($)
2009	MD+RRP	257.22 ± 29.65	58.57 ± 7.16	315.79 ± 26.08
	MD+CON	215.27 ± 30.95	82.80 ± 15.28	298.07 ± 43.68
	CON	176.29 ± 60.57	87.33 ± 6.36	263.62 ± 58.17
2010	MD+RRP	228.10 ± 12.48	79.47 ± 6.67	307.57 ± 15.15
	MD+CON	179.88 ± 19.46	72.80 ± 11.55	252.68 ± 28.41
	CON	103.73 ± 30.95	80.00 ± 11.55	183.73 ± 55.95
Pooled	MD+RRP	242.66 ± 15.79	69.02 ± 6.40	311.68 ± 13.61
	MD+CON	197.58 ± 18.17	77.80 ± 8.85	275.38 ± 25.42
	CON	140.01 ± 37.31	83.67 ± 6.12	223.68 ± 40.27

[1] Includes cost of pesticide materials and labor

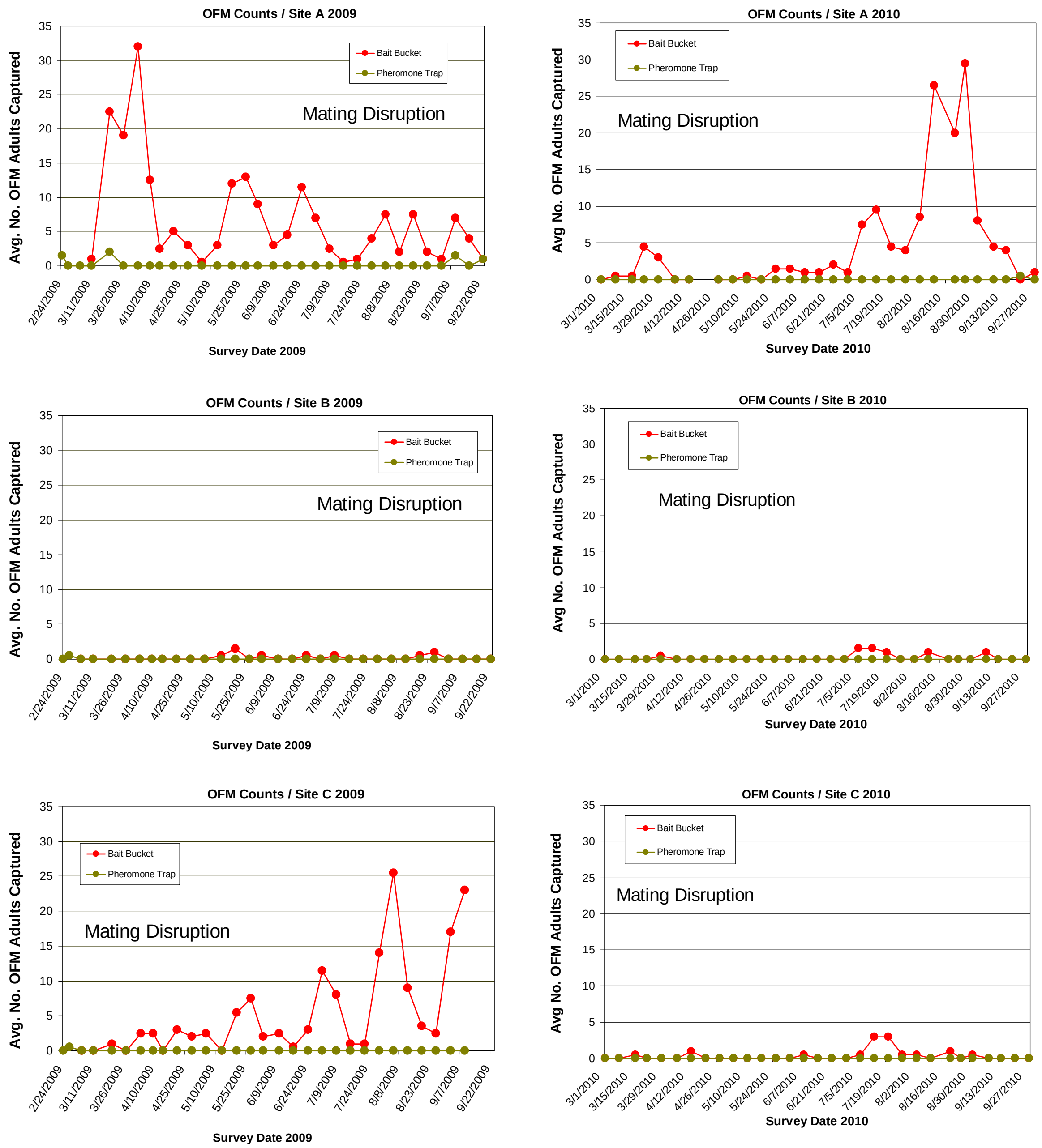


Fig. 1. Oriental Fruit Moth (OFM) bait bucket and pheromone trap counts in mating disruption + reduced-risk pesticides (MD+RRP) sections in 2009 and 2010.

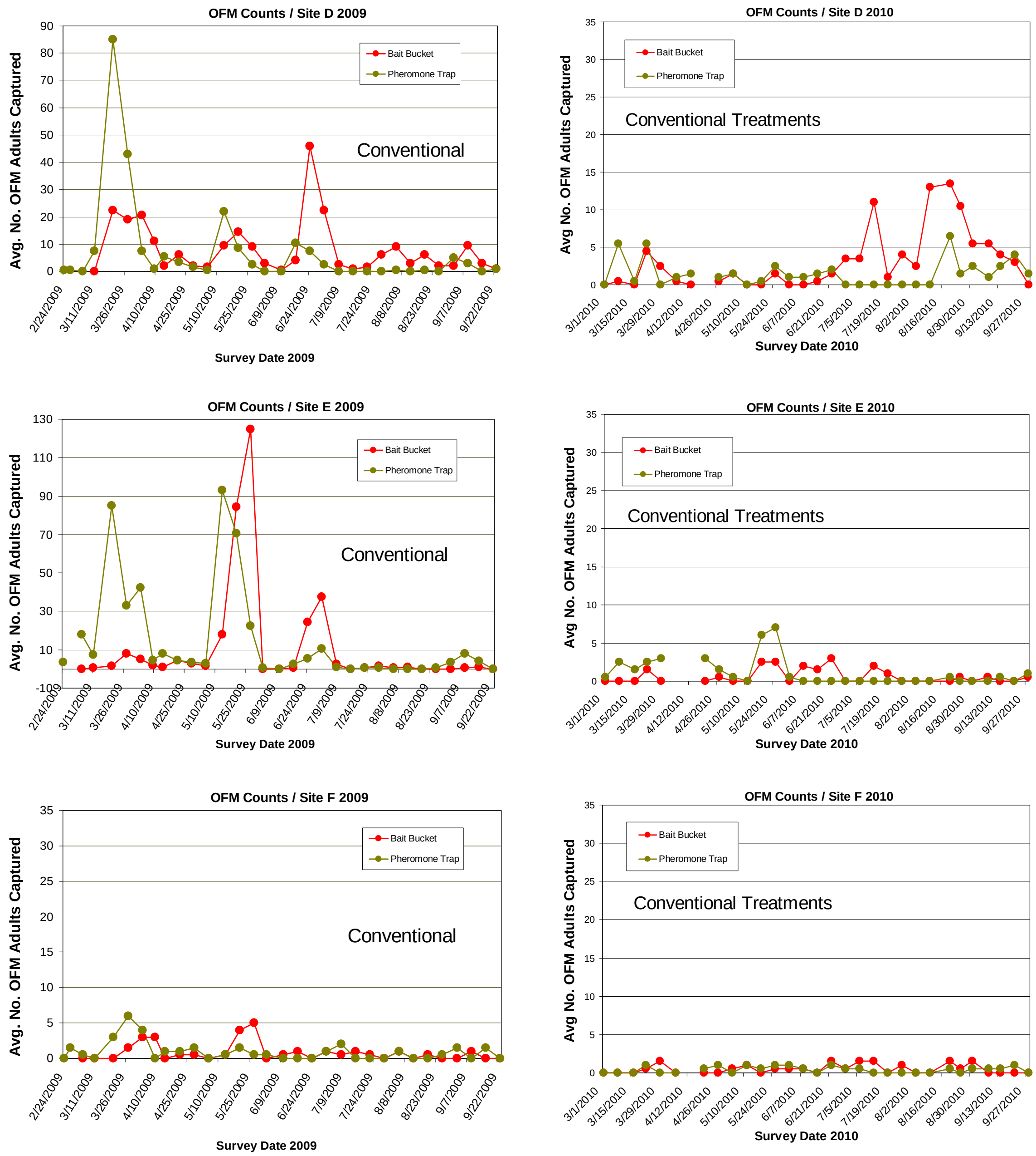


Fig. 2. Oriental Fruit Moth (OFM) bait bucket and pheromone trap counts in conventionally treated (CON) sections in 2009 and 2010.

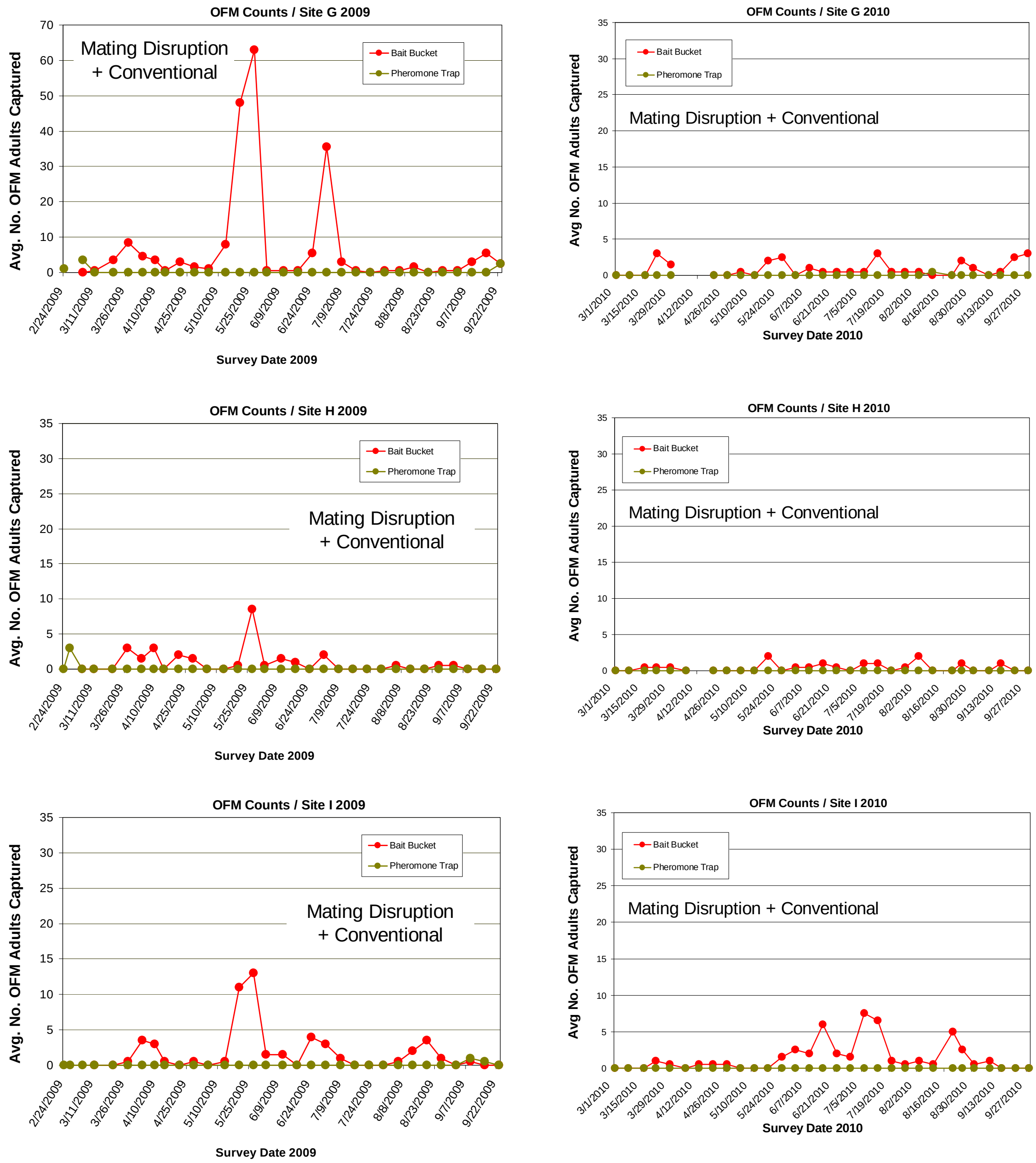


Fig. 3. Oriental Fruit Moth (OFM) bait bucket and pheromone trap counts in mating disruption and conventionally treated (MD+CON) sections in 2009 and 2010.

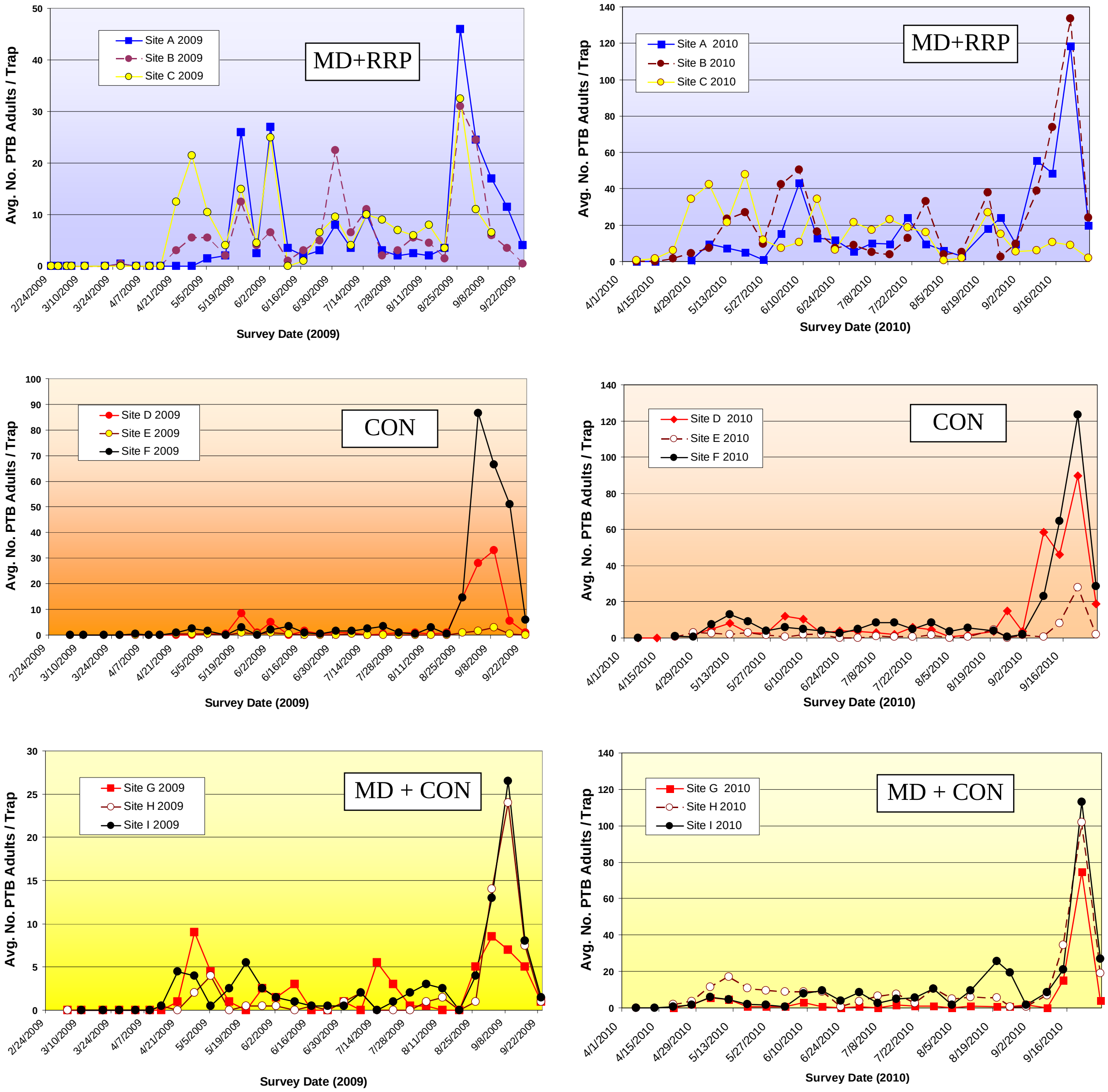


Fig. 4. Peach Twig Borer (PTB) pheromone trap counts in mating disruption + reduced-risk pesticides (Sites A, B & C), conventional treatments (Sites D, E, & F), and mating disruption + conventional treatments (Sites G, H & I) sections in 2009 and 2010.

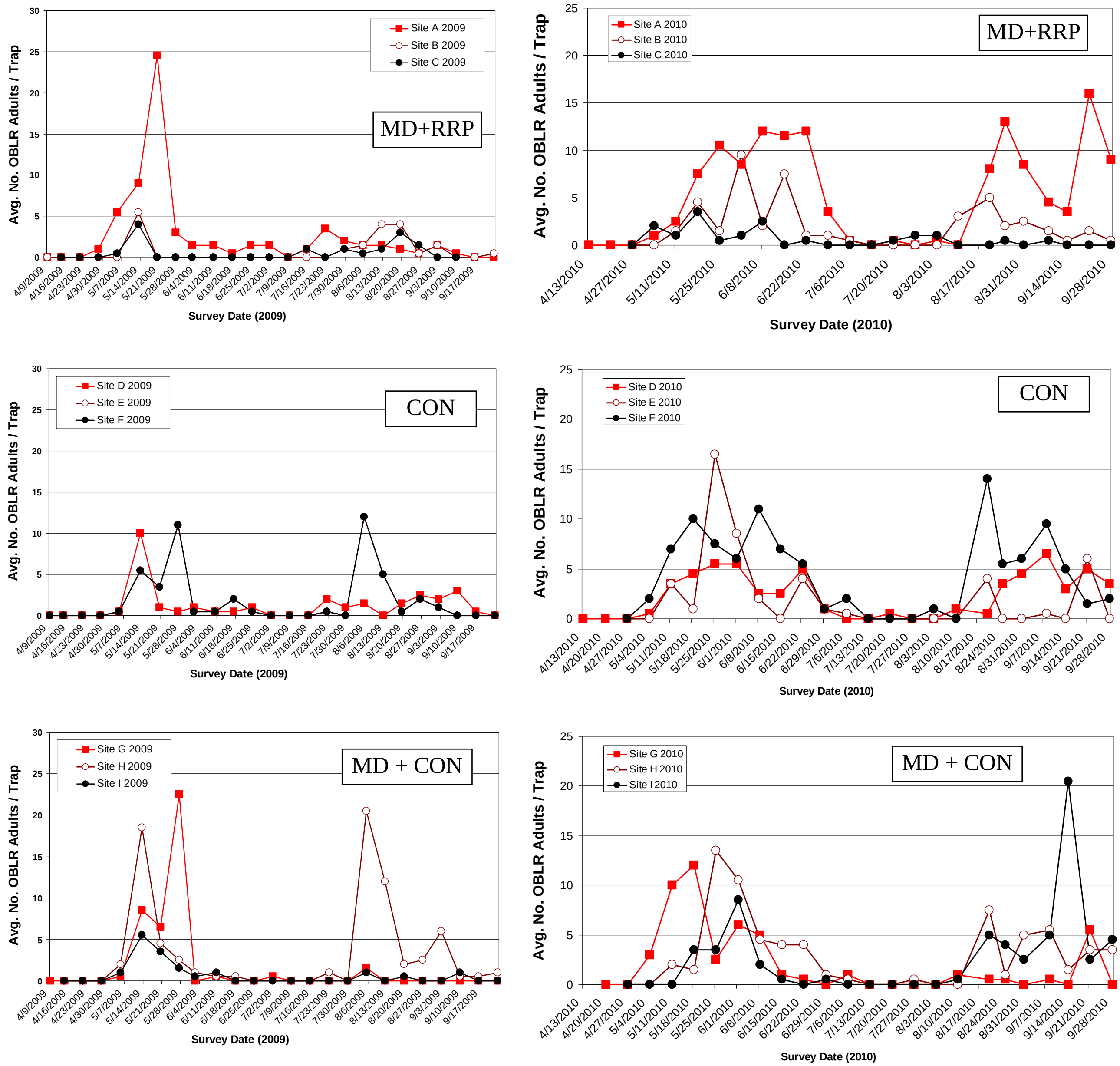


Fig. 5. Obliquebanded Leafroller (OBLR) pheromone trap counts in mating disruption + reduced-risk pesticides (Sites A, B & C), conventional treatments (Sites D, E, & F), and mating disruption + conventional treatments (Sites G, H & I) sections in 2009 and 2010.

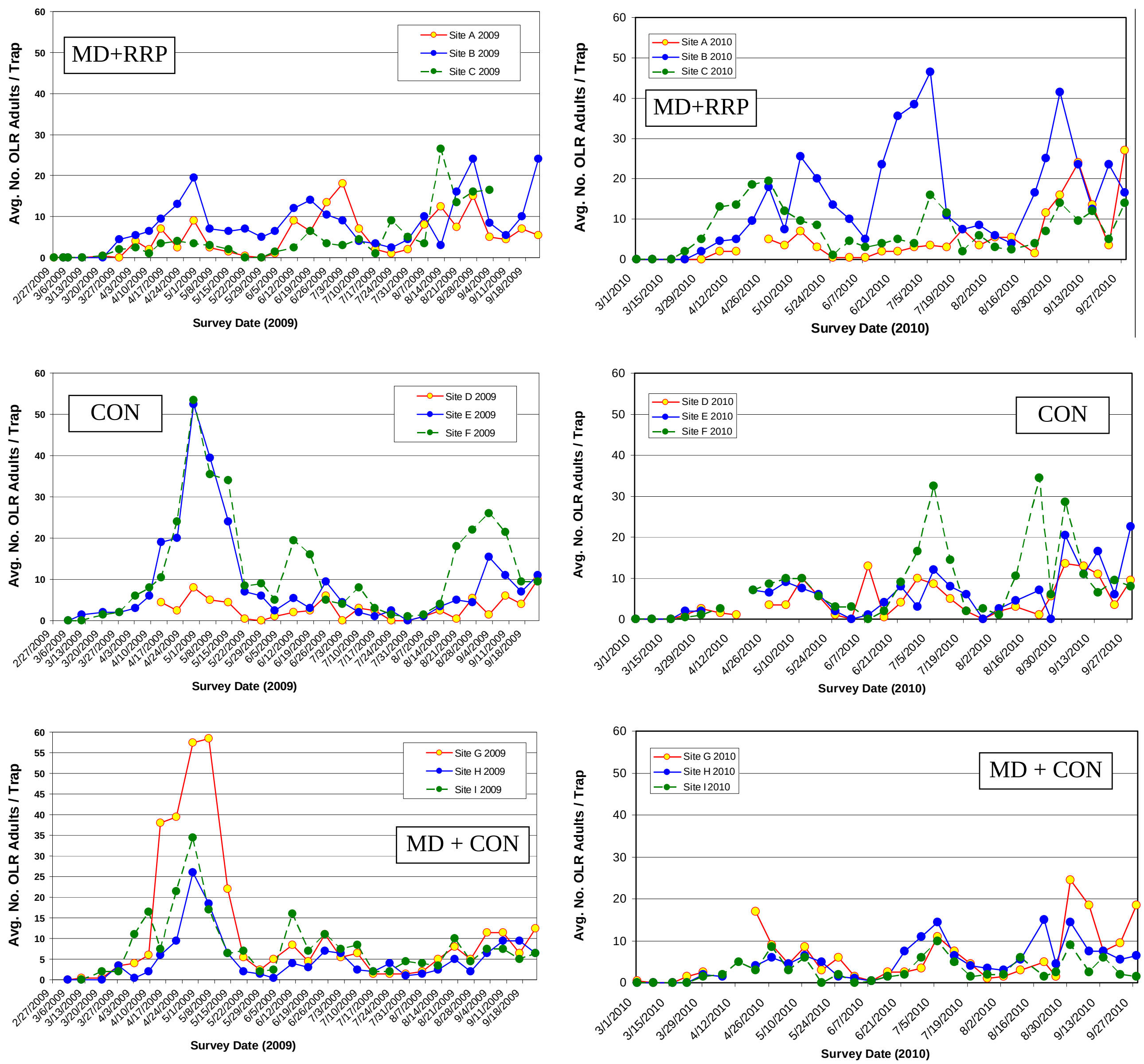
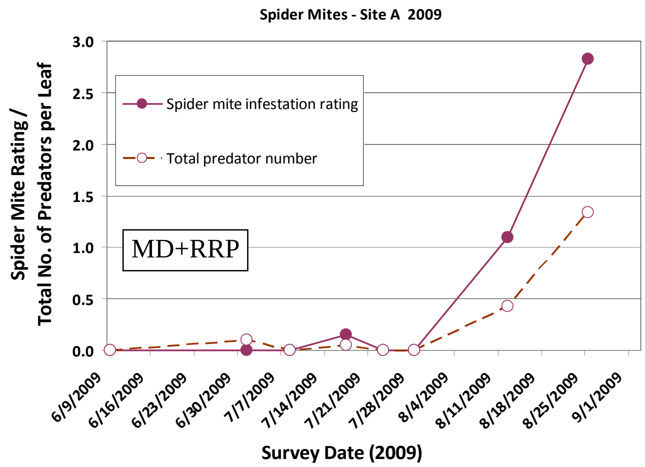
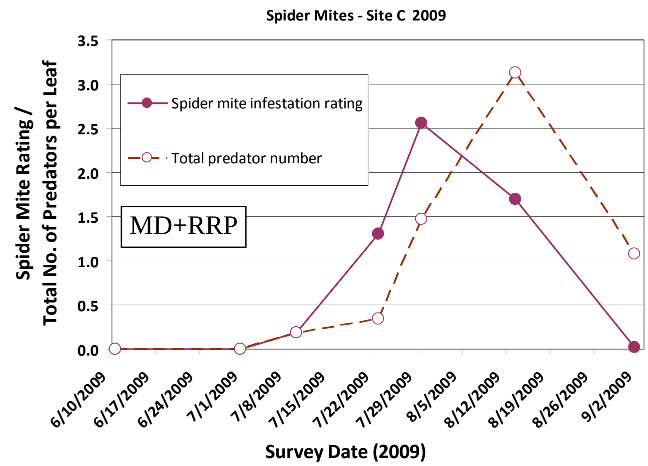
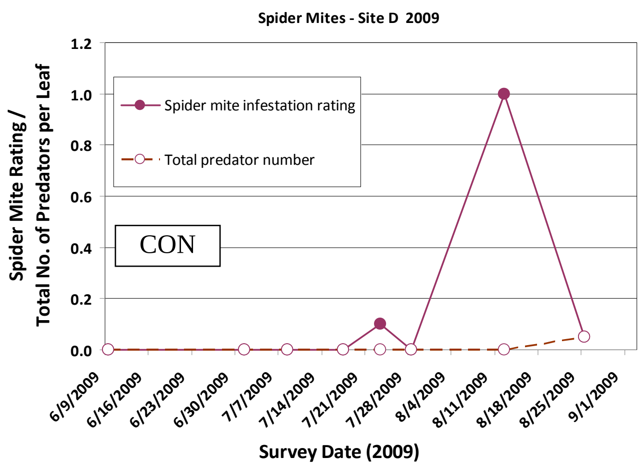
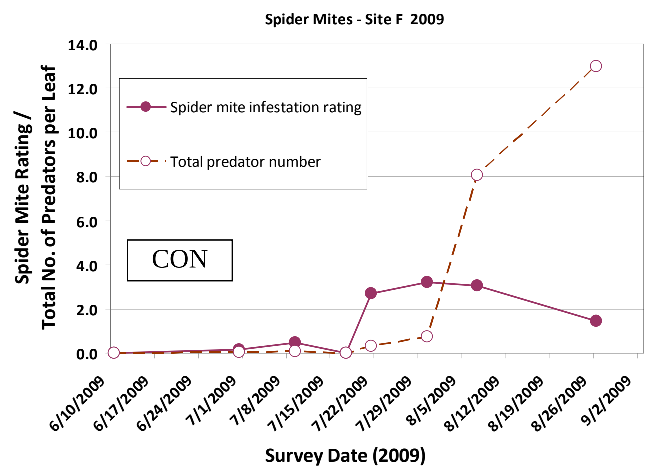


Fig. 6. Omnivorous Leaf Roller (OLR) pheromone trap counts in mating disruption + reduced-risk pesticides (Sites A, B & C), conventional treatments (Sites D, E, & F), and mating disruption + conventional treatments (Sites G, H & I) sections in 2009 and 2010.









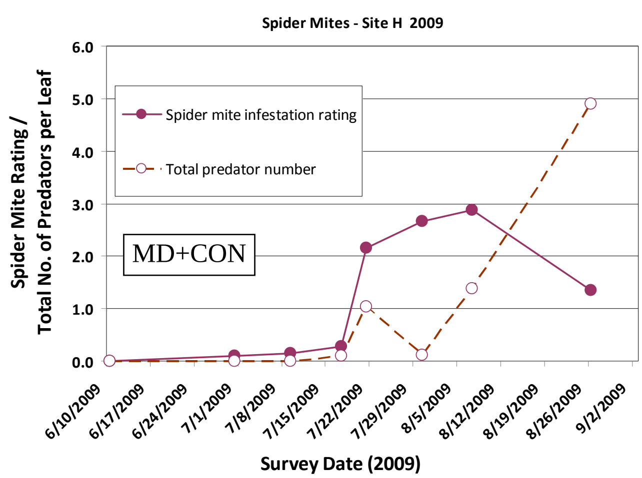


Fig. 7. Ratings[1] of spider mite adults recorded per leaf in mating disruption + reduced-risk pesticides (Sites A & C), conventional treatments (Sites D & F), and mating disruption + conventional treatments (Site H) sections in 2009. Sites B, E, G and I had zero spider mites or only occasional presence of mites (less than 1 adult leaf per week). Note that all orchard sites were harvested by 31 August 2010.

[1] Spider mite rating system: 0 = no spider mites; 1 = 1 to 10 mites (and no eggs); 2 = 1 to 10 mites (with eggs); 3 = 11 to 50 mites with eggs; 4 = 51 to 100 mites with eggs (definite webbing); and 5 = > 100 mites with eggs (lots of webbing).

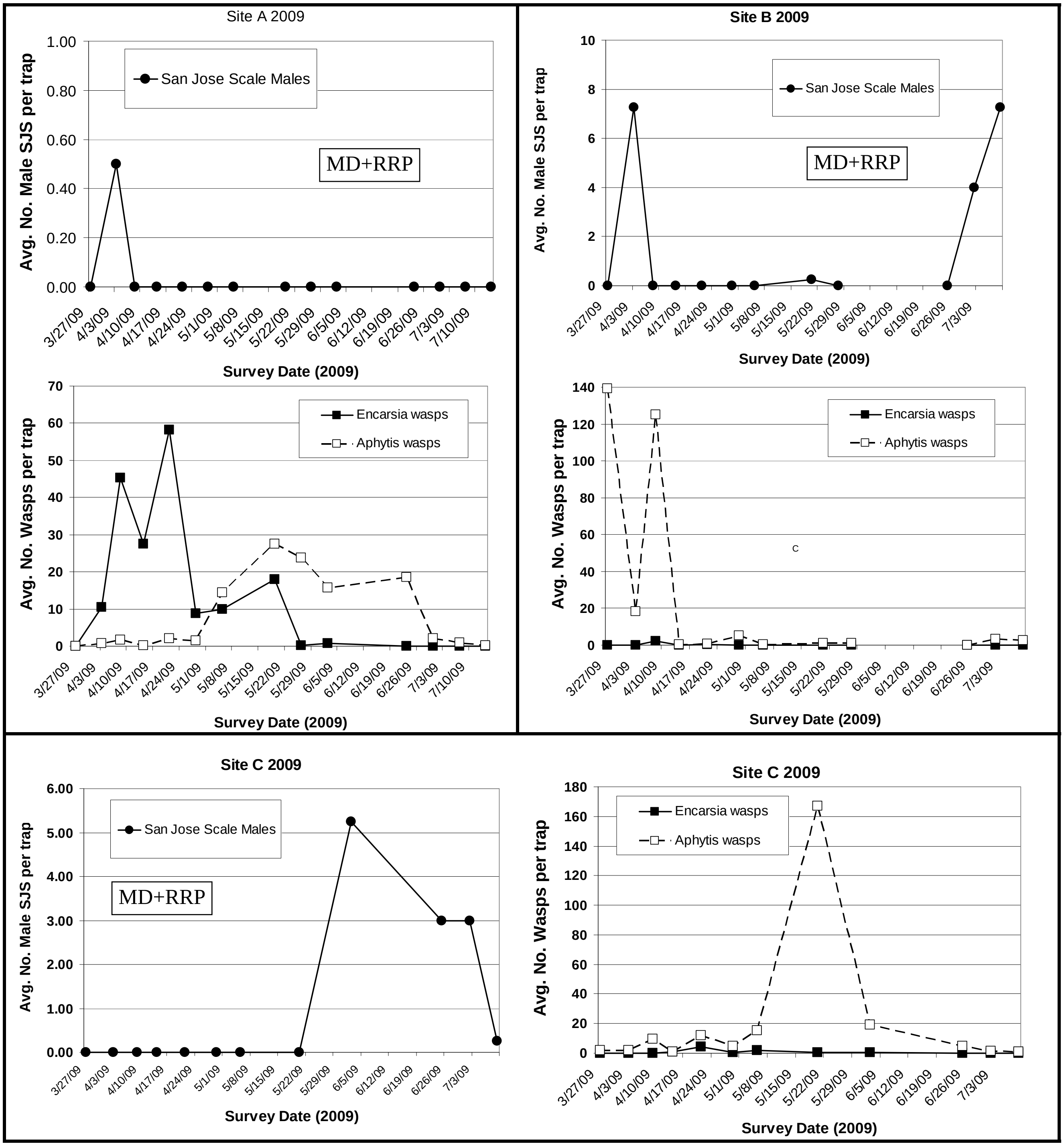


Fig. 8. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in mating disruption + reduced-risk pesticide treatments (Sites A, B & C) sections in 2009.

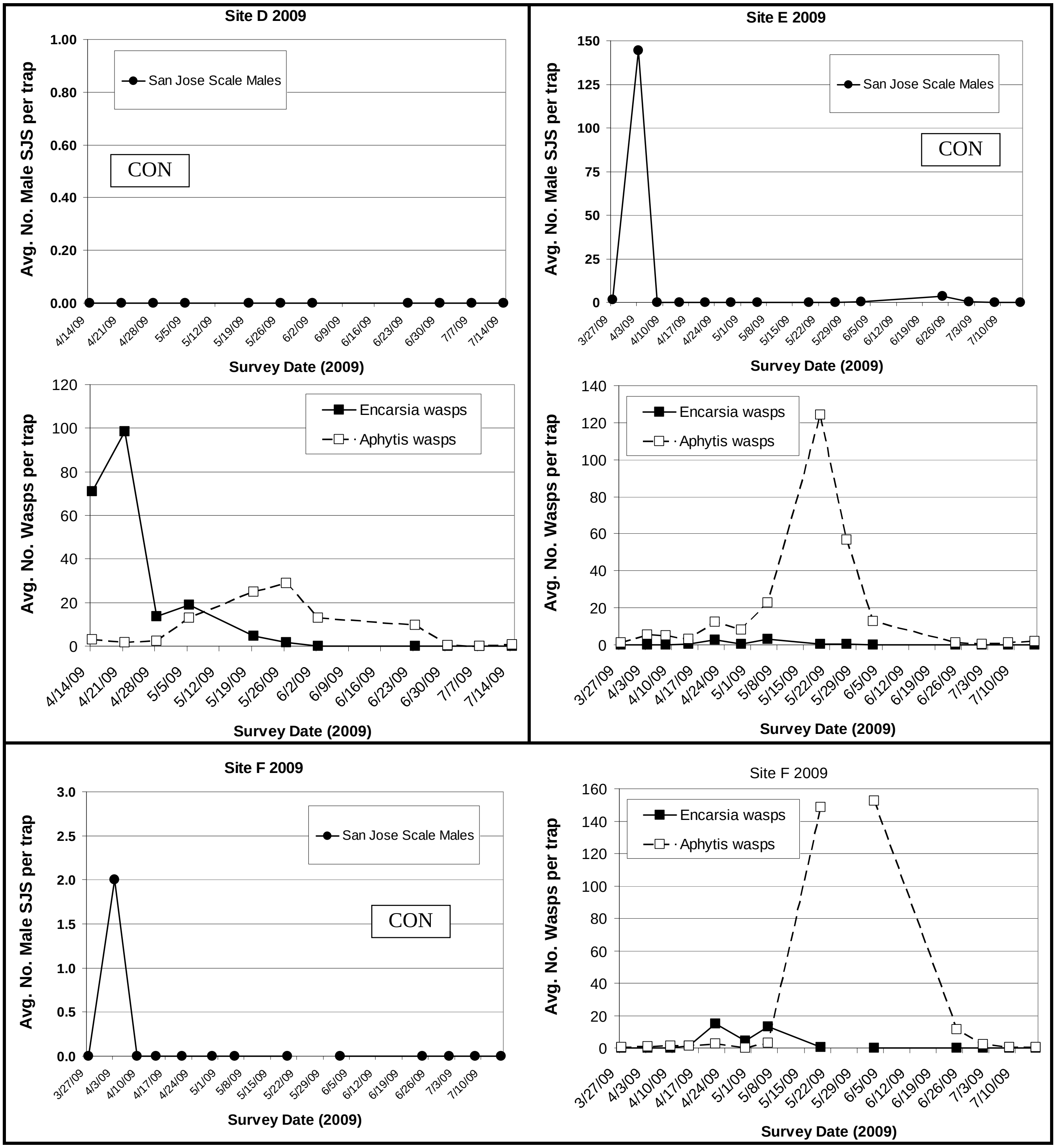


Fig. 9. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in mating disruption + reduced-risk pesticide treatments (Sites D, E & F) sections in 2009.

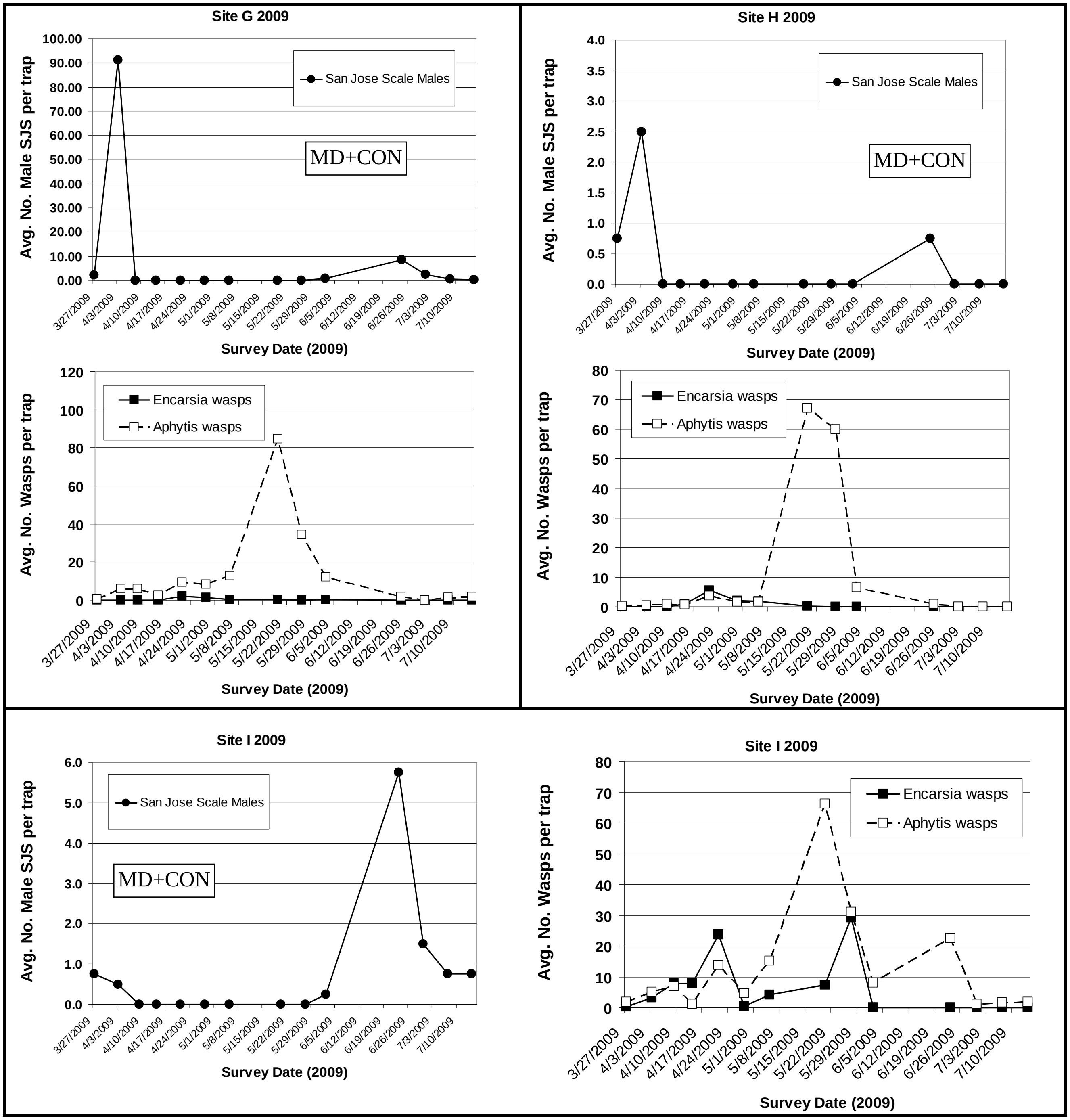


Fig. 10. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in mating disruption + reduced-risk pesticide treatments (Sites G, H & I) sections in 2009.

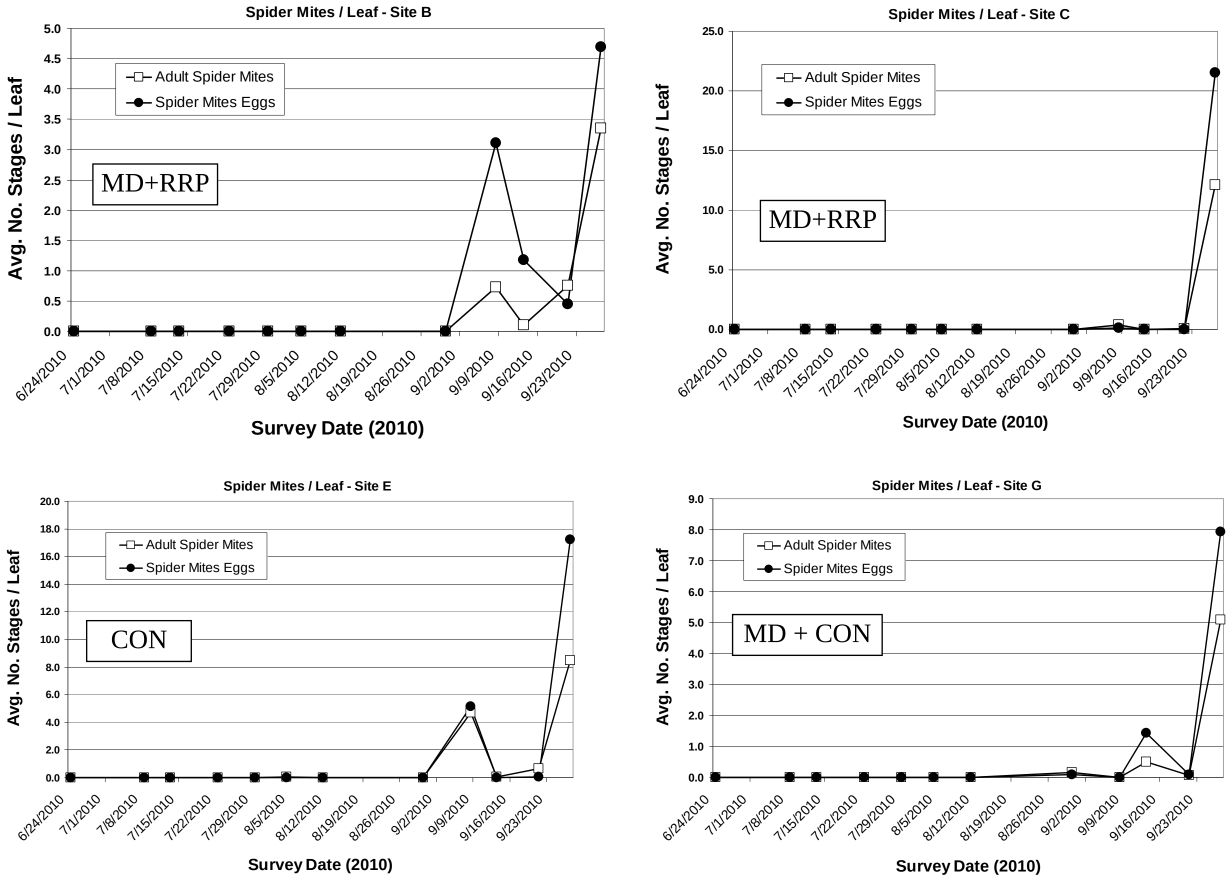


Fig. 11. Densities of spider mite eggs and adults recorded per leaf in mating disruption + reduced-risk pesticides (Sites B & C), conventional treatments (Site E), and mating disruption + conventional treatments (Site G) sections in 2010. Sites A, D, F, H and I had zero spider mites or only occasional presence of mites (less than 1 adult leaf per week). Note that most orchard sites with spider mites were harvested by 31 August 2010, except G that was completed by mid-September.

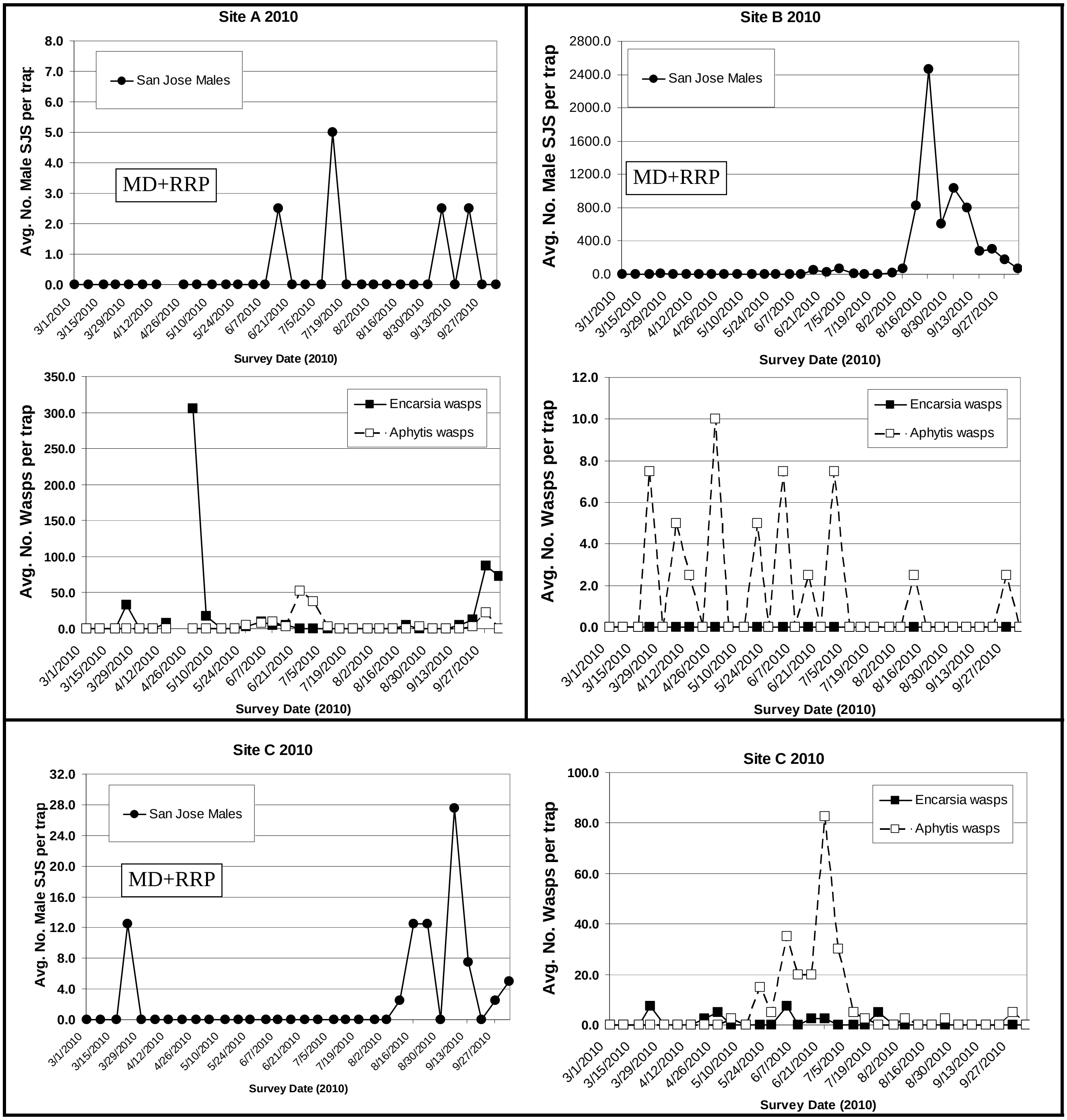


Fig. 12. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in mating disruption + reduced-risk pesticide treatments (Sites A, B & C) sections in 2010.

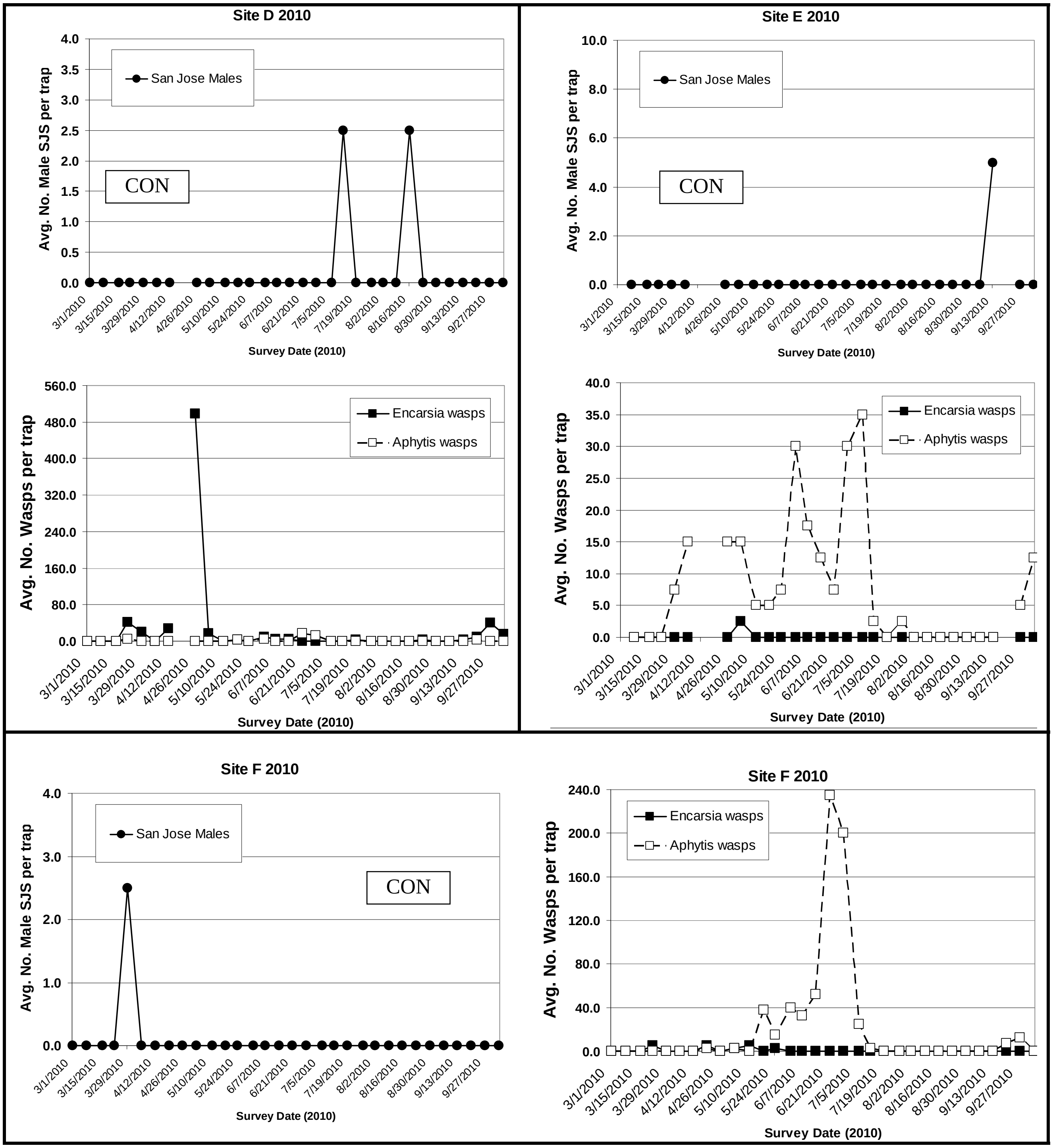


Fig. 13. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in conventional pesticide treatments(Sites D, E & F) treatment sections in 2010.

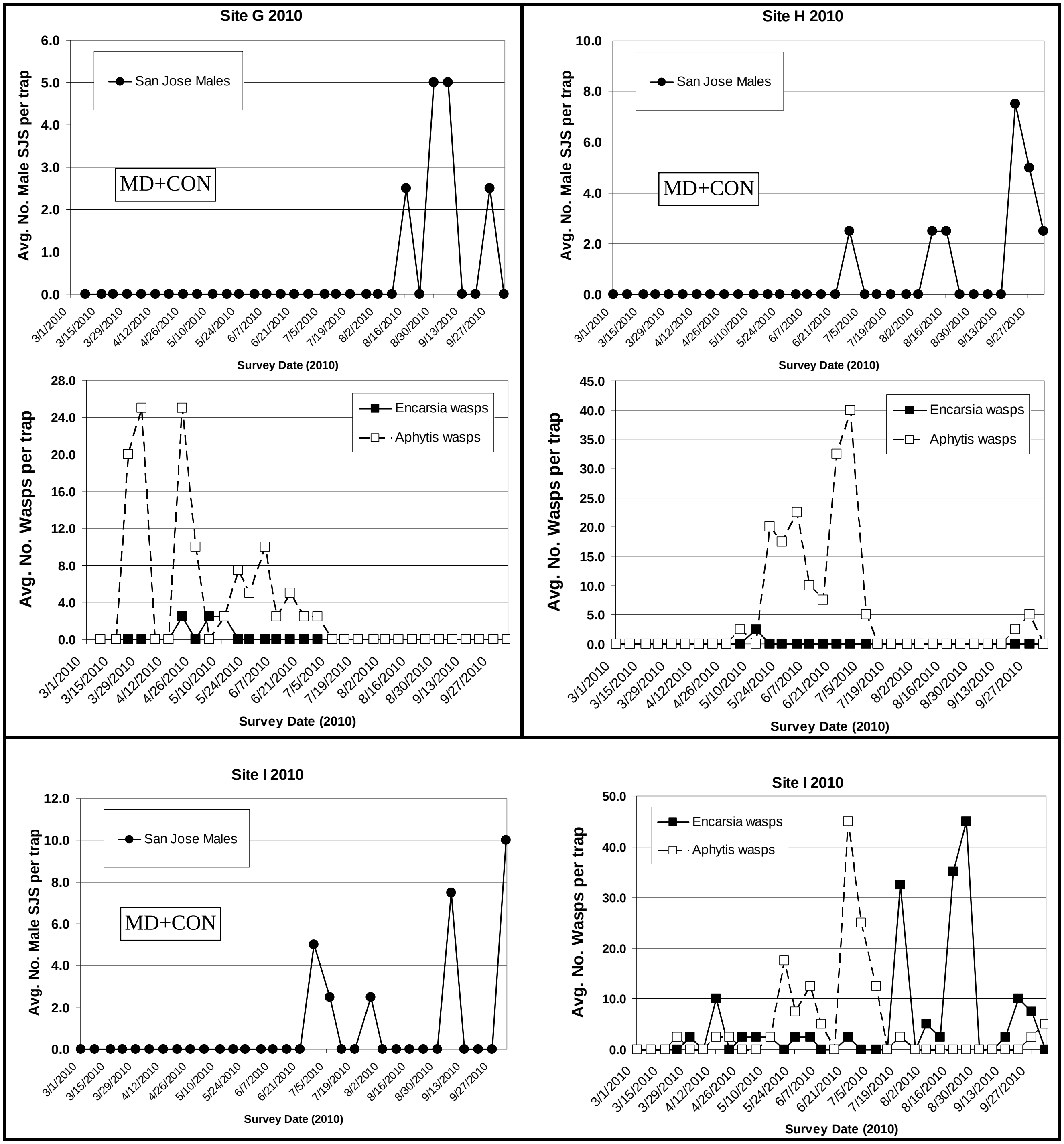


Fig. 14. San Jose Scale pheromone trap counts including *Aphytis* and *Encarsia* parasitoids in mating disruption + conventional pesticide treatments (Sites G, H & I) sections in 2010.

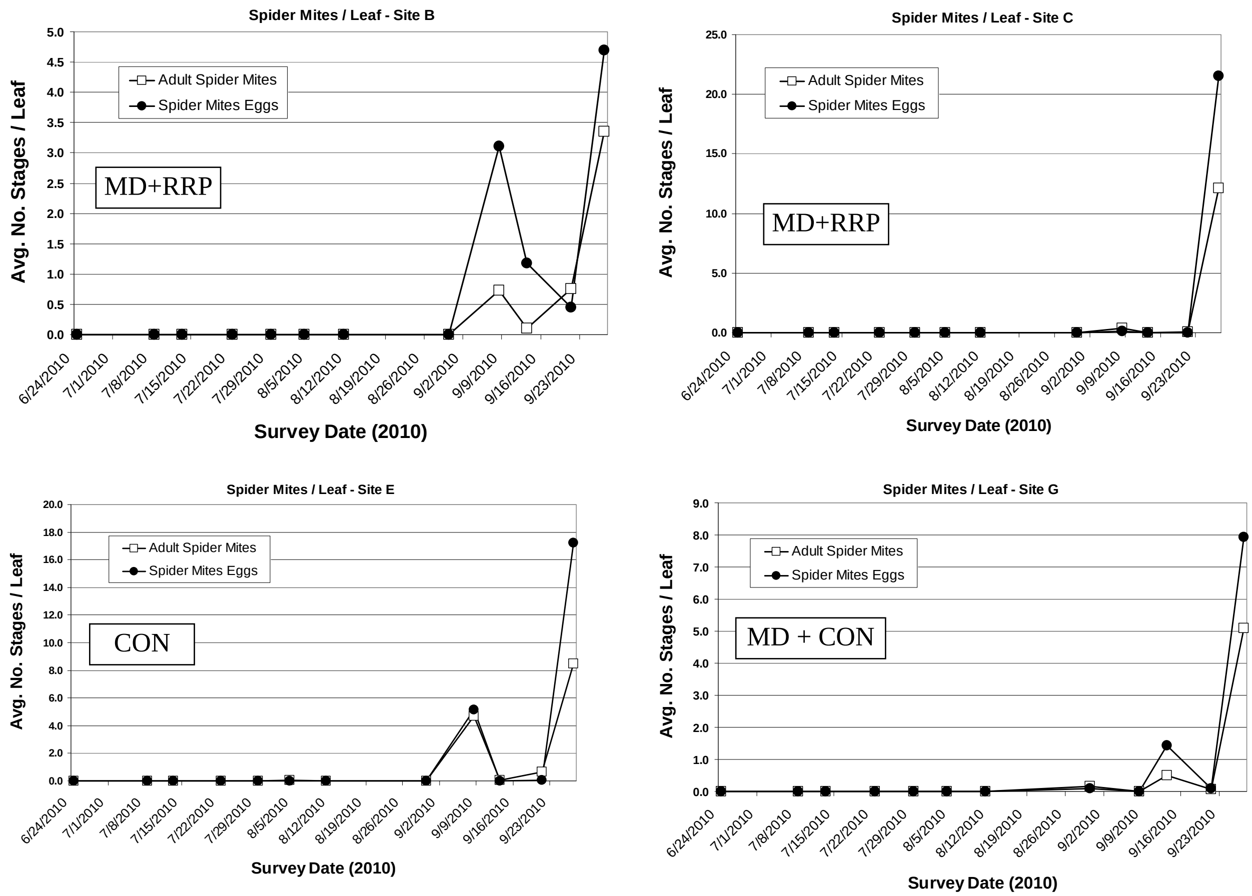


Fig. 15. Densities of spider mite eggs and adults recorded per leaf in mating disruption + reduced-risk pesticides (Sites B & C), conventional treatments (Site E), and mating disruption + conventional treatments (Site G) sections in 2010. Sites A, D, F, H and I had zero spider mites or only occasional presence of mites (less than 1 adult leaf per week). Note that most orchard sites with spider mites were harvested by 31 August 2010, except G that was completed by mid-September.

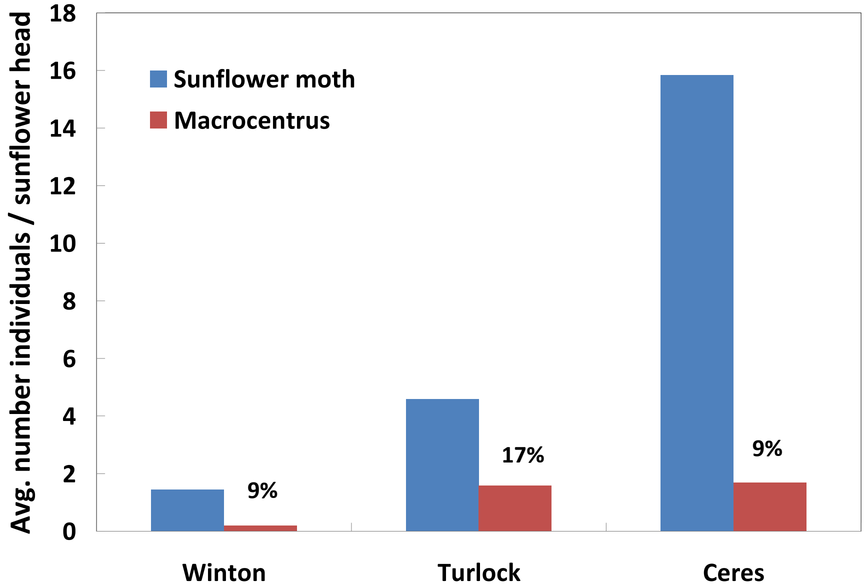


Fig. 16. Average number of sunflower moth and *M. ancylivorus* adults reared per sunflower heads (n = 20) at various orchard sites where commercial sunflowers were planted in May 2009 to conserve overwintering parasitoid populations. The numerical values above the red bars indicated the percentage of potential sunflower moths that were parasitized by M. *ancylivorus.*

APPENDIX I

Managament plans provided to growers

Canning Peach PMA 2009

Pest Management Plan for Experimental Mating Disruption Blocks
(in the rest of the orchard, continue as in 2008)

Month/season	Action	Notes
Dormant period	If needed: • Apply oil alone (for mites, scales). • Can apply Dimilin (12 oz) for PTB.	-More cost effective to include Dimilin with fungicide AT BLOOM than during dormant period.
February	• Hang OFM pheromone traps.	-Supplied and placed by project.
Late February	• Hang OFM mating disruption dispensers, 1/tree, up to 180/acre. • Hang 1 bait bucket trap for OFM.	-Dispensers supplied by project, hung by grower crew. -Bucket traps supplied and hung by project.
Bloom	If needed, apply: • Dimilin (12 oz), or • Success (4-8 oz), or • Delegate (4.5-7 oz)	-Do not apply any of these a second time if used in dormant application. -Can include with fungicide sprays.
Early May	• Count OFM, PTB shoot strikes.	-By project (PCA involved)
May	If needed: • Apply Intrepid (16 oz) for OFM and/or PTB.	-50 OFM per Bait Bucket indicates need. -1 to 2 PTB shoot strikes/tree indicate need.
June	• Count OFM shoot strikes.	-If 3 or more OFM strikes, treat NEXT generation in late July-early August.
July	If needed: • Apply Altacor (1-3 oz) for OFM (follow preharvest interval)	-Decision made in June shoot strike count.
September	If needed: • Apply flowable CheckMate OFM-F mating disruption, every 2 weeks.	-Rise in OFM in pheromone traps may indicate need.

Reports on pest counts in the experimental block will be emailed or faxed to you and your PCA on a weekly basis.

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APPENDIX II - PEACH IPM FIELD DAY – Stanislaus County / 19 June 2009

QUESTIONS -- 19 June 2009	Mark Box	
	YES	**NO**
10 attendees		
1. Have you previously used "mating disruption" to manage Oriental Fruit Moth (OFM) in peaches?	**8** (80%)	**2** (20%)
2. If YES to the above question, which method did you use to apply the pheromone → • Sprayable pheromone?	**8** (100%)	
• Pheromone emitter (e.g., twist tie)?	**7** (87%)	
• Puffer?	**0**	
3. Prior to this meeting, were you familiar with the *Macrocentrus* wasp that naturally kills OFM?	**5** (50%)	**5** (50%)
4. Would you consider planting and maintaining sunflowers to help *Macrocentrus* overwinter for better OFM control?	**8** (80%)	**2** (20%)
5. Which profession better describes you → • Grower?	**4** (40%)	
• Consultant	**5** (50%)	
• Industry representative?	**1** (10%)	
6. Which stone fruit types do you work with → • Cling Peaches?	**10** (100%)	
• Freestone Peaches?	**6** (60%)	
• Nectarines?	**6** (60%)	
• Others?	**4**(40%)	
7. Do you frequently have to treat for spider mites in peaches?	**7** (78%)	**2** (22%)
8. Which of the IPM tactics that were discussed today do you use → • Selective pesticides?	**8** (88%)	**1** (11%)
• Mating disruption for OFM?	**7** (87%)	**1** (12%)
• Pheromone traps for monitoring?	**6** (86%)	**1** 16%)
• Bucket traps to monitor OFM?	**5** (83%)	**1** (16%)
• Sunflowers to aid *Macrocentrus*?	**1** (25%)	**3** (75%)
• Sticky traps for San Jose Scale?	**2** (40%)	**3** (60%)
9. Do you use day-degrees to help time sprays for OFM?	**9** (90%)	**1** (10%)
10. Do you frequently have to treat for San Jose Scale in peaches?	**4** (40%)	**6** (60%)
11. Do you often have to apply additional sprays for OFM control in those peaches harvested late in the summer?	**6** (66%)	**3** (33%)

12. How many acres of cling peaches do you grow? ___ acres
13. How many acres of freestone peaches do you grow? ___ acres

14. Rank how much did you learn today? Circle a number → Little 0 1 2 3 4 5 A lot

0	**0**	**0%**
1	**0**	**0%**
2	**0**	**0%**
3	**4**	**40%**
4	**3**	**30%**
5	**3**	**30%**

APPENDIX III - PEACH IPM FIELD DAY – Merced County / 19 June 2009

QUESTIONS -- 19 June 2009		Mark Box	
		YES	**NO**
11 attendees			
15. Have you previously used "mating disruption" to manage Oriental Fruit Moth (OFM) in peaches?		**6** (54%)	**5** (45%)
16. If YES to the above question, which method did you use to apply the pheromone →	• Sprayable pheromone?	**4** (66%)	
	• Pheromone emitter (e.g., twist tie)?	**2** (33%)	
	• Puffer?		
17. Prior to this meeting, were you familiar with the *Macrocentrus* wasp that naturally kills OFM?		**7** (63%)	**4** (36%)
18. Would you consider planting and maintaining sunflowers to help *Macrocentrus* overwinter for better OFM control?		**9** (90%)	**1** (10%)
19. Which profession better describes you →	• Grower?	**3** (27%)	
	• Consultant	**6** (54%)	
	• Industry representative?	**2** (18%)	
20. Which stone fruit types do you work with →	• Cling Peaches?	**10** (91%)	
	• Freestone Peaches?	**4** (36%)	
	• Nectarines?	**3** (27%)	
	• Others?	**4** (36%)	
21. Do you frequently have to treat for spider mites in peaches?		**3** (33%)	**6** (66%)
22. Which of the IPM tactics that were discussed today do you use →	• Selective pesticides?	**9** (82%)	
	• Mating disruption for OFM?	**7** (63%)	**1** (9%)
	• Pheromone traps for monitoring?	**9** (82%)	
	• Bucket traps to monitor OFM?	**4** (36%)	**3** (27%)
	• Sunflowers to aid *Macrocentrus*?	**2** (18%)	**2** (18%)
	• Sticky traps for San Jose Scale?	**4** (36%)	**2** (18%)
23. Do you use day-degrees to help time sprays for OFM?		**8** (72%)	**3** (27%)
24. Do you frequently have to treat for San Jose Scale in peaches?		**1 (11%)**	**8** (89%)
25. Do you often have to apply additional sprays for OFM control in those peaches harvested late in the summer?		**3** (30%)	**7** (70%)

26. How many acres of cling peaches do you grow? ___ acres
27. How many acres of freestone peaches do you grow? ___ acres

28. Rank how much did you learn today? Circle a number → Little 0 1 2 3 4 5 A lot

0	**0**	**0%**
1	**0**	**0%**
2	**1**	**9%**
3	**1**	**9%**
4	**6**	**54%**
5	**2**	**18%**