Insect and Mite Research

Project No.: **11-ENTO7-Zalom**

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Objectives:

1. Purchase pheromone traps, navel orangeworm (NOW) bait traps, and lures for UC Cooperative Extension Farm Advisors for their ongoing monitoring and extension efforts.
2. Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against peach twig borer.
3. Evaluate efficacy and May treatment timing for newly registered and candidate insecticides against navel orangeworm; Conduct associated research on NOW development on selected varieties
4. Determine potential for *Blattisocius keegani* (Acari: Ascidae) as a biological control for navel orangeworm.

Interpretive Summary:

In the 2011-12 funding cycle, our focus included evaluating efficacy and treatment timing for the navel orangeworm (NOW) and the peach twig borer (PTB) at the May spray timing, with emphasis on products with more specificity that we assume will be less disruptive of naturally occurring biological control agents. The NOW study was completed during the 2011 season, and was the third of a 3 year effort intended to determine efficacy of sprays of 3 of the newer products, Altacor, Delegate, and Intrepid applied at 3 treatment timings. Additional products including Bacillus thuringienses, insect growth regulators and diamide insecticides were also compared to damage in an untreated control. The PTB study, conducted in 2012, was intended to evaluate the diamide insecticides directly to one another and compared to Lorsban and *Bacillus thuringiensis*. The recommended May spray timings for NOW and PTB overlap sufficiently such that a well-timed spray using a degree-day model for either insect can render control of both pests.

A study of 11 almond varieties harvested from a Regional Almond Variety Trial and deployed into almond trees in one orchard the following year. The technique offers means of conducting a field bio-assay of NOW susceptibility and NOW damage varied as expected across varieties.

A field study of the predatory Ascid mite *Blattisocius keegani* indicated that the mite can indeed survive in the field and also migrate to other trees, and that the mites are also capable of moving by phoresy (clinging) on NOW females.

Materials and Methods:

Objective 1. Monitoring. Each year through this project, trapping supplies are purchased for use by UC Cooperative Extension Farm Advisors to help them monitor the phenological activity of almond insect pests in their counties. The Advisors use the data gathered from these traps to update pest status for local growers and PCA's. Continuing to coordinate regional insect trapping and collaborating with new monitoring research allows for consistency and improvements in this important component of almond IPM.

Objective 2. Peach twig borer. May sprays have some advantages over dormant sprays for PTB control in that there is less concern for pesticide runoff and better weather conditions for applications occur at that time. There is also the potential to obtain coincidental control of NOW with the May spray or even primary control of the first generation if the May spray is timed for NOW directly when using insecticide products that are effective against both species since the May treatment timings for these insect are somewhat similar in many years depending on location. May sprays can be timed using degree-day models for PTB (Rice et al., 1982) or for NOW egg hatch (Engle and Barnes, 1983; Zalom et al., 1998). For the past 3 years, we have evaluated newer products that could be used at the May spray timing and multiple timing for selective products, and applied 3 of the products, Delegate, Intrepid and Altacor at 3 timings based on start of navel orangeworm egg laying, at 100 NOW degree-days (the recommended timing for NOW), and at 400 PTB degree-days. Interestingly, PTB and NOW control efficacy was not significantly different for the products at the different treatment timings, but there were differences in efficacy among the products for PTB. In 2012, we focused on comparing efficacy of the diamide insecticides to one another. The diamides include Altacor (chlornitraniliprone), Belt (flubendiamide), Tourismo (flubendiamide and buprofezin), and cyazypyr (cyantraniliprole) which is not yet registered and does not yet have a trade name. All the diamide insecticides were applied with Dyne-Amic at 0.25% v/v. The *Bacillus thuringiensis* product Dipel was applied twice, at 100 NOW degree-days and 10 days later. Lorsban applied at 4 pts per acre served as the standard control. Application rates of products and application timings are provided on the data table.

This year's study was conducted on second leaf almonds located near the site of our navel orangeworm study orchard for 2012, a mature almond orchard near Ripon, San Joaquin Co. The treatments were blocked by variety with 2 replicates of each insecticide treatment for each variety (6 replicates in all). The PTB biofix for the site was determined to be April 19, and the navel orangeworm biofix April 26. PTB pheromone traps and navel orangeworm (NOW) egg traps were deployed to determine biofix for the first flights of both species so that degree-days could be calculated to time treatments. All applications were made at a timing as close to 400 DD degree-days (Zalom et al, 1992) as practical which is the treatment timing for PTB recommended in the *UC Pest Management Guidelines for Almonds*. Altacor was again applied at 3 treatment timings corresponding to the start of NOW egg-laying, 100 NOW degree-days and 400 PTB degree-days, and Dipel at the 100 degree-day NOW timing and 10 days later. The actual application date for most treatments was May 14, 2012, at 402 PTB degree-days. The application dates for the two applications of Dipel were May 7 (108 NOW degree-days) and May 17. Dates of the different Altacor treatment timings were April 26 for the earlier treatment (0 NOW degree-days) and later on May 7 (108 NOW degree-days). All sprays were applied at the equivalent of 100 gal of water per acre with an Echo Duster-Mister Air Assist Sprayer. PTB shoot strikes were evaluated on June 5, 2012, at 758 PTB degree-days following biofix. Log-transformed data were analyzed by one way ANOVA and treatment means separated from the untreated control by Student's t-test.

Objective 3. Navel orangeworm. As mentioned for PTB, the 'May spray' timing offers the potential to obtain some level of control of both NOW and PTB as these insects have flights that overlap somewhat in many years. The May spray controls the first generation of NOW following spring moth emergence. Females of the first flight lay their eggs on the mummy nuts that remain in the orchards, so the infestation of mummy nuts can be quite high. The current May spray timing recommendation for NOW is 100 degree-days after the first eggs are laid for 2 consecutive sampling periods on egg traps. Like the recommended PTB treatment timing of 400 degree-days after the start of the spring flight, the NOW timing is based on research developed for organophosphates that caused direct mortality to both the NOW and PTB larvae. Many of the newer insecticide products have different activity against larvae, so we surmised that spray timing may need to be earlier (or later) relative to products that kill larvae directly.

The site of the 2011 May navel orangeworm control study was a mature 20 acre almond orchard on near Ripon, but in San Joaquin Co. The block had not been dormant treated by the grower and had a mummy load recorded on February 1, 2011, averaging 21 per tree. Mummies could still be found in trees when this study was initiated in late April, 2011, when NOW egg traps and PTB pheromone traps were hung to establish the biofix for each species. Ten black navel orangeworm eggs traps were hung for better resolution of a biofix.

Using the same protocol as proved successful for us in 2009 and 2010, twenty uninfested Nonpareil nuts saved from the 2010 harvest were hot glued to strands of vegetable mesh during April, 2011, and 449 strands were prepared in all. They were all deployed at mid-canopy in Nonpareil trees on May 10, the biofix date. There were 20 treatments in all, with 10 mummy strands allocated for each treatment including 19 to the water only controls. Treatments of Intrepid, Altacor, and Delegate were applied directly to the strands at 3 timings, May 10 (0 NOW degree-days), May 25 (100 NOW degree-days), and May 27 (400 PTB degree-days). All products were applied as close to the treatment timing for NOW in the *UC Pest Management Guidelines for Almonds* (100 DD using navel orangeworm degree-day developmental thresholds) as practical. Three products, Intrepid, Altacor and Delegate were applied at earlier and later treatment timings as well. All treatments were applied at the equivalent spray volume of 100 gpa, and any adjuvants included with each treatment are indicated as footnotes to the results table. The nuts were removed from the field on July 11 before the start of the hullsplit flight and handcracked to determine NOW infestation. Arcsine-transformed data were analyzed by one-way ANOVA and treatment means compared by Student's t-test. Although this study was initiated during the 2010-11 funding cycle, it was not completed until the 2011-12 cycle. A related study initiated in the spring of 2012 is in progress and results will be reported next year.

Hamby et al. (2009) analyzed data for a number of varieties from the 3 Regional Almond Variety Trials, and correlated percent damage to both their hullsplit dates and shell seal. Hullsplit date and shell seal were significantly related to damage across varieties in this analysis as expected, but there were a few varieties in those trials (some of which are not grown commercially) that seemed to have more or less damage than the trend would indicate as measured by hullsplit date or shell seal alone. Eleven varieties representing standard commercial varieties such as Nonpareil and many others selected because they did not fit the trend lines were collected at the time of each of their harvests in Fall 2010, from the original almond variety trial that is still maintained at Delta College in Manteca. While it is impossible to control for all variables that affect trees in an orchard, it might be expected that nuts from trees grown within the same orchard and using the same horticultural practices would have as few uncontrolled variables as might be possible in a field setting.

Nuts that had been shaken from trees were collected at the harvest timing for each variety and returned to UC Davis. Twenty uninfested nuts with hulls intact of each variety were hot glued to strands of plastic vegetable mesh in the lab, redeployed outdoors in a sheltered area in Davis for the winter, and returned to the orchard in San Joaquin County where they hung in Nonpariel trees (to avoid possible confounding factors associated with hanging them in more than one almond variety) on May 10, 2011, at the initiation of oviposition of the overwintering adult females (as measured by NOW egg traps). These methods were similar to those used successfully in 2009 and 2010 for the efficacy and treatment timing study described previously. There were 10 replicates for each of the 11 variety deployed at random in Nonpariel rows of the orchard. The 11 varieties selected for the experiment were Nonpareil, Johlyn, Livingston, Wood Colony, Padre, Price, Sonora, Plateau, Aldrich, Monterey and Carmel. The strands were collected before the start of the second generation flight, and returned to the lab where each almond was hand-cracked and scored for presence of navel orangeworm larvae, pupae, damage and evidence of bird damage.

Data were analyzed by one way ANOVA followed by means comparison of damage recorded in each variety to Nonpariel using Dunnett's test following log transformation to meet normality.

<u>Objective 4. Spider mite and predator research.</u> In 2009, my lab found a predatory mite, *Blattisocius keegani* (Acari: Ascidae), feeding on navel orangeworm eggs. The mite family Ascidae is not the same as the mite family Phytoseiidae that includes the familiar spider mite predators including *Galendromus occidentalis* and *Neoseiulus californicus* that can be mass reared and released. My lab has already conducted extensive laboratory feeding studies with *B. keegani* to determine how many navel orangeworm eggs a single female will eat and other biological parameters of its development, and we have determined how to mass rear the mite in culture on navel orangeworm eggs. More importantly we have also learned to mass rear the mite on eggs of another pyralid, *Ephestia kuehniella*, the meal moth, which is often, used by insectaries to mass-rear the parasitic wasp, *Trichogramma* spp., for sale and release. We have recently published these findings (Thomas et al., 2010). Interestingly, the mite appears to be phoretic meaning that it can cling to a moth and be distributed in this manner. All of our work to date has been in the laboratory. Whether this mite could be released and survive in the field and its capacity to be distributed by phoresy in the field is not known. That is the purpose of our current objective.

In 2011, two types of field releases were performed to evaluate mite survival and movement via phoresy. The studies were conducted in the almond orchards on the Plant Pathology farm at UC Davis where the endemic NOW population is known to be quite low. For the study to determine survival and establishment, twenty mites were placed on 1 inch by1 inch pieces of one-ply paper towel ("release papers"). Twenty of these pieces of paper towels were placed with T-pins in the field for each release. At the same time, twenty "mite traps" were pinned in the same tree at varying distances from the release papers, ranging from touching to four feet apart. Mite traps consisted of a 1 inch by1 inch piece of one-ply paper towel and twenty NOW eggs. Both traps and the release papers were checked daily for live mites and dead mites, and remaining NOW eggs on the traps were counted. For the second study, to establish the possibility of the mites to travel phoretically on moths in the field, 100 female NOW moths were placed in a lab colony of mites, and checked every few hours until all moths carried 3 to 5 mites at which time the moths were removed from the colony. To monitor the release, NOW eggs traps were suspended inside of a sticky wing trap with the objective being to capture female moths flying to the egg trap and in the process being captured in the wing trap. Twenty traps were placed in the eight trees immediately surrounding the release trees. Moths were released, and traps were checked every other day. Any moths captured were placed in an individual Petri dish and returned to the lab to be inspected under the microscope. Three phoresy releases were completed throughout the summer in two different trees in the field on June 15, June 30, and July 15.

Results and Discussion:

<u>Objective 1. Monitoring.</u> Each year through this project, trapping supplies are purchased for use by UC Cooperative Extension Farm Advisors to help them monitor the phenological activity of almond insect pests in their counties to update pest status for local growers and PCA's. The trapping supplies are standardized to insure consistency in data collected over years. For the 2012 season, supplies purchased and distributed included 220 traps of various kinds, 250 pheromone lures for peach twig borer (PTB), San Jose scale (SJS), and oriental fruit moth (OFM), and 8 lbs of NOW bait. Six Farm Advisors received these supplies.

<u>Objective 2. Peach twig borer</u>. The diamide insecticides provided similar or better control of peach twig borer to the standard insecticides during the 3 previous years of our May spray studies. However, we have never had all of these products in our study in one year. In 2012 we evaluated the registered diamide products Altacor, Belt and Tourismo as well as cyazypyr which is not yet registered. We also applied Altacor at the same three treatment timings as in our 2012 NOW study that is being conducted in a nearby orchard. Although the full impact of the diamides insecticides is not known, they are believed to be less toxic to natural enemies than the organophosphate or pyrethroid insecticides and they appear to be effective against both PTB and NOW based on our results from previous seasons. Unpublished data suggest that Altacor might have some negative impact on green lacewings. Tourismo, a mixture of flubendiamide and buprofezin, has the added benefit of providing some control of Hemipterans. However, not all Hemipterans are pests and some are beneficial insects, so the choice of products is important depending on the target pest species. It has also been suggested that buprofezin may have a negative impact on predaceous lady beetles.

Results from our 2012 study revealed significant differences between treatments. Means were separated by Student's t-test. The analysis revealed that all of the insecticide treatments significantly reduced the number of peach twig borer shoot strikes relative to the untreated check (**Table 1**). Both cyazypyr treatments and the Altacor treatment applied at the 400 PTB degree-day timing had significantly fewer shoot strikes than recorded in the Dipel treatment.

Table 1. Mean (± SD) peach twig borer shoot strikes per tree, 2012

Treatment	Rate	Application date	PTB strikes/tree* Mean ± SD	
Control	NA	NA	5.83 ± 2.76	A
Dipel	1 lb + 1 lb	5/7/12 + 5/17/12	2.17 ± 1.83	B
Lorsban	4 pt	5/14/12	1.67 ± 1.63	BC
Belt SC	4 oz	5/14/12	1.00 ± 1.10	BC
Tourismo	14 oz	5/14/12	1.00 ± 1.26	BC
Altacor	4 oz	4/26/12	0.67 ± 0.82	BC
Altacor	4 oz	5/14/12	0.50 ± 0.84	C
Altacor	4 oz	5/17/12	0.67 ± 1.03	BC
Cyazypyr 10SE	13.5 oz	5/14/12	0.50 ± 0.84	C
Cyazypyr 10SE	16.9 oz	5/14/12	0.33 ± 0.52	C

*Means followed by the same letter do not differ significantly at $P<0.05$ by Student's t-test.

Objective 3. Navel orangeworm.

Figure 1 presents accumulated NOW and PTB degree-days and trap captures for the site. Treatments and application dates are indicated on **Table 2**. ANOVA indicated significant treatment differences (F=3.8322, df=21, 222, P<0.0001) in infested nut meats. All products significantly reduced kernel infestation except for the 2 MBI products and the 2 diflubenzuron products. There were no differences between the 3 treatment timings for Delegate, Intrepid and Altacor.

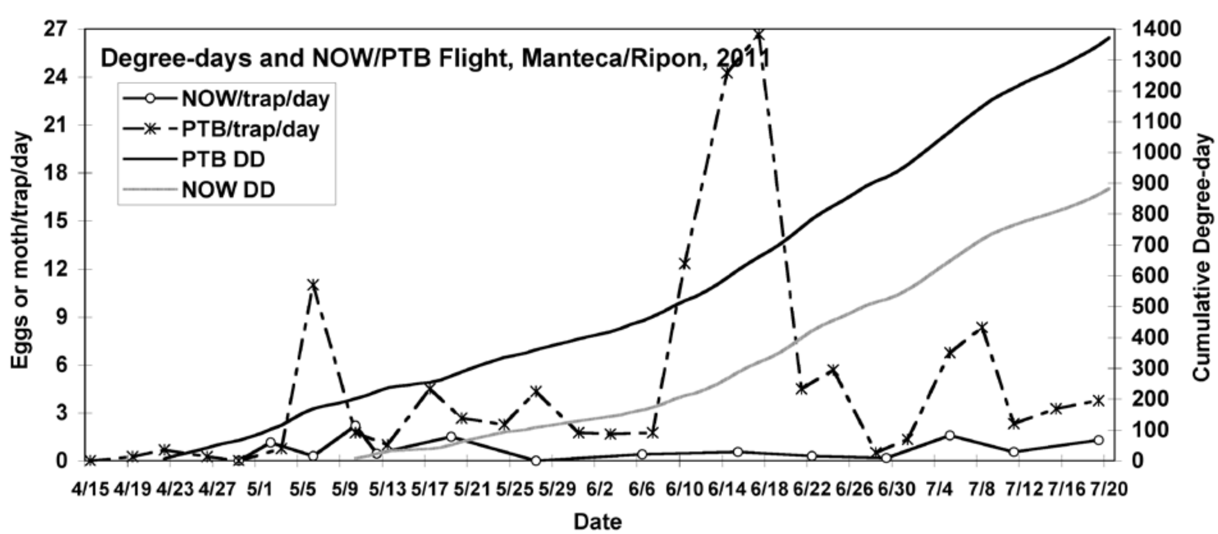

Figure 1. Navel orangeworm and peach twig borer degree-days and trap count at the Ripon site, 2011.

Table 2. Mean (± SD) proportion of NOW infested mummy nut meats in each treatment, Ripon, 2011.

Treatment	Rate (form./acre)	Treatment date	Mean ± SD[1]			
Control (water)	na		10.9	±	15.7	ABCD
Dipel*	1 lb + 1 lb	5/9 + 5/27	4.9	±	9.3	DE
MBI-203*	2 gal	5/9 + 5/27	10.0	±	6.6	AB
MBI-206*	2 gal	5/9 + 5/27	15.1	±	17.6	A
Dimilin 2L	12 oz	5/25	14.3	±	11.5	A
diflubenzuron (generic)	12 oz	5/25	11.0	±	11.8	ABC
Lorsban	4 pt	5/25	0.0	±	0.0	E
Intrepid 2F***	16 oz	5/10	1.7	±	3.7	E
Intrepid 2F***	16 oz	5/25	1.5	±	3.2	E
Intrepid 2F***	16 oz	5/27	0.9	±	2.6	E
Delegate 25WG ***	7.0 oz	5/10	2.6	±	4.2	E
Delegate 25WG***	7.0 oz	5/25	2.2	±	4.6	E
Delegate 25WG ***	7.0 oz	5/27	0.7	±	2.3	E
Altacor 35WDG***	4.0 oz	5/10	0.8	±	2.4	E
Altacor 35WDG***	4.0 oz	5/25	1.9	±	4.2	E
Altacor 35WDG***	4.0 oz	5/27	0.0	±	0.0	E
Assail 70WP + Lambda-Cy 11.4EC	4.1 oz + 2.56 oz	5/25	4.4	±	6.1	CDE
Assail 70WP + Lambda-Cy 11.4EC	2.3 oz + 5.12 oz	5/25	3.5	±	8.3	E
Belt 4SC**	4 oz	5/27	2.7	±	4.6	E
Dimilin 2L + Lorsban EW	12 oz+4 pt	5/25	3.2	±	5.7	DE
Dimilin 2L + Altacor 35WDG	12 oz+3 oz	5/25	1.6	±	3.0	E
HGW86	16.9 oz	5/27	5.0	±	7.4	BCDE

[1] Means followed by the same letter do not differ significantly at *P*=0.05 by Student's t-test following arcsine transformation.
*LI-700 added @ 0.25% v/v
**Dyne-Amic @ 0.25% v/v
*** Induce @.25% v/v

ANOVA also indicated significant treatment differences (F=4.2071, df=21, 222, P<0.0001) in infested nut meats and hulls combined (**Table 3**). Results were similar to those for kernel infestation alone. The total infestation of nuts is important in May as adults emerging from these larvae will attack the new crop nuts.

Table 3. Mean (± SD) proportion of NOW infested mummies (total with larvae in meats and hulls) in each treatment, Ripon, 2011.

Treatment	Rate (form./acre)	Treatment date	Mean ± SD[1]			
Control (water)	na		13.8	±	17.3	AB
Dipel*	1 lb + 1 lb	5/9 + 5/27	4.9	±	9.3	CD
MBI-203*	2 gal	5/9 + 5/27	11.6	±	7.7	AB
MBI-206*	2 gal	5/9 + 5/27	15.1	±	17.6	AB
Dimilin 2L	12 oz	5/25	14.9	±	11.2	A
diflubenzuron (generic)	12 oz	5/25	13.0	±	11.8	AB
Lorsban	4 pt	5/25	0.0	±	0.0	D
Intrepid 2F***	16 oz	5/10	1.7	±	3.7	CD
Intrepid 2F***	16 oz	5/25	1.5	±	3.2	CD
Intrepid 2F***	16 oz	5/27	2.0	±	3.9	CD
Delegate 25WG ***	7.0 oz	5/10	2.6	±	4.2	CD
Delegate 25WG***	7.0 oz	5/25	3.2	±	4.9	CD
Delegate 25WG ***	7.0 oz	5/27	0.7	±	2.3	D
Altacor 35WDG***	4.0 oz	5/10	1.7	±	3.6	CD
Altacor 35WDG***	4.0 oz	5/25	1.9	±	4.2	CD
Altacor 35WDG***	4.0 oz	5/27	0.0	±	0.0	D
Assail 70WP + Lambda-Cy 11.4EC	4.1 oz + 2.56 oz	5/25	4.4	±	6.1	CD
Assail 70WP + Lambda-Cy 11.4EC	2.3 oz + 5.12 oz	5/25	3.5	±	8.3	CD
Belt 4SC**	4 oz	5/27	3.3	±	4.6	CD
Dimilin 2L + Lorsban EW	12 oz+4 pt	5/25	3.7	±	5.6	CD
Dimilin 2L + Altacor 35WDG	12 oz+3 oz	5/25	1.6	±	3.0	CD
HGW86	16.9 oz	5/27	7.0	±	9.0	BC

[1] Means followed by the same letter do not differ significantly at *P*=0.05 by Student's t-test following arcsine transformation.
*LI-700 added @ 0.25% v/v
**Dyne-Amic @ 0.25% v/v
*** Induce @ 0.25% v/v

While cracking nuts, we found a considerable number of earwigs in the hulls and split nuts, so we recorded these data. **Table 4** presents the number of live and dead earwigs found when cracking the nuts. We noted previously that earwigs are commonly associated with mummy nuts at the Manteca site. Differences in occurrence and survival may suggest differences between treatments in nontarget effects or in some cases possibly a greater infestation of navel orangeworm larvae.

Table 4. Number of mummy nuts with live and dead earwigs following application of various chemicals at the 'May' treatment timing, Manteca, 2011.

Treatment	Mean ± SD[1,3] live earwigs				Mean ± SD[2,3] dead earwigs			
Control (water)	0.3	±	0.5	AB	0.0	±	0.0	C
Dipel	0.0	±	0.0	B	0.2	±	0.4	BC
MBI-203	0.3	±	0.5	AB	0.3	±	0.5	BC
MBI-206	0.2	±	0.4	B	0.0	±	0.0	BC
Dimilin 2L	0.0	±	0.0	B	0.0	±	0.0	BC
diflubenzuron (generic)	0.1	±	0.4	B	0.3	±	0.5	BC
Lorsban	0.0	±	0.0	B	0.8	±	0.4	A
Intrepid 2F (5/10)	0.2	±	0.4	AB	0.2	±	0.4	BC
Intrepid 2F (5/25)	0.7	±	0.8	A	0.3	±	0.5	BC
Intrepid 2F (5/27)	0.6	±	0.5	A	0.0	±	0.0	BC
Delegate 25WG (5/10)	0.0	±	0.0	B	0.2	±	0.4	BC
Delegate 25WG (5/25)	0.0	±	0.0	B	0.2	±	0.4	BC
Delegate 25WG (5/27	0.0	±	0.0	B	0.0	±	0.0	BC
Altacor 35WDG (5/10)	0.0	±	0.0	B	0.2	±	0.4	BC
Altacor 35WDG (5/25)	0.0	±	0.0	B	0.2	±	0.4	BC
Altacor 35WDG (5/27)	0.2	±	0.4	B	0.0	±	0.0	BC
Assail 70WP+Lambda-Cy 11.4EC	0.0	±	0.0	B	0.0	±	0.0	BC
Assail 70WP+Lambda-Cy 11.4EC	0.0	±	0.0	B	0.3	±	0.6	ABC
Belt 4SC	0.2	±	0.4	AB	0.4	±	0.5	AB
Dimilin 2L+Lorsban EW	0.0	±	0.0	B	0.0	±	0.0	BC
Dimilin 2L+Altacor 35WDG	0.2	±	0.4	AB	0.0	±	0.0	BC
HGW86	0.0	±	0.0	B	0.1	±	0.4	BC

[1] F=1.7541, df=21, 127, P<0.0334
[2] F=1.7177, df=21, 127, P<0.0389
[3] Means followed by the same letter do not differ significantly at P=0.05 by Student's t-test.

Results of our study evaluating navel orangeworm damage to 11 almond varieties exposed to the spring flight in an orchard in San Joaquin Co. resulted in significant differences among varieties (**Figure 2**). Nonpariel had the greatest damage with 21.98 ± 0.059 (mean ± SE) percent. Damage to Aldrich, Carmel, Monterey, Padre, Plateau and Price was significantly (P<0.05) lower than Nonpareil when compared by Dunnett's test. We also noted that nuts of any variety damaged by birds were more likely to be damaged by navel orangeworm. We are repeating this study in spring, 2012, but have not yet evaluated the nuts for damage.

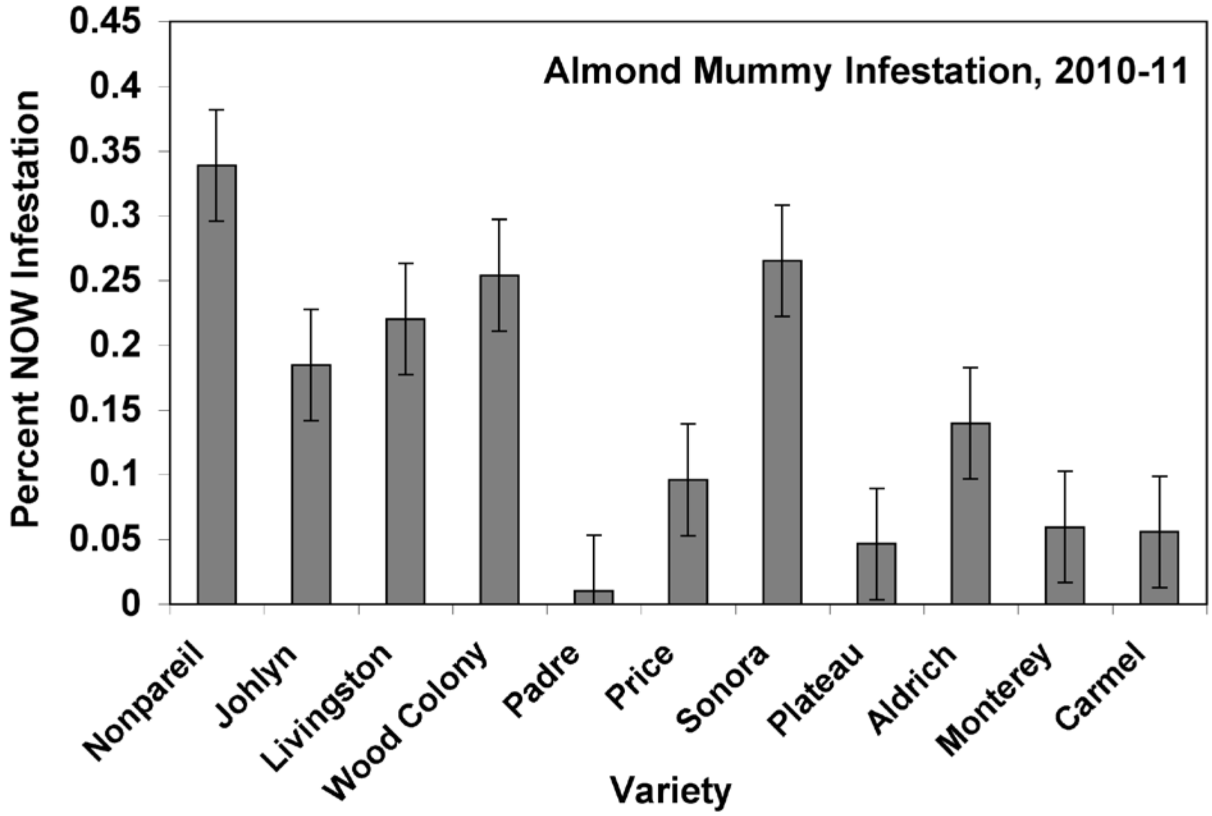

Figure 2. Percent navel orangeworm damaged 'mummy' nuts recorded for 11 varieties exposed to oviposition during the flight of the overwintering generation in a orchard near Manteca, San Joaquin Co, 2011 (n=10).

Objective 4. Spider mite and predator research. By the second day after traps and release papers were placed in a tree, the detection of mites as well as the number of NOW eggs remaining was low enough that continued monitoring no longer provided additional data. Three of these releases were performed throughout the summer, each in trees in different areas of the orchard (June 8, June 23, and July 18). Thirty-five live mites were recovered of the total 600 released (approximately 6%). Mites were also found mating on the traps on multiple occasions. In the phoresy experiment, a total of four moths were captured throughout the summer, with a total of twelve mites being recovered from 3 of the moths (**Table 5**). One moth did not have any mites and may have not been one of our released moths.

In addition to the monitoring described for the 2 types of releases, we also made four surveys for mites throughout the season. The survey involved placing mite traps (paper towel card infested with NOW eggs) in all release trees and in trees immediately north, south, east and west of the release trees. Traps were also placed in control trees in other areas of the orchard where releases had not been made. Interestingly, mites were found throughout the summer, not only on actual release trees, but also on control trees throughout the orchard. The field survival release trees were situated in three corners of the orchard, yet we captured mites on the traps in a control tree placed in the fourth corner late in the season. Not only did mites seem to disperse throughout the field, but also survived through typical summer heat and a mid-summer rain. A total of 39 mites were captured in the four surveys (**Table 5**).

Table 5. Summary of *Blattisocius keegani* captures following releases on egg cards and female NOW adults in an almond orchard.

Date	Release type	Survey method	Mite and NOW captures
6/8/2011	On NOW egg card	NOW egg card	7 mites
6/15/2011	On NOW female	NOW egg trap	4 mites + 1 NOW moth
6/23/2011	On NOW egg cardl	NOW egg card	16 mites
6/30/2011	On NOW female	NOW egg trap	0 mites + 1 NOW moth
7/1/2011	No release, survey only	NOW egg card	3 mites
7/8/2011	No release, survey only	NOW egg card	22 mites
7/14/2011	No release, survey only	NOW egg card	9 mites
7/14/2011	On NOW female	NOW egg trap	6 mites + 2 NOW moths
7/18/2011	On NOW egg card	NOW egg card	12 mites
8/1/2011	No release, survey only	NOW egg card	5 mites

These preliminary results indicate that *B. keegani* may play a role as a biological control agent in the management of NOW. *B. keegani* appears to survive successfully in the field, and also presumably reproduces since we observed it mating in the field and we captured mites using egg cards at each of the survey timings. The mite is able to locate NOW eggs on an almond tree from its release point, and it appears to successfully move by phoresy on female moths. Phoresy experiments are continuing at 3 sites in 2012.

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