Almond Insect Pests: Leaffooted Bug and Secondary Moth Pests

Project No.: **08-ENTO3-Daane**

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Objectives:

1. Investigate the formation and population dynamics of leaffooted bug aggregations to determine if these aggregations can be manipulated for monitoring or control.
2. To document the species of secondary moth pests in almonds and produce a description brochure of the larvae and adults.

Interpretive Summary:

California almonds are attacked by a variety of Hemiptera, or true bugs. Our research has focused on the “big” bugs, which include the redshouldered stink bug (*Thyanta pallidovirens*), Uhler's stink bug (*Chlorochroa uhleri*), flat green stink bug (*Acrosternum hilare*), and the leaffooted bug (*Leptoglossus clypealis*). These big bugs can cause the same damage as their smaller relatives during the first half of the season; however, the big bug adults can continue to puncture the shell later into the season and will feed on more nuts – resulting in greater total nut loss.

In recent years, many California almond and pistachio growers had significant crop loss from adult leaffooted bugs. Most damage occurred early, from April to May, when the bugs’ mouthparts piercing the small almond nuts resulted in the damaged nuts dropping from the tree. In previous years, we showed that the overwintering adult leaffooted bugs cause this damage and, therefore, are the most important stage to monitor and control. One problem is that these adult bugs are strong flyers and can quickly move into the orchard, in large numbers, and cause damage before monitoring programs detect their presence. For this reason, from 2007 through 2009, we studied leaffooted bug

overwintering biology and the cues that cause them to form winter aggregations and, more importantly, to disperse from the aggregations.

A key insect pest is the Navel Orangeworm (NOW), *Ameylois transitella*. Currently, a large multi-agency project is targeting NOW for control, including the use of mating disruption, our role on a collaborative project on NOW (directed by Dr. J.P. Siegel, USDA-ARS) is to determine the impact of a NOW mating disruption program on population densities of insect pests and their natural enemies. While NOW has long been considered the primary moth pest in almonds. However, other moths can cause considerable damage and their incidence may increase if hull split sprays are reduced after successful mating disruption for NOW. Most often the list of the “other moths” includes oriental fruit moth (*Grapholita molesta*) and peach twig borer (*Anarsia lineatella*) as the most common and geographically widespread; in some areas the fruittree leafroller (*Archips argyrospila*), obliquebanded leafroller (*Choristoneura rosaceana*), and the filbertworm (*Melissopus latiferreanus*) can also reach damaging levels. For example, one PCA reported nearly 10% nut infestation by the filbertworm, which the grower believed was NOW.

In addition to the leaffooted bug, we sought to document the secondary moth pests collected during the NOW areawide program, and tabulate the species composition and occurrence in different almond growing regions.

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Materials and Methods:

<u>Leaffooted Bug</u>

Field samples. We surveyed leaffooted bug winter aggregation sites, in 2007. 2008 and 2009, in Madera, Fresno and Tulare counties. Sites were located near almond or pistachio orchards in which leaffooted bugs have been reported. Nearby overwintering refuges (e.g., citrus, Eucalyptus) will be sampled to locate winter aggregations. From December to March, we sampled both crop and refuge using a 2 hour visual search by two or three persons (4-6 hr timed count per site). Leaffooted bug adults found were categorized by aggregate size: 1, 2-10, 11-25, 26-50, 50-100, greater than 100. A frequency distribution table was used to compare aggregate size categories. The aggregations were sampled every 2-4 weeks and the changes in bug densities recorded.

Aggregation formation. Intraspecific and/or environmental cues may be used by leaffooted bug adults to form aggregations. Likely cues are temperature, food, and shelter, vibrations on plant material, sounds, or pheromone (sex or aggregation). In

2006/2007, we attempted to create artificial shelters, baited with 10-20 male, female, or male and female leaffooted bug adults. These studies were largely unsuccessful. In 2008-2009, we used large field cages (which will provide better control) to follow the response of leaffooted bugs to different aggregation cues. The cages are 12 X 12 ft at base and 7 ft tall; with nylon mesh siding, a cloth top, and bare floor. Four treatment groups were tested: virgin females and food/shelter (e.g., citrus, Italian cypress), males and food/shelter, males and females and food/shelter, and a no-insect control with food/shelter. For each trial, one of the treatments was placed in a corner of the cage and marked adult leaffooted bugs were released in the cage center at 10:00 hr (day 1). Their movement recorded at 12:00 and 16:00 hr (day 1) and 700, 12:00 and 16:00 hr (day 2). After completion of each 2 day trial, treatments were randomly reassigned to a new cage corner and the process was repeated, resulting in 4 replicates per treatment tested.

<u>Moth Pests</u>

Collections and sampling. In the 2008/09 season, we helped set up plots in San Joaquin Valley almonds with Project Co-Leaders Dr. Joel Siegel and Dr. Chuck Burks. In the 2008 harvest, we collected and dissected >50,000 harvested nuts from these sites to look for moth pests and their natural enemies. We also collaborated with Project Co-Leaders Dr. Frank Zalom and Dr. Steve Welter to receive >10,000 harvested nuts from Sacramento Valley almond orchards.

During the season, we placed pheromone traps in selected San Joaquin Valley fields, organized by Drs. Siegel and Burks and Paramount Farms (organized by Brad Higbee), for peach twig borer (*Anarsia lineatella*), oriental fruitmoth (*Grapholita molesta*), filbert worm (*Melissopus latiferreanus*), obliquebanded leafroller (*Choristoneura rosaceana*), omnivorous leafroller (*Platynota stultana*) and fruittree leafroller (*Archips argyrospila*).

During the winter period, we worked with Dr. Burks, and helped collect >10,000 “mummies” from San Joaquin Valley almonds orchards. Dr. Burks’ crew dissected the nuts and provided us with all live moths and parasitoids and we reared these to the adult stage.

In spring 2009, we changed the sampling routine to place sentinel NOW larvae and eggs in selected fields to monitor parasitoid activity. This was necessary as pest levels were so low in the 2008 season that very little data on natural enemy activity were collected.

Results and Discussion:

<u>Leaffooted Bug</u>

We searched for aggregations in regions near (<250 meters) almond and pistachio orchards that reported leaffooted bug populations from 2006 to 2009. In winter 2007/08 and 2008/09, we found small aggregations in a citrus, Eucalyptus, Italian cypress, and palm trees. An extremely large population was found in an olive orchard that abutted a pomegranate field. We followed both winter temperatures (**Figure 1A**) and the size of twenty individual aggregations in the olive orchard (**Figure 1B**). The numbers of leaffooted bug adults in the olive aggregations remained relatively constant in winter during which time the temperatures were relatively mild. Beginning in January there were periods of cold weather during which the numbers of bugs dropped, and we often found dead leaffooted bug adults below the aggregations when low temperatures dipped below freezing for three or more consecutive nights. Dispersion from the aggregations was not observed until after February 20, when temperatures increased sharply. Within 15 days (February 25 to March 7), all healthy leaffooted bug adults had left the overwintering aggregations to move to spring feeding sites.

In most years, there is considerable leaffooted bug mortality during the winter period – especially when temperatures drop below freezing for any length of time. We have used the results from our winter mortality surveys to correctly predict leaffooted bug damage in 2007, 2008 and 2009. A regional overwintering sampling program has been considered, but this season's sampling has shown that difficulty in finding appropriate overwintering aggregations for monitoring. A better program would use temperature data on leaffooted bug development thresholds (e.g., what low temperatures will kill the bugs) such that regional winter temperatures can be used to predict bug mortality. Currently, suggestions for sampling leaffooted bugs were developed and 4-page brochure was provided by the almond industry.

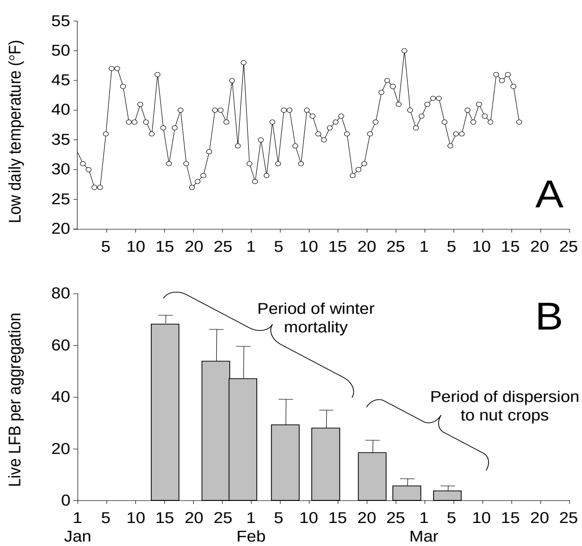

Figure 1. Leaffooted bug winter aggregations in an olive orchard

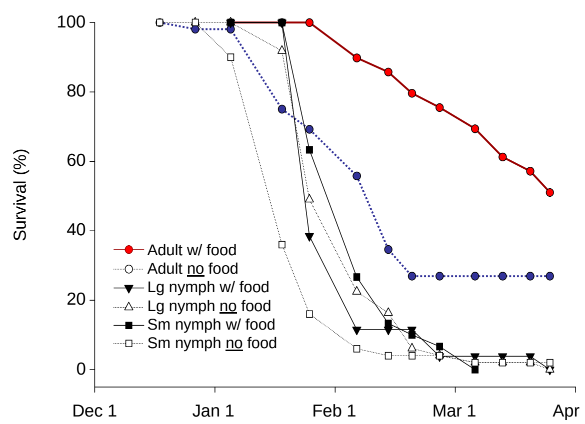

Figure 2. Leaffooted bug winter survival

Previously, we showed that leaffooted bugs have three complete generations each season. We have also sought to better understand leaffooted bug biology during the winter / spring generation. We asked the questions: Do the overwintering leaffooted bugs need to feed? When do they mate? Can both adults and nymphs survive the winter? Results show that adults are the leaffooted bug stage that best survives the winter (**Figure 2**). Adults both with and without food were able to survive until late

March, when egg laying began. More adults that had food provisions survived, as was to be expected. Because most overwintering aggregations are not on sites where "nut" crops are available, we suspect that the most important element of the food was moisture – keeping the adults from desiccating. None of the medium sized or large nymphs survived the winter. The results suggest that the adults can survive outside the orchard, without food, and still be a problem. During the winter period, we never observed mating, which was first observed in March.

We also investigate cues that trigger formation of aggregations. While we have been unable to determine what signals are used to form how aggregations – in other words to call together the adults – we have shown that aggregations form from some kind of signal rather than simply the physical attributes of any location. This work may help develop programs that can manipulate aggregations for control, such as attract and kill, or monitoring (pheromone work should be done by Dr. Jocelyn Millar, UC Riverside).

Moth Pests

Navel Orangeworm densities in harvest nuts and overwintered mummy nuts were low at all sites, <1%.

Not surprisingly, levels of parasitism were also low (<10% of the collected NOW) in both harvest and overwintered nuts. Surprisingly, *Copidosoma plethorica* was the more common parasitoid reared, with *Goniozus legneri* rarely recovered.

Pheromone trap catches showed peach twig borer, obliquebanded leafroller, fruittree leafroller, and oriental fruitmoth were often collected at levels >50 adults per trap per week. Nevertheless, NOW was the most common moth larvae found in the dissected harvest and overwintered nuts.

What is important to consider is that previous biological control work in the 1970s resulted in the importation of two NOW natural enemies: *Goniozus legneri* and *Copidosoma* (= *Pentalitomastix*) *plethorica*. In the past 40 years, while NOW has continued to be a significant pest, there has not been any more attempts to search for NOW natural enemies. Thes initial studies to document the levels of NOW parasitism in different orchard systems will be compared to that earlier work (1970s and 1980s). These results will help determine how to proceed towards better NOW biological control.

One aspect of NOW parasitism is the other moth (or worm) pests in the orchard. The oriental fruit moth and peach twig borer are the most common and geographically widespread; in some areas the fruittree leafroller, obliquebanded leafroller, and the filbertworm are also found. These pests can also reach damaging levels and may be confused with NOW. Moreover, these other moth pests might also be hosts for parasitoids that could be "shared" among the worms – resulting in higher overall levels of control. We are also documenting the kinds and densities of these moth pests, and cataloging which parasitoid species are found in the almond and pistachio orchards attacking them. This work will help select new NOW parasitoids.

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