SUMMARY OF ALMOND RESEARCH 2002

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Project Title: The role of natural enemies in the regulation of the obliquebanded leafroller and the leaffooted bug, two secondary pests that have reached primary pest status in some almond and pistachio orchards

This research focused on two potential secondary almond pests, the obliquebanded and the leaffooted bug, that have recently increased in densities and have been reported to cause economic damage in some almond orchards. Both pests attack a variety of crops, including pistachios. Our work combined funds from the Almond Board of California and the California Pistachio Commission to investigate pest and natural enemy biologies.

OBLR. The obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, is a moth pest of almond, pistachio and other crops (e.g., apple, cherry, prune, peach) that has, in some Central Valley orchards, recently moved from a minor to a primary pest. Unlike some of the other moth pests, OBLR larvae can feed on both almond leaves and nuts. In pistachio, the primary damage resulting from OBLR feeding is not to the crop but to the leaves! In some infested pistachio orchards, OBLR population densities have been observed at such high levels that extensive defoliation resulted in yield loss and crop damage. The exact causes for these outbreaks are not known, but their frequency and intensity appears to have increased over the past five years (Brent Holtz, Gary Weinberger, personnel observations). OBLR's pest status in almonds has not been clear: very high counts of male OBLR can be found in pheromone traps, but it is very difficult to search the almond tree and find OBLR larvae in the nuts or leaves. In contrast, OBLR larvae and their distinctive "folding" or "webbing" of infested leaves are quite obvious in pistachio orchards throughout the season.

Natural enemies are often cited as one of the primary factors in OBLR regulation. We surveyed for OBLR natural enemies in almonds and pistachios from 2000-2002. Overwintered OBLR, collected in April, had parasitism levels ranging from 0-15%, depending on the orchard block sampled. Parasitism steadily increased to 40-60% in July and August and then to 80-100% from late August to October. Parasitoids collected included *Trichogramma pretiosum*, which parasitized 60-80% of the egg clusters in August and September collections. OBLR larval parasitoids included (from most to least common) *Macrocentrus iridescens* (Hym. Braconidae), *Goniozus* sp. (Hym. Bethylidae), *Actia* sp. (Dip. Tachinidae), *Spilochalcis* sp., an unidentified eulophid species, an unidentified tachinid species and *Scambus* sp. (Hym. Branconidae). Listed in the literature are many more parasitoids attacking OBLR and there is also a wide range of generalist predators, such as green lacewings, that prey on moth larvae.

In 2001, we compared OBLR and natural enemy population densities in orchards reported to have low and high pest status. Some of the more basic biological information for these pests is unknown. For example, "What is the relationship of pheromone trap catches to orchard population? Are these moths a transient (from one of its many alternate host plants) or resident (an established population in the orchard) pest?" To answer some of these questions, three almond blocks with reported OBLR populations were sampled (near Madera, CA). At each sample block, no insecticides directed at OBLR or navel orangeworm (NOW) were planned. Throughout the season, adult OBLR were monitored with pheromone traps (three per field). Periodically, foliage was searched for OBLR eggs and larvae. The presence of generalist predators were determined by taking 50 "beat" samples every other week in each sampled orchard. Insects collected were taken to the laboratory for identification and these samples will be compared to data collected from pistachio orchards without OBLR damage. Results indicate that while pheromone trap catches showed high adult catches of OBLR at each site, a visual search of almond foliage found very few OBLR strikes on almonds. We found no almond nuts positively infested with OBLR. Note that the study began in May – which may be important.

In 2001 and 2002, we set up cage trials to determine the potential of OBLR to feed on almonds throughout the season. In other words, are there vulnerable periods that the field surveys missed. When flowering began, we isolate almond nuts/flowers to provide insect-free sites. OBLR larvae were placed into the cages with the developmental stages used matching the naturally occurring OBLR stages in the field. We set up new OBLR in clean cages at "early" (trials beginning in March and April), "middle" (trial beginning in May and June) and "late" (a trial in July) periods to match OBLR flights. During each trial we determined external feeding damage to leaves and nuts and we dissected all nuts at harvest to determine internal damage. Results show that in all trials OBLR prefers to feed on leaves. In the very early season, OBLR feed on the outside of the nut and caused about 40 of 1000 nuts to drop (4% dropped nuts), however, this occurred during a period of high natural nut drop and it is not know whether or nut the tree compensates for these lost nuts. Harvest-time dissections of nuts from the early season trial showed 1 of 1000 nuts had internal damage. In mid season trials there was external feeding damage to about 23 of 1000 nuts, with 1.5 of 1000 nuts dropped and no nuts with internal damage at harvest. In late season trials there was minor external feeding (when leaves were webbed against the nut) with no dropped nuts and no internal damage.

We conclude that early season presence of OBLR can result in some nut damage – primarily through dropped nuts. However, it is difficult to separate the importance of these dropped nuts from the natural drop that occurred in all our March – April trials. We conclude that mid and late-season feeding of OBLR in almonds is not important and that high OBLR counts in pheromone traps are a result of migrating OBLR adults. Furthermore, while OBLR may lay egg masses on almond trees, the mid and late-season almond foliage was not a preferred host in the orchards sampled and OBLR densities and damage to almond were not significant.

Leaffooted Bug. Many Hemiptera, or true bugs, are capable of causing damage directly to almond or pistachio nut. Most of these pests are present early in season, especially the "small" bugs, includes several species of Miridae and Rhopalidae, such as lygus (*Lygus hesperus*). These small bugs may be abundant early in the season; however, they cease to cause damage after the shell begins to harden. The second group is composed of species of Pentatomidae (the stink bugs) and Coreidae (leaffooted bugs). These "big bugs" can cause the same damage as their smaller relatives during the first half of the season. However, later in the season (from shell-hardening until harvest) the big bugs may be able to puncture the nut-meat through the shell, causing damage and possibly transmitting fungal pathogens. Currently, control measures rely singularly upon insecticides, applied soon after hemipterans are discovered, and there are no true economic injury levels identified for these pests.

We investigated the leaffooted bug, *Leptoglossus clypealis*, because its densities dramatically increased in the 1999 and 2000 seasons in many crops (including almonds and pistachios). More research is needed to better understand hemipteran biology, ecology and pest status, including (1) overwintering sites, (2) migration and dispersal behaviors, (3) host plant relationships (e.g., alternate hosts), and (4) almond nut damage and (5) biological control.

In 2001 and 2002, natural leaffooted bug densities were low, and all studies were conducted in field cages, using leaffooted bugs from an insectary colony. We caged bugs on nuts to determine damage levels – with the cages established in a similar manner as described for the OBLR study. Nymph and adult leaffooted bugs (separate cages for each development stage tested) were placed into the field cages at various times throughout the season. The insects were left to feed on the almond nuts for 7 days and then removed from the cages. This means that each branch had severe exposure to a healthy, leaffooted bug – thereby intensifying damage. During the "feeding" trial, points of insect damage to nuts (punctures) were marked and crop damage later determined. These cage trials were conducted at the Kearney Agricultural Center and commercial orchards with five different cultivars (Butte, Carmel, non-pareil, Fritz, and Mission) tested to determine if leaffooted bug damage varies among cultivars because of shell hardness. These "cultivar" trials were conducted at early (April), mid (June) and late (July) season periods. For both the feeding and cultivar tests, we used 7- 10 replicates for each trial (e.g., tested period, cultivar or bug development stage). Nuts were collected from these cages at harvest and dissected for damage.

Table 1 Percent Dropped Nuts in Different Almond Cultivars

	Non-Pareil	Fritz	Carmel	Butte	Mission
April-trial	2.1	10.7	20.2	10.5	5.6
June-trial	4.5	0	0	1.0	0
July-trial	0	0	0	0	0

Table 2 Percent External Damage at Harvest in Different Almond Cultivars

	Non-Pareil	Fritz	Carmel	Butte	Mission
April-trial	8.0	12.3	17.5	6.5	0
June-trial	10.0	17.5	1.4	8.0	9.6
July-trial	6.9	8.1	5.9	5.0	15.5

Table 3 Percent Internal Damage at Harvest in Different Almond Cultivars

	Non-Pareil	Fritz	Carmel	Butte	Mission
April-trial	5.0	6.9	1.2	3.3	0
June-trial	0	5.5	0	0	0
July-trial	0	2.1	0	0	2.1

Results show that leaffooted bugs can cause significant damage to almond nuts early in the season (Tables 1, 2 and 3). In the April trial, damaged nuts typically shriveled and fell from the almond (Table 1). There is probably some compensation by the tree for these damaged and dropped nuts as the control cages also had far more "clean" nuts that were dropped than damaged nuts – but until the level of compensation for leaffooted bug feeding is unknown. Few nuts dropped from the trees in mid- and late-season trials (Table 1). At harvest, a number of the nuts showed signs of leaffooted bug feeding or external damage to the puncture (gummosis extruding from the puncture wound) (Table 2). However, we were surprised to find that when these harvested nuts were dissected, few showed signs of nut meat damage (Table 3).

The complete data set is still being analyzed, but initial summary indicates that leaffooted bug is an important early-season pest and can not easily puncture to the nut meat later in the season – although puncture wound on the outer nut may be evident. The cultivar that appeared most susceptible is Fritz, with most other cultivars showing very little internal damage to the nut meat. Here, we have not taken into account dropped nuts and a more thorough analysis will compare the natural drop in control and treatment cages to the damaged and dropped nuts.

We conclude that leaffooted bug is primarily an early-season pest, with a greater importance on the softer shelled cultivars especially later in the season. Natural regulation of leaffooted bug will provide the needed late-season control. In commercial blocks that we searched, a small egg parasitoid (*Gryon pennsylvanicum*) was found to dramatically suppress leaffooted bug densities (with >80% parasitism of the eggs in samples collected after July). That leaffooted bug densities exploded in 1999 and, to a lesser extend, in 2000, we attribute to the lack of egg parasitism. However, we still do not understand what events (e.g., the 1998 winter freeze) may have led to a reduction in activity of this parasitoid. We will conclude these studies with laboratory work on leaffooted bug biology and studies of *Gryon pennsylvanicum* temperature tolerances to help predict years when leaffooted bug populations may increase in density and the resulting early-season damage.