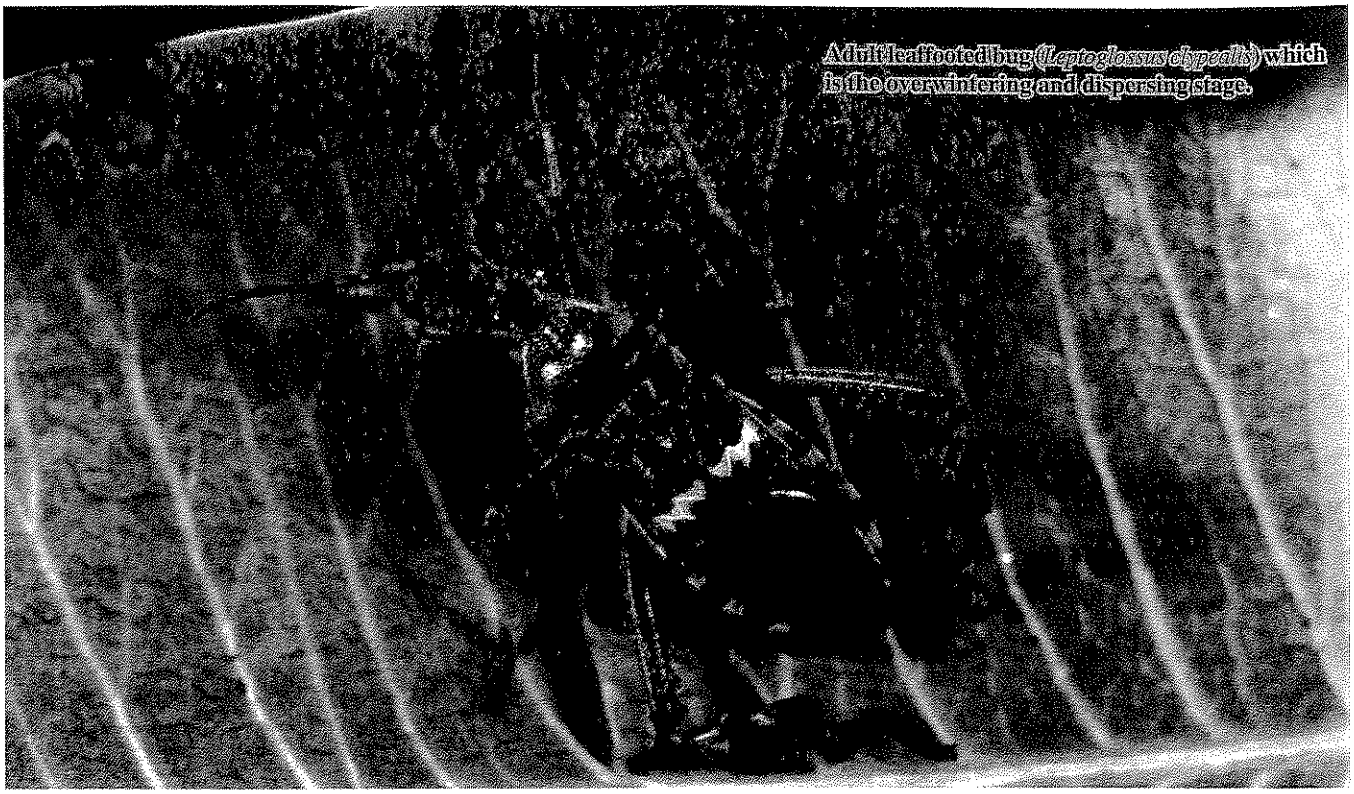


Adult leaffooted bug (*Leptoglossus clypealis*) which is the overwintering and dispersing stage.

Leaffooted Bug Hammers Almonds, Pistachios

Growers Experience Worst Damage in 20 years

This past spring, many California almond and pistachio orchards had significant crop loss from adult leaffooted bugs.

The occurrence of leaffooted bug populations covered a wide geographic range, including nut producing regions from the northern, western, and southern Central Valley. However, leaffooted bug densities and damage varied considerably, with some growers reporting significant bug densities and more than 50% crop loss, while nearby growers reported few leaffooted bugs and little crop damage. Regardless, spring 2006 was the worst leaffooted bug year over the past 20 years. Here, we answer some basic questions on leaffooted bug biology and control.

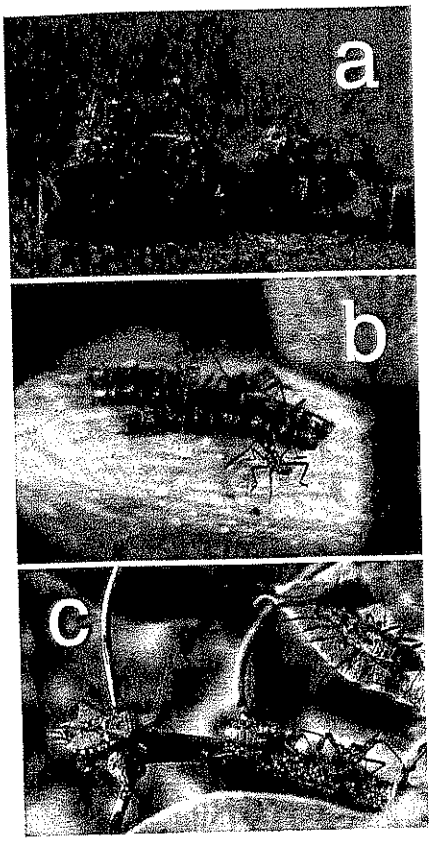
Identification

Adult leaffooted bugs are relatively large (about ¾ inch), dark brown insects. They are easily recognized by a distinctive white stripe, which zigzags across the wings transecting the body, and the flattened "leaf-like" hind leg section (the tibia) for which they are named. Adult females lay barrel-shaped eggs that are placed end-to-end, typically forming a line of 6-12 eggs. The eggs are often found on leaves, twigs and nuts. After nymphs emerge from a round hole atop the egg, they develop through five instars. Outwardly, the nymphs have the same general shape as the adults, but can be easily mistaken for other bug species – including some beneficial bugs. Small immatures are orange and brown and, as the bugs mature, they become darker and their wing pads enlarge. Generally speaking, the last larval stage and the adult look the same except for the presence or absence of fully developed wings with the white stripe. (PHOTO SET 1)

Life Cycle

Leaffooted bugs overwinter as adults, typically in aggregations located in protected areas, such as in woodpiles, barns, under the bark of eucalyptus trees, in cypress trees or juniper trees. These pests can also overwinter in the orchard in plant debris, pump houses, or cracks along the tree trunk. In April and May, adults disperse to find food sources. These insects are primarily seed-feeders and, once in the orchard, they will feed directly on the developing nuts or on ground vegetation seeds.

The adults are strong flyers and can disperse from overwintering sites not directly adjacent to the orchard and move quickly within the orchard. Overwintered adults are long-lived, from September/October to April/May. Their eggs are laid in spring; some *Leptoglossus* species deposit over 200 eggs. The immature leaffooted bugs develop to adults in 6-8 weeks. Because the adults are long-lived and can lay eggs over an extended period, the population can consist of all life stages by late June. We suspect there are 2 – 3 generations per year, dependent on temperatures and food sources. Fall climate cues the adults to seek overwintering locations, although details about overwintering site selection are still relatively unknown.



Leaffooted bug stages: (a) bugs emerging from their eggs, (b) first instar nymphs near an egg cluster, (c) an adult and many nymphs, the adult is distinguished by the presence of fully developed wings with a white stripe which transects the body.

Damage

Leaffooted bugs have piercing-sucking mouthparts, which are long and well-developed in the older nymphs and adults. When the mouthparts penetrate into the nut, three types of damage are caused: 1) gummosis on the surface of the hull (March through May), 2) damage to the interior shell (April to July), and 3) kernel necrosis which may involve fungal pathogens (April to July). Gummosis, or sap production is by itself not damaging and indicates nothing more than that a leaffooted bug fed on the hull. Gummosis can occurs regardless of whether mouthpart-penetration was shallow, in which case no damage occurs, or whether penetration went all the way to the kernel. Interior shell damage occurs when the mouthparts have nearly or fully penetrated the outer shell, kernel necrosis occurs when the insect mouthparts penetrate and damage the kernel itself.

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Leaffooted Plant Bug

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When any type of damage occurs from March through May the tree often compensates by aborting the damaged fruit, causing it to drop. Fruit damaged later in the season remain on the tree and represent crop loss at harvest. While late-season kernel necrosis is not common, it can be a serious concern as processors may have less than 1 to 2% tolerance levels for damaged kernels.

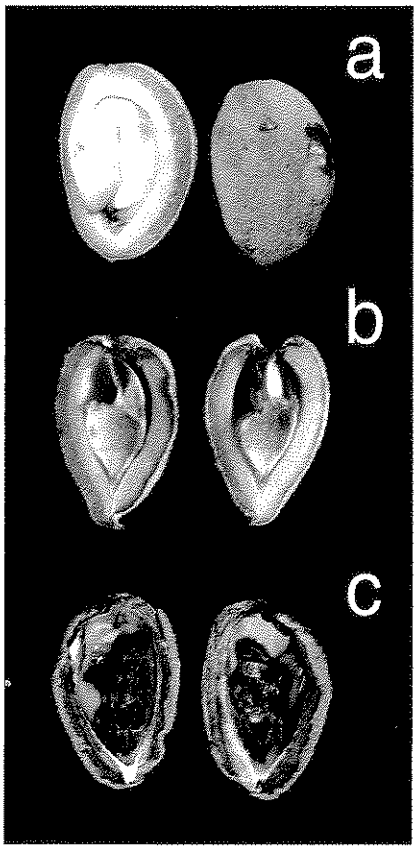
The type and amount of damage will depend on the population size, the insect's development stage, the time of season, and the cultivar. In most years, leaffooted bug populations are not large enough to cause significant crop damage. A combination of factors probably led to the damaging spring 2006 population – a large population in fall 2005, mild winter temperatures that increased survival of the overwintering adults, spring rains that increased annual weeds, and cool April temperatures that delayed and then synchronized the movement of leaffooted bugs into the orchards after fruit set but before shell hardening – just at the worst time. Insect size (or age) is important because the larger bugs have bigger, stronger mouthparts that can penetrate the outer shell, live for a longer period, and need to feed more.

The time of season is critical because the earlier nuts have softer shells that are more easily penetrated and are more prone to shell damage and nut drop in response to insect damage. Cultivar is important, especially for almonds, because cultivars with softer shells are more susceptible to bug damage for a longer period during the season. This explains why it is not uncommon to have a high percentage of Sonora nuts on the ground while nuts in the adjacent row of non-Pareil are still in the tree.

During 2002-2003 the type and amount of seasonal damage to almond nuts were investigated using small organdy cages (covering about 1 foot of fruit wood), enclosing one insect for a 7 day feeding period. For example, adult

Hull with gummosis, caused by bug feeding

Leaffooted bug damage (a) The first evidence of nut damage is gumming. A cut underneath the gumming area may reveal where the mouthparts penetrated the shell, (ba) kernel necrosis, where the nutmeat is darkened, often develops a sunken or distorted area, and may have an off-flavor (c) many pathogens are associated with leaffooted bug feeding.



leaffooted bugs were caged on almonds just after fruit set (17 March) when the nuts were still "pea-sized." Each cage enclosed about 25 nuts. Results showed 66.4% dropped nuts in the leaffooted bug cages, but only 14.3% dropped nuts in the check. In this early-season trial there was plant compensation by the almond tree (Butte *cv.*) as there were nearly the same number of nuts per treatment by harvest. During this early-season period, all damaged nuts dropped from the tree, and there was no evidence of shell damage or kernel necrosis at harvest.

In April trials, leaffooted bug feeding had a more serious consequence on crop damage. In this trial, five almond cultivars were simultaneously tested. Each cage enclosed about 10 nuts. After the 7 day feeding period, some cultivars (Fritz and Carmel) had more than a 30% crop loss resulting from a combination of dropped nuts, shell damage and kernel necrosis **(Table 1).** In April and May, the number dropped almonds due to leaffooted bug feeding is more critical because the tree has set the fruit load that it is capable of maturing to harvest and damaged nuts are more clearly related to lost crop.

In the June and July almond trials with adult leaffooted bugs, there was very little nut drop resulting from leaffooted bug feeding (Table 2). There was damage to the outer shell (typically less than 1 of 10 nuts per cage); however, only in Fritz and Mission *cv.* did we find kernel damage. During this same period, the smaller leaffooted bug nymphs (second and third instars) were also tested – but did not damage the crop.

Table 1. April feeding damage by an adult leaffooted bug during a 7-day period on 10-12 nuts per cage.

	Percentage of Total Nuts				
	Non-Pareil	Fritz	Carmel	Butte	Mission
Dropped nuts	2.1	10.7	20.2	10.5	5.6
Shell damage at harvest	8.0	12.3	17.5	6.5	0.0
Kernel necrosis at harvest	5.0	6.9	1.2	3.3	0.0
Total damage	15.1	29.9	38.9	20.3	5.6

Table 2. Average June and July feeding damage by an adult leaffooted bug during a 7-day period on 10-12 nuts per cage.

	Percentage of Total Nuts				
	Non-Pareil	Fritz	Carmel	Butte	Mission
Dropped nuts	2.2	0	0	0.5	0
Shell damage at harvest	8.4	12.8	3.6	6.5	12.5
Kernel necrosis at harvest	0	3.8	0	0	1.0
Total damage	10.6	16.6	3.6	7.0	13.5

Sampling

There are no effective ways to directly sample for leaffooted bugs. The beating tray is still the best method for nymphs; however, the adults will often fly away unseen or hide behind leaves and twigs rather than drop onto the beating tray. This is important because the most critical sampling period is in early spring, when only adults are present. UC IPM guidelines for pistachios suggest that "1 leaffooted bug per 15 to 20 beats" may require treatment. No such thresholds exist for almonds. It is probably more effective to search for nuts with gummosis and cut across the penetration site to determine if damage is superficial (hull only) or if kernel damage has occurred.

Growers and PCAs will need to make their own decision on whether or not a spray is needed. Important factors to consider are the number of bugs and damage found, the time of season (early-season is when most damage occurs), the bug development stage, the susceptibility of the almond cultivar (soft shelled cultivars are more susceptible), and the tolerance for damage in the crop (e.g., crop load). PCAs basing treatments on gummosis and nut drop should also recognize that there can be a 7-10 days lag time between when feeding takes place and when gummosis and nut drop occurs – so the dispersing insects may already have moved to another block.

Control

In most years leaffooted bug populations in and near almonds are controlled

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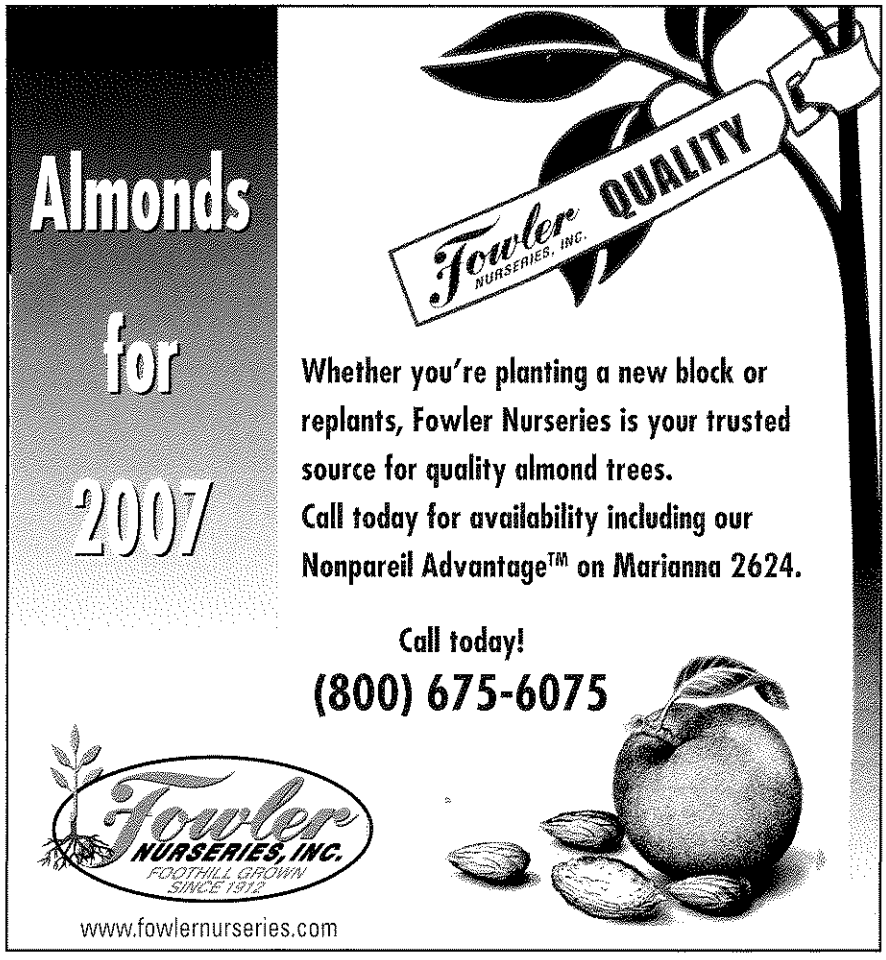

Leaffooted Plant Bug

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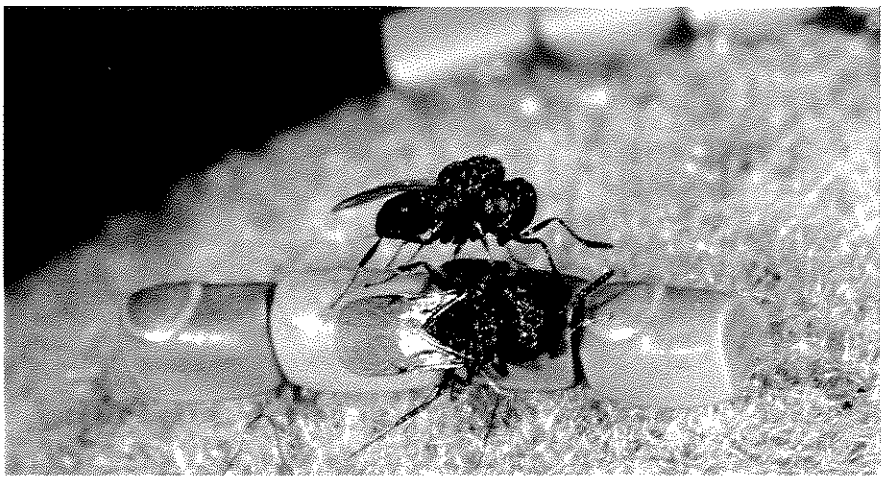
by natural mortality from temperature extremes and an egg parasitoid (called *Gryon pennsylvanicum*). However, as was evident this season, these natural controls can not be relied upon if there is a large overwintering population. This is especially true during the critical spring period as the egg parasitoid will only impact the adult's offspring, and it is the overwintered adult that will cause most damage.

Control is currently based on April or May applications of Lorsban, pyrethoids, or permethrin to kill overwintering adults that have migrated into the orchard. The biggest concern with these products is the potential to flare spider mites later in the season. Also note that pyrethroids typically have a short residual period, which is not as effective when adults are repeatedly entering the orchard from overwintinering sites. In general, control in June is not needed because populations of overwintering adults have declined and most nymphs are too small to penetrate into the kernel. By July, however, large nymphs and new adults may be of sufficient size to cause kernel damage, although most of their attempts to reach the kernel fail because of the hardened shell.

Due to the very low tolerance for this damage at the processor, growers may consider a treatment prior to hull split; others may choose Imidan or permethrin for their hull-split navel orangeworm spray in an effort to reduce leaffooted bug populations during the month before harvest. For more information on insecticide rates and application timing, see the UC IPM website http://www.ipm.ucdavis.edu/ .

Egg parasitoids, seen here attacking freshly laid leaffooted bug eggs, help reduce summer LFB population, but are not effective against the overwintering adult bugs.



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