Understanding Aggregation Behavior of the Leaffooted plant bug *Leptoglossus zonatus*

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OBJECTIVES

- Determine which factors result in aggregation and/or attraction of *L. zonatus* under lab conditions
- Determine which factors result in aggregation and/or attraction of *L. zonatus* under field conditions
- Determine which factors result in dispersal from aggregations of *L. zonatus* under lab and field conditions

INTRODUCTION

Leaffooted bugs (*Leptoglossus* species) are large, seed-feeding insects that move from native host plants to crops such as almonds, pistachios, and pomegranates. Their long mouthparts pierce through almonds, feeding on developing kernels (Fig. 1a). In the early stages of almond development this feeding can cause gummosis or sap on developing almonds (Fig. 1b), indicating the bugs have been feeding; early season feeding also causes the almonds to discontinue growth and drop from the tree. Bug feeding later in the season can impact the kernel, with strikes or lines on the almond kernel.

Fig. 1a. *L. zonatus* feeding

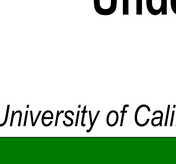

Fig. 1b. Gummosis

When substantial gummosis or almond drop is observed, insecticide applications are often applied for insect control. However, by the time the damage is observed, the insects may have already dispersed. Management of these insects may be more effective through monitoring with traps to detect insects as they move into an orchard before damage is significant, or perhaps to trap insects late in the season.

Fig. 2 a) *L. clypealis* 2b) *L. zonatus*

During the last few years, we worked with collaborators to collect leaffooted bugs throughout the central valley of California. We determined there are two species of leaffooted bugs infesting almond orchards (Figs. 2a,b). *L. zonatus* (above right) is about twice as large as *L. clypealis*. We also conducted a field-cage study for 2 years, and found that *L. zonatus* caused significantly more damage than *L. clypealis* on almonds (Fig. 3).

Fig. 3. Field-cage study of feeding damage by leaffooted bugs.

Aggregation Behavior

Background:

L. zonatus has an aggregation behavior which might be exploited for insect management. As eggs hatch, nymphs cluster together and tend to remain in groups. Adult *L. zonatus* are observed in aggregations as well.

Fig. 4a. *L. zonatus* eggs hatching; Fig. 4b. *L. zonatus* nymphs clustering together; Fig. 4c. *L. zonatus* adults on pomegranate.

Previous studies describe *Leptoglossus* species including *Leptoglossus zonatus* aggregating in winter, under tree bark, in buildings and in the interior of trees (McPherson et al. 1990). In the central valley as well, *Leptoglossus* spp. have been observed aggregating in winter. As temperatures warm up in the spring, *Leptoglossus* spp. have been observed dispersing from aggregations (Daane et al. 2008).

Winter Aggregations:

Aggregations of adult *Leptoglossus* spp. are observed in winter (Fig. 5a). For another species, *L. occidentalis*, aggregation behavior of adults is seasonal (Blatt and Borden 1996). This may similarly be the case for *L. zonatus* in the central valley of California. Understanding the factors or cues which contribute to the ***formation*** of aggregations, and also the factors or cues which contribute to ***dispersal*** from aggregations, will help us understand the timing of when we may see *L. zonatus* in fields and anticipate the need for management.

Fig. 5a. *L. zonatus* aggregation, Gustine, Merced County, Cal.

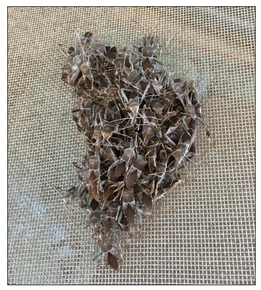

Fig. 5b. *L. zonatus* collections November 2016.

Objective 1

Objective 1: Determine which factors result in aggregation and/or attraction of *L. zonatus* under lab conditions.

Attraction will be investigated in lab bioassays using sexually mature virgin male and female adult *L. zonatus*. Lab trials will be run using standard lab conditions, 25ºC and 14:10 light: dark conditions.

Preparing insects for bioassays

Lab colonies of *L. zonatus* are maintained year round, with additional insects collected from the field when they are abundant. If you find leaffooted bugs or aggregations, please call the Joyce Lab and we will come collect the insects. We are thankful for the help finding additional field sources of leaffooted bugs whenever possible.

Fig. 6a. 5th instar *L. zonatus*. These are isolated in groups and checked daily to remove newly emerged, virgin male or female adults.

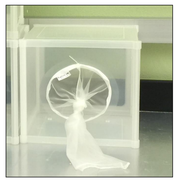

Fig. 6b. Cages such as this are used to isolate newly emerged virgin males in a separate room from cages of adult virgin females until they are sexually receptive.

Cages of fifth instar nymphs of *L. zonatus* are set up weekly (Fig. 6a,b). These cages are checked daily to collect newly emerged virgin adult *L. zonatus*. New adults are identified as male or female, and separated into male only or female only cages. Male only cages are maintained in a separate room from female only cages. This prevents insects from being exposed to odors prior to behavioral bioassays.

Objective 1-Continued

Q: Are *L. zonatus* females more attracted to males, females, or a combination of both?

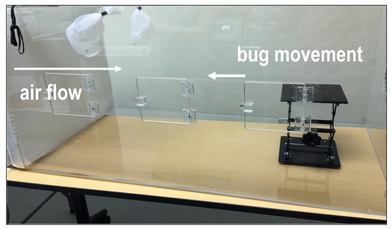

Fig. 7. Wind tunnel used for lab behavioral assays with adult *L. zonatus*

A laminar flow wind tunnel used to test attraction of females to odors associated with *L. zonatus* and their food plants, under summer conditions (Fig.7). At least 30 replicates will be conducted for each test. Insects will only be used for one trial. Trials will also be done under winter conditions.

Objective 2

Objective 2:

•Determine which factors result in aggregation and/or attraction of *L. zonatus* under field conditions

Factors which were found to influence attraction and aggregation in the lab will be manipulated under field conditions. Understanding the aggregation behavior of *L. zonatus*, and the ability to manipulate *L. zonatus* behavior in the field are the goal of this work. Field work is critical to determine if lab results holdup in the field. This work will be conducted in field cages from spring through fall. Large numbers of insects will be required for this work to replicate results. We will maintain large colonies throughout the year.

Objective 3

Objective 3:

Determine which factors result in dispersal from aggregations of *L. zonatus* under lab and field conditions

In the spring with warming temperatures, aggregations of *L. zonatus* begin to disperse. We will observe aggregations in the field to determine the conditions which promote their dispersal. Our goal is to observe a number of aggregations in the field. Both natural occurring aggregations and lab reared insects in field cages will be observed.

Aggregation of *L. zonatus*

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