

# PHENOLOGY AND DISTRIBUTION OF BROWN MARMORATED STINK BUGS IN AND NEAR CALIFORNIA PEAR ORCHARDS

Chuck Ingels<sup>1</sup>, Lucia Varela<sup>2</sup>, Rachel Elkins<sup>3</sup>, and Cort Hurley<sup>1</sup>

<sup>1</sup>UC Cooperative Extension, Sacramento County

<sup>2</sup>UC Cooperative Extension, North Coast

<sup>3</sup>UC Cooperative Extension, Lake & Mendocino Counties

## ABSTRACT

In the midtown Sacramento infestation area, 23 BMSB traps were placed and checked weekly to help evaluate BMSB phenology. Approx. half were standing 4-ft. pyramid traps and half were double cone traps secured to branches. Traps were placed 24 Feb and checked weekly through 26 Oct. Late February and early March were unusually warm, and the first adults were found in traps on 3 Mar. Intense searching for eggs was conducted early to mid-April, and the first eggs were found on 14 April (20 days earlier than 2014). The first nymph was trapped on 19 May and dozens were found on 1 June. A moderate peak of nymphs was seen in traps through most of June, and a large peak was seen in early Sept. A moderate peak of adults was seen in late September. Two generations were found in both 2014 and 2015, which agrees with the BMSB model. In addition to BMSB, hundreds of individuals of three predator species were found in the traps through the season. The ratio of nymphs:adults trapped in 2015 was 4:1. Overall, pyramid traps caught 14% more BMSB than double cone traps. Plant species found to host the largest numbers of BMSB were sunflower, tree of heaven, trident maple, Chinese pistache, and waxleaf privet. Extensive trunk feeding and oozing of sap was seen on cherry, orange, sawleaf zelkova, and Shamel ash. In March, 20 pyramid traps were placed south of Sacramento to Walnut Grove and 18 were placed in agricultural/urban interface areas in Lake and Mendocino counties and checked biweekly to determine if BMSB are present in these areas. In late October, one male adult BMSB was found in a trap in Freeport. No BMSB were found in Lake or Mendocino.

## PROBLEM AND ITS SIGNIFICANCE

The brown marmorated stink bug (*Halyomorpha halys*) (BMSB) originated in East Asia and was first identified in the US in Pennsylvania in 2001, and has now spread to 42 states ([www.stopbmsb.org](http://www.stopbmsb.org)). A large BMSB population was found in midtown Sacramento in Sept. 2013, and subsequent surveys show that dozens of individuals have been found in other areas of Sacramento County, with at least seven reproducing populations outside midtown and downtown (<http://cesacramento.ucanr.edu>).

In 2010, BMSB caused \$37 million in damage to fruit crops. BMSB has a host range of over 170 species, including most fruit crops and many vegetables with fruiting structures. Both adult and nymphal stages can damage fruits. Physical damage to fruits

includes pitting and deformation, with pithiness under the stings. This makes the fruit unmarketable as a fresh or canned product. BMSB usually produce one generation per year in cool climates and two per year in warm climates, but more generations could be produced in hotter climates (Lee et al., 2013; Nielsen and Hamilton, 2009).

USDA-ARS researchers have developed pyramid traps that are sold through AgBio, Inc. (Dead-Inn™ traps). The trap consists of an inverted clear plastic container with an entry cone opening that is attached with a bungee cord to tall corrugated plastic stands that are connected to form a pyramid shape. The “Grower” trap type stands 4 ft. tall. Research has shown that larger traps catch more BMSB than small traps, and placement on the ground is more effective than in a tree canopy (Leskey et al., 2012). However, placement in on the ground may interfere with orchard operations.

USDA-ARS researchers have also found the greatest trap capture using two lures together – a BMSB aggregation pheromone lure and a lure containing the synergist methyl decatrienoate (MDT). In addition, increasing amounts of MDT have been shown to catch greater numbers of BMSB (Leskey et al., 2012). An insecticide-laced strip (Vaportape II [Hercon]) is usually included to kill trapped bugs and prevent escape.

Traps have been shown to catch both adults and nymphs, but will attract them from less than about 100 ft. Field studies showed that 3rd and 5th instars walked 5-20 meters across a grass field to traps (Leskey, 2013). In addition to the BMSB caught inside traps, large numbers can often be found lingering outside of traps.

There are a number of native natural enemies of BMSB, both predators and parasitoids, but they have had limited impact on BMSB populations in other states. Parasitoids of BMSB (most notably *Trissolcus japonicus*) have been imported and are now under quarantine in California and are undergoing testing at UC Riverside. It is hoped that the parasitoids will be released in 2017. However, in 2014 wild *T. japonicus* were found in a sentinel egg mass placed in a forest in Maryland. In 2015, many more were found in other areas in the mid-Atlantic, and one was even found in Vancouver, WA.

## **OBJECTIVES**

### **Sacramento County:**

1. Determine seasonal phenology of BMSB and compare trap types
2. Determine the spread from the initial infestation area

### **Lake & Mendocino Counties:**

1. Conduct a BMSB survey in vegetation surrounding pear orchards and in urban areas
2. Deploy monitoring traps in pear orchards adjacent to high vehicle traffic corridors.

## **PROCEDURES**

### **Sacramento County**

## 1. Determine seasonal phenology of BMSB and compare trap types

BMSB populations were monitored weekly from late February through late October 2015. A total of 23 traps were placed in yards and landscape strips of residences and businesses in and near the central core area of the initial 2013 midtown Sacramento infestation. Approximately half were 4-ft.-tall, pyramid traps (AgBio, Inc.) and half were a homemade 1-gal. double cone traps placed in a diversity of tree species (Fig. 1). Each trap was baited with a pair of AgBio Combo lures (aggregation pheromone and MDT) and a Hercon Vaportape II insecticide strip (Figs. 2 and 3), all of which were replaced monthly. Three traps were ultimately lost: Two trees were cut down and at one site the traps kept disappearing and was replaced twice before the site was abandoned.

The sex of BMSB adults in each trap was determined; also, 1-2 meters of foliage was searched within 1-2 meters of each trap. Foliage of trees and a community garden were checked twice per week for eggs in early to mid-April to start the development model for predicting the number of generations per year. In addition, one-minute searches and beat tray sampling were conducted approx. monthly on potential host plants in four 16-block zones of the infestation area.

Three additional minor projects (unfunded) were conducted:

- A comparison of lures, using AgBio Combo, Rescue, and a new Trece lure, which is a dark-colored, stiff strip approx. 1" wide x 5" long x 1/8" thick, and is embedded with both aggregation pheromone + MDT (Fig. 2). Each lure type was placed singly in 3 AgBio Homeowner traps (18 in. tall) in tree of heaven trees (total of 9 trees) in early September and checked weekly.
- Three trap types with Trece lures were compared on two dates (21 and 28 Sept.): AgBio Homeowner, a new Trece double cone trap, and a new AgBio sticky trap (Fig. 3). Three each of the latter two trap types were placed singly in Chinese pistache trees (total of 6 trees), and results were compared to the AgBio Homeowner traps in tree of heaven used in the lure study.
- A "trap crop" of sunflowers and sorghum were planted around three community garden plots at the Fremont Community Garden at 14<sup>th</sup> & Q St. The goal was to evaluate the attractiveness of BMSB to the two plant species and to see if damage to vegetable crops was reduced.

## 2. Determine the spread from the initial infestation area

In March, 20 pyramid traps with Rescue lures and an insecticide strip in each were placed from the Pocket area of Sacramento south to the Walnut Grove area (Fig. 4). Traps were placed at the following types of locations, chosen because of their higher risk from people travelling from midtown/downtown Sacramento:

- Farms that host visitors (5)

- Pear orchards near which a resident commutes to Sacramento (5)
- Packing sheds and trucking companies (6)
- Pocket area to Freeport (4)

Traps were checked every two weeks through October. Foliage of nearby susceptible hosts was checked for BMSB with visual searches and beat sheet samples. This monitoring was in addition to following the spread within Sacramento and nearby communities based on reports of BMSB sightings and verification that the stink bugs were actually BMSB; the findings in Sacramento have grown each year (Fig. 5).

## **Lake and Mendocino Counties**

1. Conduct a BMSB survey in vegetation surrounding pear orchards and in urban areas

At three locations each in Mendocino and Lake Counties, host plants adjacent to pear orchards were monitored bi-monthly during spring and summer for BMSB using beating tray samples. In late summer and early fall host plants were surveyed visually in the cities of Ukiah and Lakeport.

2. Deploy monitoring traps in pear orchards adjacent to high vehicle traffic corridors.

Three 4-ft. tall, black pyramid traps (Dead-Inn™, AgBio Inc.) were deployed in early March at each of three locations in both Lake and Mendocino Counties and removed at the end of September. The orchards chosen were adjacent to heavy vehicle traffic. The orchards in Lake County were in: Upper Lake, Finley and Kelseyville; those in Mendocino County were close to Ukiah in: Perkins, Hastings and River Rds. At each location two of the traps were baited with AgBio lures (aggregation pheromone + MDT) and one trap was baited with Rescue 9-week stink bug attractant. Lures were changed following manufactures' recommendations. A Hercon Vaportape II insecticide strip was placed in each trap and changed monthly.

## **RESULTS**

### **Sacramento County**

1. Determine seasonal phenology of BMSB and compare trap types

Trap placements and cumulative trap counts in midtown Sacramento showed that traps in the central area of initial infestation caught the most BMSB, and traps on the outskirts generally caught less than 100 (Fig. 6). In 2014, four of the 10 midtown traps caught a substantial number of BMSB (Fig. 7). In 2015, two of those traps caught very few BMSB (data not shown), but eight of the 20 traps caught more than 100 BMSB through the season (Fig. 8). Traps were placed on 24 February and overwintering adults were found on the first check on 2 March. Very few adults were trapped except in Sept. The first eggs were found on a tree of heaven leaf on April 17, which was nearly 3 weeks earlier

than 2014 due to early warm temperatures in 2015. The first nymphs were found in traps on May 19, two weeks earlier than 2014. Nymph peaks were found in June and early September, which was similar to 2014. The BMSB model (low 57°F and high 97°F; Nielsen, 2008) predicted 2 generations both years, which the graphs confirm. Among all traps, the ratio of nymphs to adults trapped in 2015 was 4:1 (in 2014 it was 3:1).

In addition to BMSB, 205 digger wasps (*Astata occidentalis*), 102 carabid beetles (*Laemostenus complanatus*), and 104 jumping spiders (Salticidae family) were found in the midtown traps through the season. The digger wasp is a large, solitary, predatory wasp that preys on adults and nymphs of stink bugs, carabid beetles have been shown to feed on eggs, and jumping spiders can feed on all stages.

**Vegetation Survey.** In foliage searches in the four 16-block zones, the most BMSB per plant were found on tree of heaven and unpruned privet shrubs (Table 1). Moderate numbers were found on Chinese hackberry, Chinese pistache, olive, sweet gum (liquidambar), and trident maple. However, trident maple trees were found to host large numbers in 2014.

Periodic examinations of fruit trees found that large numbers of BMSB and severe fruit damage was found on apple, peach, nectarine, Asian pear, and persimmon (Fig. 9), but not on fruits of plums, citrus, or grapes. A Bartlett pear outside the main infestation area (7<sup>th</sup> St., between R and S St.) had no obvious damage. Extensive feeding on trunks and oozing of sap was seen on orange, cherry, Shamel ash, and zelkova trees.

**Lure Study.** Trece lures appeared to result in higher trap catches, with Rescue lures catching slightly fewer and AgBio catching the fewest BMSB (Figure 10). In the trap study, the AgBio sticky traps were counted weekly but not removed after counting. Birds were seen feeding on the trapped BMSB, so numbers went down over time and data were not included. Only three traps were compared for the Trece double cone and AgBio Homeowner traps on two dates (Sept. 21 and 28), and the average number of BMSB trapped per week were very similar (AgBio Homeowner: 40, Trece: 44).

**Sunflower Study.** Sunflowers attracted hundreds of BMSB, but far fewer were attracted to the sorghum even when the seeds approached maturity. Viewing, counting, and removing BMSB on the sunflowers were far easier than doing so on vegetable plants, especially tomatoes. To read the report and view photos of the project, visit <http://cesacramento.ucanr.edu/BMSB/Management/Sunflower/>.

## 2. Determine the spread from the initial infestation area

No BMSB were found in traps south of the Pocket area until October 23, when one male was found at the Bartley Cavanaugh Golf Course in Freeport (see Fig. 4). As in the Sacramento traps, beneficial insects were found in these traps: A total of 65 digger wasps, 14 Carabid beetles, and 51 jumping spiders were found through the season.

## Lake and Mendocino Counties

No BMSBs were detected in either the pyramid traps or during the host plant surveys in Lake or Mendocino Counties.

## DISCUSSION

The greater trap catches with pyramid traps agrees with previous research showing that large pyramid traps are most effective (Leskey et al., 2013). This study confirmed 2014 results that two BMSB generations per year occur in Sacramento. It also shows that adults will become active in winter when days are warm, as temperatures in the upper 60s and low 70s occurred on several days in the second half of Feb. 2015. Warmer than normal temperatures also led to the very early discovery of the first egg mass (April 17). However, the timings of the two generational peaks were similar to those of 2014.

Based on the BMSB development model (Nielsen, 2008) and a start date of 17 April, second generation adults should start to be seen on Aug. 25. Eggs of the overwintering generation are laid over an extended period (17 April was only the very beginning), so nymph and adult populations generally overlap by early to mid-summer, although few were caught late July through mid-August. The large adult population spike in mid-September reflects the large number of second generation adults as well as the possible increased attraction to the pheromone and synergist (MDT) scents.

The finding of a single male BMSB in a trap in Freeport may indicate movement by car with someone visiting the golf course rather than a steady southward movement from Sacramento. Nonetheless, it is likely that the trapped bug was not the only one present at the site (although none were seen by golf course staff), and additional traps will be placed on the site in 2016. Not finding BMSB in agricultural areas and anywhere in the North Coast does not necessarily mean that no BMSB are present in those areas. Lure scents are known to attract BMSB from only short distances – less than 100 ft. away (Leskey et al., 2013). Also, it takes 4-5 years for BMSB populations to build up to major pest levels after the first introduction (T. Leskey, personal communication). It is possible that the pest could be present and populations beginning to increase somewhere in agricultural areas but not yet detected.

## LITERATURE CITED

- Leskey, T.C. 2013. Presentation at Cumberland-Shenandoah Fruit Workers Conference. Dec. 2013.
- Leskey, T.C., S.E. Wright, B.D. Short, et. al. 2012. Development of behaviorally based monitoring tools for the brown marmorated stink bug in commercial tree fruit orchards. *J. Entomol. Sci.* 47(1):76-85.
- Nielsen, A. 2008. Developmental rate estimation and life table analysis for *Halyomorpha halys*. *Environ. Entomol.* 37(2):348-355.

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Figure 1. AgBio pyramid trap (left) and 1-gal. double cone trap in tree (right).



Figure 2. Liquid-filled pheromone and MDT lures for AgBio Combo (upper left) and Rescue (upper right), and combined pheromone and MDT Trece lure (lower left). Lure(s) and insecticide strip (red) were placed in each AgBio Homeowner model trap



hung in trees (lower right).



Figure 3. Trece double cone trap, secured to branch (left), and AgBio sticky trap (right).

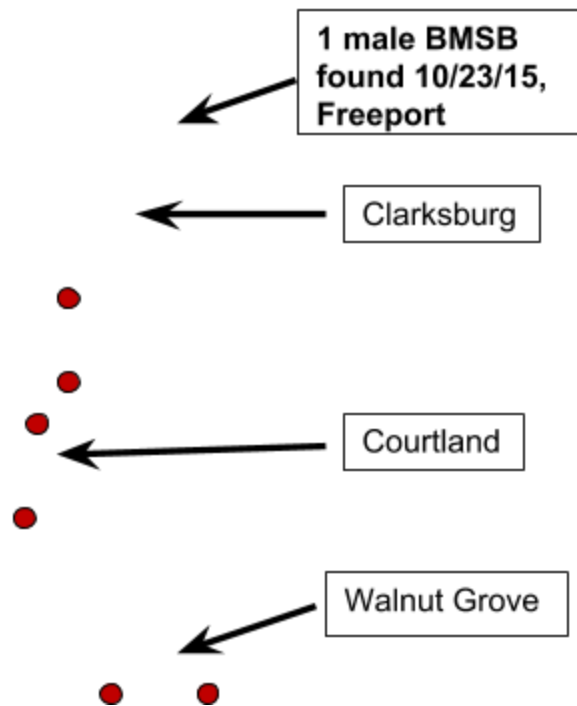


Figure 4. Locations of the BMSB traps placed from South Sacramento to Walnut Grove.

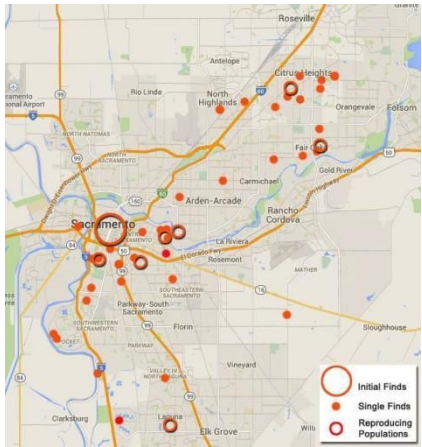
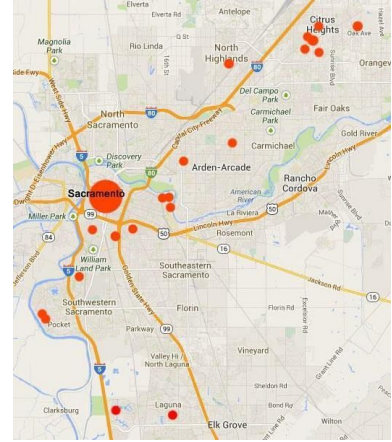
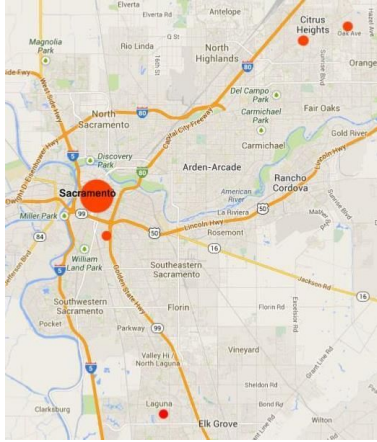


Figure 5. Locations where BMSB have been found in the Sacramento region, Jan. 1, 2014 (left), Jan. 1, 2015 (middle), and Dec. 1, 2015. Small dots indicate single finds and circles indicate reproducing populations.

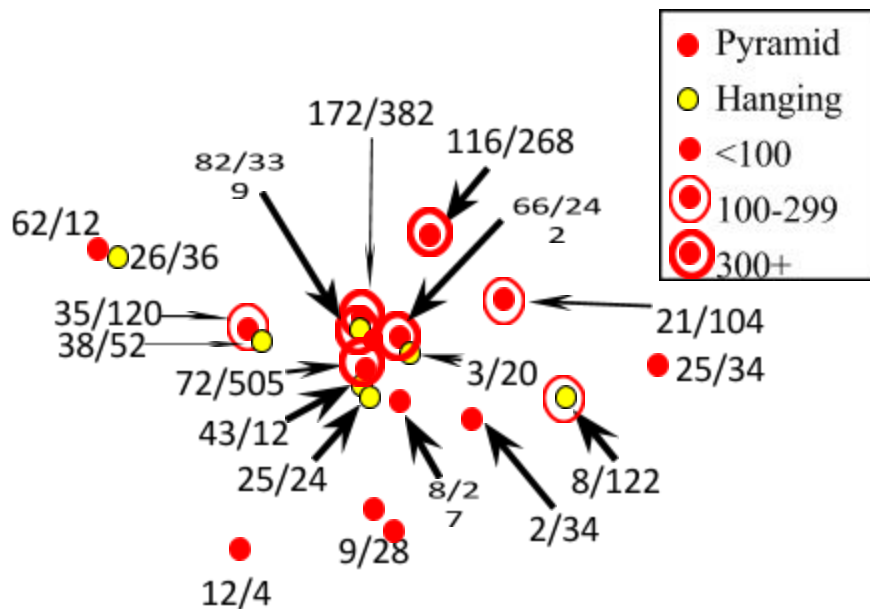


Figure 6. Cumulative trap counts (adults/nymphs) in Midtown Sacramento in 2015. Eight traps (circled) caught more than 100 BMSB through the season.

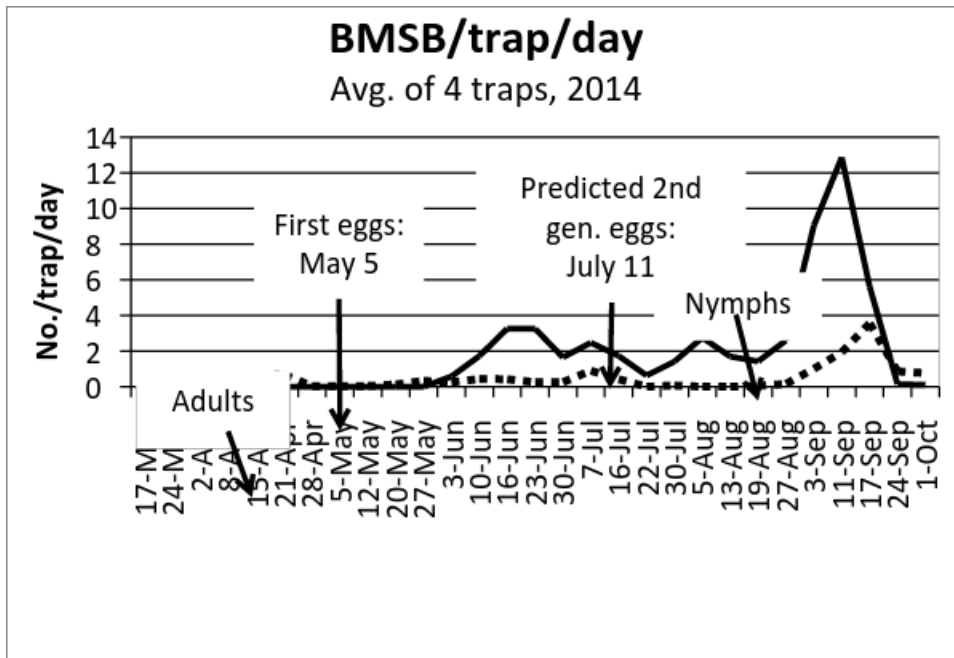


Figure 7. Average number of adults and nymphs per trap per day found in the 4 Midtown traps that caught substantial numbers in 2015.

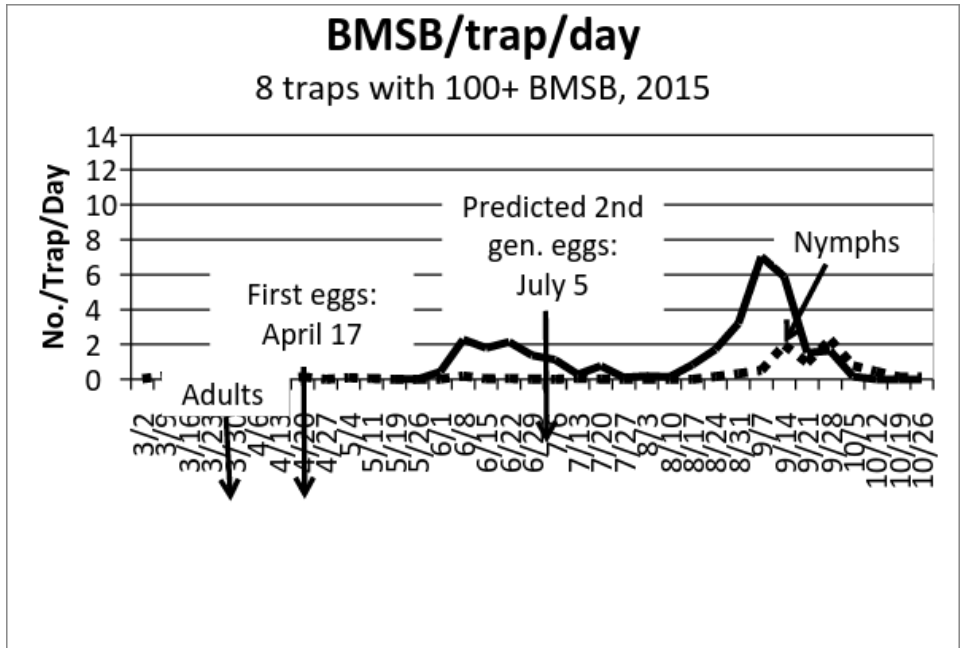


Figure 8. Average number of adults and nymphs per trap per day found in the 8 Midtown traps that caught >100 in 2015.



Figure 9. BMSB on apple (left) and persimmon (middle), and damage on persimmon, early September 2015.

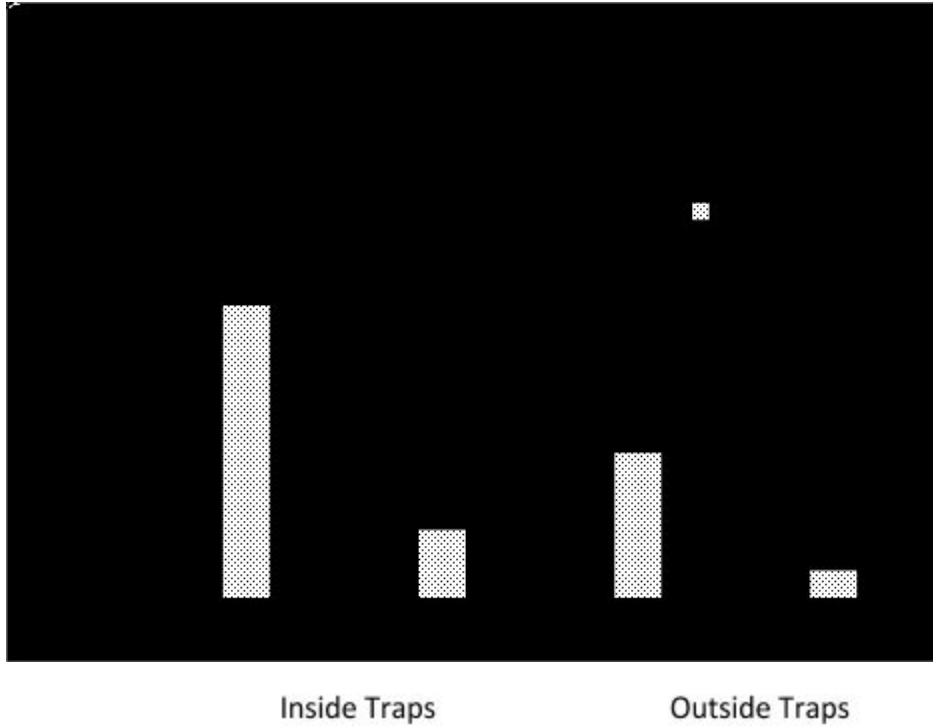


Figure 10. Average number of BMSB in traps per week with different lures, Sept. 1-28.

Table 1. Average number of BMSB found per plant in four 16-block section of midtown Sacramento, checked 3-5 times late spring through summer, 2015.

No. of BMSB	Species
None	Chinese elm, Chinese tallow, coast live oak, red oak, scarlet oak, heavenly bamboo, English ivy, black walnut, chestnut oak, privet (hedged), Southern magnolia, wisteria
<5/plant	Heavenly bamboo, linden, butterfly bush, white birch
5-10/plant	Chinese hackberry, Chinese pistache, olive, liquidambar, trident maple
>10/plant	Privet (unpruned), tree of heaven