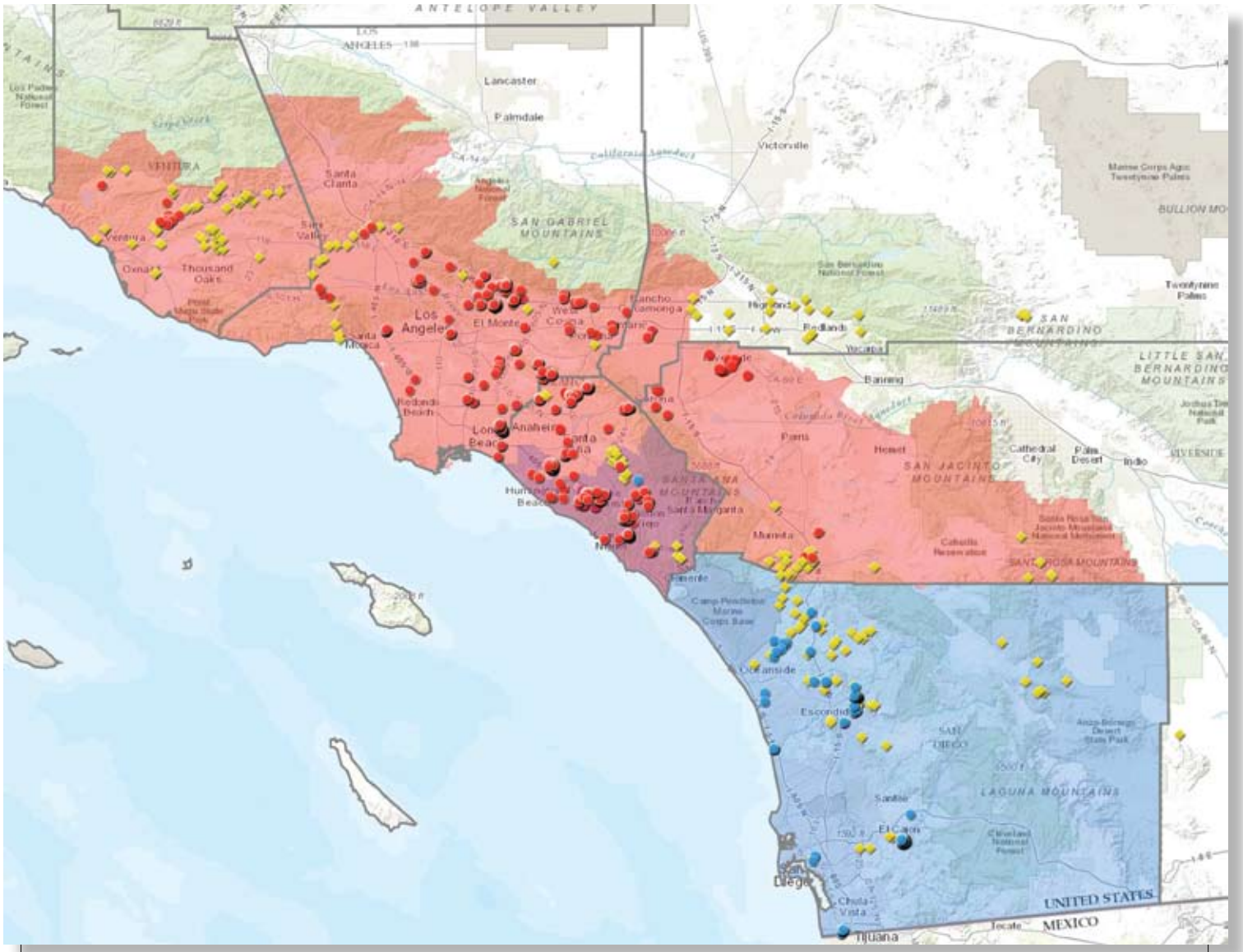


*Polyphagous shot hole borer (red) and Kuroshio shot hole borer (blue) distribution in southern California as of September 2, 2016. The yellow diamonds indicate the locations of traps, and red and blue dots represent PSHB and KSHB trap finds, respectively. The red and blue layers indicate the presumed range of PSHB and KSHB infested areas, with the purple area in Orange County showing the overlap of the two beetle populations.*

# Shot Hole Borer Research and Monitoring Programs Evolving

By Tim Spann
*Research Program Director*

Since 2012, when what is now known as the polyphagous shot hole borer (PSHB) was first discovered in the Whittier Narrows area of Los Angeles County on backyard avocado trees, the California Avocado Commission (CAC) has invested about $2.6 million in research and grower education on this pest. When first discovered, it was unknown what this beetle was, where it came from or what it would do to trees. Thanks in large part to CAC's funding, we now have answers to these questions.

The PSHB, and its very closely related cousin the Kuroshio shot hole borer (KSHB), are ambrosia beetles — fun-

gus farmers. This group of beetles carry with them fungal spores, which they grow in their host trees to feed on. Although they bore into the wood of trees they do not actually eat the wood, they merely shovel out the sawdust and inoculate the walls of their gallery with the fungal spores. The adults and all stages of the immature beetles then feed on this fungal garden.

Through DNA analysis, Dr. Richard Stouthamer's lab at UC Riverside was able to determine that the PSHB most likely originates from Vietnam and south China. The KSHB, which looks identical but is slightly different genetically, originates from Taiwan. How both of these beetles made their way to Southern California is a mystery, but the most likely route was through wood packing material.

Both beetles carry with them, in specialized mouth parts, the spores of their fungal symbionts. In the case of PSHB, there are three fungi – *Fusarium euwallacea*, *Graphium euwallacea* and *Paracremonium pembeum*. All three of these fungal species were described in whole or in part by Dr. Akif Eskalen and his lab at UC Riverside. KSHB carries with it two fungi, a *Fusarium* species and a *Graphium* species, which are still being described. Dr. Eskalen's group has shown that all of these fungi are pathogenic to avocado trees.

In addition to avocados, these beetles attack more than 137 tree species from more than 35 different plant families. Not all of these species are suitable reproductive hosts in which the beetles can cultivate their fungal garden and lay eggs. Currently, about 43 species are known to be suitable reproductive hosts for PSHB and 15 species are suitable for KSHB. At least 14 of the known reproductive hosts are California native trees. Dr. Eskalen is the lead on host identification and maintains a current list on his lab's website (http://eskalenlab.ucr.edu/avocado.html).

Drs. Joe Morse and Frank Byrne at UC Riverside have taken the lead on trying to find effective pesticides against these shot hole borers (SHB). Unfortunately, because these beetles spend so little time outside of their galleries they are difficult to target with pesticides. Drs. Morse and Byrne developed efficacy data that allowed CAC to successfully apply for a Section 18 emergency exemption for Hero® EW insecticide. This Section 18 is effective until April 8, 2017. CAC will make a decision on applying for a renewal later this year based on usage data.

In addition to work on Hero®, Drs. Morse and Byrne have been looking at systemic pesticides, which would be a more effective treatment and provide for a longer period of efficacy within the tree. Although a number of different chemicals have shown activity against SHBs in lab bioassays, many of them either are not systemic or those that are will be difficult or impossible to register on a food crop. Regardless, the best-case scenario for a full registration for a pesticide against this pest is at least four to five years.

Dr. Eskalen has been complementing the work of Drs. Morse and Byrne by evaluating fungicides for use against the beetles' fungal symbionts. Again, a number of different fungicides have shown efficacy under laboratory conditions, but there are many hurdles to develop these into commercial solutions, not the least of which is movement of the products within the tree.

Drs. Stouthamer and Eskalen also have been working on finding biocontrol solutions for the beetles and their associated fungi. Their approach to this has been to look at the beetles' native ranges and see if there are any potential biocontrol agents. They have found a wasp and a nematode associated with the beetles in Southeast Asia and are working with collaborators there to determine what they may be doing to the beetles. As luck would have it, it appears that the nematode may have hitchhiked to Southern California along with the beetle when it first arrived since the same nematode was recently discovered in Dr. Stouthamer's lab colony of PSHB. It is still unknown if the nematode can be found in field populations of the beetle and what role it may be playing, if anything.

In spite of all the funding and research, Lady Luck may just be the greatest asset our industry has right now. Although many tree species have suffered tremendous losses due to the SHBs — 140,000 willow trees dead in the Tijuana River Valley, virtually all box elders dead in Los Angeles County — avocados appear to be escaping this fate.

In early July, I visited the avocado variety block at the Huntington Gardens along with a member of CAC's Production Research Committee (PRC) and a concerned grower. This block, like the rest of the Gardens, was hard hit by the beetle in 2012 and 2013 when it was just a few years old. Dr. Eskalen's lab had done a survey of the trees at the time of the original infestation and marked existing beetle attack holes with red paint. We were pleasantly surprised to find that almost four years later the trees were growing well, bearing fruit, and had very few new beetle attacks (one tree had three fresh attacks, a couple had two, and the majority had only one or no fresh attacks). This is despite the ongoing trapping of large numbers of beetles in the Gardens. Similar observations have been made in infested groves in San Diego County.

It appears that avocados show some branch die back from the initial beetle attack, but they are able to "shake it off" and pull through. This may be because avocado is not as suitable a host as other species so the later generations of beetles move on. It appears an unknown biocontrol agent is at work, or something else entirely is going on. Whatever the reason, it seems that avocado growers may have caught a break with this pest, at least for now. It's interesting to note that the Israeli avocado industry, which has been dealing with PSHB since 2009, has documented essentially this same thing.

*Specimen trees in the avocado variety collection at Huntington Botanical Gardens 4-years after the first shot hole borer attacks, displaying vigorous new growth and overall good health.*

Based on the current situation of SHBs in avocado, the PRC made a critical evaluation of SHB spending at their August meeting. Most of the ongoing SHB projects are finishing at the end of the current fiscal year and the Committee recommended not to fund new proposals for SHB work at this time. Two projects that continue beyond the current fiscal year — biocontrol work and an epidemiology study — will continue to be funded.

In addition, the PRC concurred with staff recommendations to make changes to the ongoing trapping and monitoring program in San Diego, Riverside and Ventura counties. This program, which was initiated in late 2014 when Dr. Stouthamer discovered an effective lure, was intended to monitor SHB movement and keep growers apprised of where the SHBs are relative to avocado groves. In San Diego and southern Riverside counties, the SHBs are widespread in virtually all avocado growing areas. Thus, the PRC believes that in San Diego and Riverside counties, the program has served its purpose and growers must now be responsible for monitoring their own groves for SHB. In Ventura County, where SHB is still restricted to a relatively small area on the west side of Santa Paula, the PRC believes there is still value to the industry to continue the monitoring program. The CAC Board confirmed the PRC's recommendations on SHB funding and monitoring at its August meeting.

Although the number of research projects and monitoring efforts are being reduced, CAC will continue to be alert for any changes in the SHB situation as it relates to avocados and is prepared to jump back in if warranted.

## PSHB/KSHB Traps and Lures

Lindgren funnel traps are currently the trap of choice for PSHB/KSHB. These traps come in different configurations with varying numbers of funnels. The 12-funnel version with a wet collection cup is recommended. The wet cup should be filled with about one inch of soapy water. Antifreeze can be used, but is more hazardous and you must make sure the antifreeze does not contain alcohol, which will repel the beetles. The cups will need to be checked every three to four days (up to one week if using antifreeze).

Both beetles are attracted to a quercivorol lure. There are two companies currently producing this lure for sale in the United States and both work equally well, but there is a significant cost difference between the two. Lures last approximately 60 days and old lures should be removed when a new one is installed on the trap. Lures should be installed about mid-way along the length of the funnel trap. Although lures and pheromones are exempt from import restrictions under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Customs and Border Protect is now requiring an EPA Notice of Arrival Form to be completed **prior to** the lures arrival in the U.S. This form can be downloaded from the EPA's website (https://www3.epa.gov/) by searching for form 3540-1. As a service to growers, a number of PCAs have imported lures and offer them for sale.

### Lures and Traps

**Synergy Semiochemicals Corp** (Canada)
604-454-1122
synergy@semiochemical.com
Lure item # 3361 — $12
Trap item # 4021 — $60

**ChemTica Internacional** (Costa Rica)
506-22615396
cam@chemtica.com
Lure item # P548-Lure — $6
Trap item # P218-Trap — no price info

### Traps Only

**BioQuip Products**
https://www.bioquip.com/
2321 Gladwick Street
Rancho Dominguez, CA 90220
(310) 667-8800
Trap item # 2854 — $72