

Development of Pheromone-based Detection & Monitoring Systems for Invasive Scale Species Infesting Avocado

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This project has two main goals. First, we are working to establish colonies and mass rear some of the exotic scale species that are coming into California on shipments of fresh avocados from Mexico. We are also doing studies on the biology of these scales because little or no information is available, even for parameters as basic as how many generations a year they are likely to have, and how many offspring females produce, and the longevity of males and females. Second, we are using these colonies to try and identify sex pheromones for each species, so that the pheromones can be developed for use as sensitive tools for detection of these insects by growers and regulatory agencies along the California-Mexico border, or around packing-houses that handle shipments of fresh avocados from Mexico. Pheromone traps will also provide a very sensitive and selective means of detecting exotic scale species if populations start to develop in California. Early detection, while populations are still small and spread over a limited area, will provide the best possible chance of suppressing and eradicating any incursions of these species. If the CAC and regulatory agencies are not able to eradicate exotic scales before they become permanently established, pheromone traps will also be useful tools for monitoring, and possibly control using mating disruption or other pheromone-based control techniques.

Goal 1: Establish and mass rear cultures of exotic scale species found on commercial shipments of fresh avocados coming in from Mexico.

We have collected scales from infested fresh avocados coming into the U.S. on commercial shipments from Mexico. We successfully mass reared *Acutaspis albopicta* (Cockerell), but we have had variable success in rearing several other species, including *Hemberlesia* nr. *lataniae* (Signoret) (the so-called Mexican latania scale) and *Abgrallaspis aguacatae* Evans et al. In the latter two cases, small colonies have been started several times but they have not yet taken off to provide the thousands of insects that we need for the pheromone identification work. We have also reared colonies of the asexually reproducing California latania scale (i.e., that has females only) for comparison with the sexually reproducing Mexican latania scale. We are currently looking at the effects of rearing these two species at different temperatures, to try and find the optimum rearing temperature for each.

Because there was virtually nothing known about the life history and reproduction of *Acutaspis albopicta*, as an add-on to this project, we have conducted some basic biology studies with this species. Some key results are as follows:

- This scale species must mate in order to reproduce; it cannot reproduce asexually, the way that the California latania scale does.
- Adult males are very short-lived, lasting only about 2 days.

- Males require relatively high humidity to complete their development. This could be a key factor in hindering the establishment and limiting the spread of this scale species if it does become established in California.
- The optimal temperature for development appears to be ~25°C. There was no survival at 35°C, and at 15°, development was extremely slow. This appears to be a species better adapted to moderate to cool conditions, similar to avocado thrips.
- Females produce about 50 offspring during their 3-4 month lifetimes.
- We soon will have a degree-day model for this insect which will be useful for our ongoing laboratory studies. It will also be vitally important should the insect establish in California (so far, it is known only from Texas in the U.S.).

Goal 2: To identify sex pheromones of exotic scale species from Mexico, so that the pheromones can be developed as trap lures for detection and monitoring of invasive scale species as early as possible.

We have completed the identification, synthesis, and testing of the female-produced sex pheromone for *Acutaspis albopicta*, and the manuscript describing this work has been accepted for publication in the Journal of Economic Entomology (Millar et al. in press). This work included the synthesis and testing of different isomers of the pheromone, as part of the identification process, and to test whether any of the other isomers might interfere with the activity of the natural isomer. In the event, we saw no signs of inhibition by the unnatural isomers in laboratory bioassays. This is important, because it is much easier and cheaper to make the pheromone as a mixture of isomers, rather than as one pure isomer. Because the scale is not known to be present in California, the pheromone was tested in bioassays in the room used to rear the scale in the UCR quarantine facility. The pheromone proved to be highly attractive to male scales (Figure 1). Thus, we fully expect that pheromone baited traps will indeed provide a very sensitive method of detecting the scale. We currently have sufficient pheromone on hand to produce several thousand lures for use by CAC or regulatory agencies. Copies of the manuscript describing the synthesis will be sent to pheromone companies as soon as the paper is published. It will also be sent to CDFA and USDA-APHIS, so that regulatory agencies will be aware that there is now an excellent surveillance and monitoring method available for this species.



Fig. 1. Male *Acutaspis albopicta* trapped on a pheromone-baited sticky card in a bioassay to test the activity of the synthetic pheromone.

We have also examined extracts of the headspace odors from colonies of California latania scale by gas chromatography-mass spectrometry. We did not detect any compounds that might be pheromones, based on their structures, but this was not all that surprising because this species is unisexual, producing only females, so there is no longer any need for it to produce a pheromone.

However, we wanted to check this anyway, both because the switch to asexual reproduction may have occurred quite recently in terms of the scale's evolutionary history. We also wanted to have reference samples from this species for comparison with the Mexican latania scale, *Hemiberlesia* nr. *lataniae*, which does reproduce sexually, i.e., comparison of extracts from females of the two species might show compounds that were associated only with the sexually reproducing Mexican species, i.e., likely pheromone components. We have not yet been able to make these comparisons because of difficulties in establishing a robust and continuous colony of Mexican latania scale. These efforts are continuing, both with Mexican latania scale, and with another species that is very common on imported Mexican avocados, *Abgrallasipis aguacatae*.

In summary, we have delivered a new pheromone for the exotic scale species *A. albopicta*. We have also carried out the first studies of its life history and reproductive biology, providing baseline biological data that will be critically important for its control or even eradication if it does successfully invade California. Progress on the other species, particularly Mexican latania scale and *Abgrallasipis aguacatae* has been slow and difficult, but it is moving forward. If we can establish continuous colonies of these species, identification and synthesis of their pheromones will only be a matter of time.

CITED REFERENCES:

Jocelyn G. Millar, Satya P. Chinta, J. Steven McElfresh, Lindsay J. Robinson, and Joseph G. Morse. 2012. Identification of the pheromone of the invasive scale *Acutaspis albopicta* (Hemiptera: Diaspididae) arriving in California on shipments of avocados from Mexico. *Journal of Economic Entomology*, in press.

ORAL PRESENTATIONS RELATED TO THE PROJECT:

1. Invited symposium presentation: Millar, J.G., J.S. McElfresh, L.J. Robinson, and S. Chinta. "Sex Pheromone of *Acutaspis albopicta*, an Invasive Exotic Pest Entering California on Shipments of Fresh Avocados from Mexico", 95th Annual Pacific Branch Meeting of the Entomological Society of America, Waikoloa, HI, March 30, 2011.
2. Invited international symposium presentation: Millar, J.G., M.S. Hoddle, and J.G. Morse. "Proactive Chemical Ecology: Strategies for Identification of Pheromones for Invasive Species", 6th Conference of the Asia-Pacific Association of Chemical Ecologists, Beijing China, October 12-15, 2011.
3. Oral presentation: Waterworth, R.A., L.J. Robinson, J.G. Millar, and J.G. Morse. "Basic biology and identification of the sex pheromone of the invasive scale species *Acutaspis albopicta*. *Entomological Society of America Annual Meeting*, Reno NV, Nov. 13-16, 2011.