

Pest and Diseases

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**Survey for Armored Scales and their Natural Enemies on California Avocados**

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**SUMMARY OF THE PROBLEM:**

Between 1914 and 2007, a quarantine protected California avocado groves from pests that might be introduced into the state along with fresh, imported avocados. Soon after Mexican avocados were first allowed entry on 1 February 2007, live specimens of several species of armored scales (Family Diaspididae) not believed to be present in California were detected on Hass avocados entering the state from Mexico. In order to determine if this was a dangerous situation, we examined fruit entering California via the Blythe border station and found eight species of scales, seven of which are believed to be exotic to the state (Morse et al. 2009). Over an 8-month period, September 2007 - April 2008, we estimated that 67 million Mexican Hass avocados entered California and based on samples from 140 trucks containing 15.6% of the total volume of fruit entering the state, approximately 47.6 million live, sessile scales (first instars and older that can't move from where they are attached; including females which can produce more crawlers) and an additional 20.1 million live eggs and crawlers (the life stages that can establish new populations; some species produce eggs and other species hatch eggs internally and birth live crawlers) were imported. The only species found on Mexican avocados believed to already be present in California was latania scale (*Hemiberlesia lataniae*), which is a parthenogenetic species (females only). Interestingly, latania scale was relatively rare on Mexican avocados but a common species (and one that was previously unknown) was the very similar *Hemiberlesia* sp. near *lataniae*, which is a sexually reproducing species. The other 6 exotic species found were *Abgrallaspis aguacatae*, *Abgrallaspis perseae*, *Acutaspis albopicta*, *Diaspis miranda*, *Diaspis* sp. near *miranda*, and *Pinnaspis strachani*.

How dangerous a situation is this? USDA-APHIS allowed the fruit importations because they believe live scales on fruit pose a "low risk" to pest establishment. We disagree with this assessment, partly because we have determined that scale crawlers can disperse to new environments by hitch-hiking on flying insects (via Project # 65102; Magsig-Castillo et al. 2010).

If one or more of these exotic armored scales were to establish on California avocados, how serious a pest would they be? We don't really know the answer to this. On many crops, armored scales can be severe pests, unless they are effectively controlled by natural enemies (see Miller et al. 2005). For example, California red scale is a serious pest of citrus in the San Joaquin Valley where endemic biological control is not strong, but it is generally under fairly effective biological control on southern California citrus. In some cases, it is possible to return to the country the scale originated from and find natural enemies, which can control it effectively. However, in the absence of good biological control, exotic armored scales could be severe pests on California avocados and would be difficult to

control chemically, especially with treatments applied by helicopter (in contrast to many pests, thorough spray coverage is often needed for effective control of armored scales).

#### OUR RESEARCH APPROACH:

If one or more of the exotic armored scales found on Mexican avocados were to establish in California to a degree such that eradication is not feasible, a preferred method of management would be biological control. For example, latania scale was once quite common on California avocados (38% of 27,868 trees surveyed in 1930 were infested according to Mackie 1931). Presently, latania scale is not present at high levels in CA avocado groves (but it appears to be present at low levels in many groves) and we believe the reason is that natural enemies introduced for control of California red scale on citrus (in the 1950's or earlier) moved onto avocados and controlled latania scale. We do not know to what degree parasitoids and predators already present in California would control some or all of the 7 species of exotic scales found on Mexican avocados.

Our project has 3 objectives:

#### **OBJECTIVE 1. Survey California avocados for armored scale species present on the crop.**

It is important to know what the more common species of armored scales are on avocados in California and to develop data that suggests whether or not one or more of the 7 exotic species found on Mexican fruit have already established in the state.

#### **OBJECTIVE 2. Survey for natural enemies associated with armored scales on California avocados.**

This objective is important for two reasons. First, we need to know what parasitoids and predators are present on armored scales on California avocados so we can test these species to see if they will attack the exotic Mexican scales. Second, we need to compare key parasitoids and predators present in California versus those that are found attacking armored scales in Mexico. For exotic scales that might establish in California, this would help us prioritize Mexican species for possible importation and release (once permits for this have been obtained).

#### **OBJECTIVE 3. Initiate cultures of the more important natural enemies that are found and test their ability to attack various exotic armored scales that are reared in UCR's Quarantine facility.**

Our first step under this objective is to develop colonies of key armored scales so that we have the infrastructure to evaluate armored scale parasitoids and predators. We will then test the more common California natural enemies against Mexican armored scales inside UCR's Quarantine facility (we have a state permit allowing us to rear these scales inside Quarantine).

#### PROGRESS TO DATE:

**Surveys of California Avocado Groves for Scales and Parasitoids.** To date, we have surveyed a large number of California avocado groves and found 4 armored scale species. The 4 scale species identified are latania scale (*Hemiberlesia lataniae*), greedy scale (*Hemiberlesia rapax*), California red scale (*Aonidiella aurantii*), and oleander scale (*Aspidiotus nerii*). All reports from growers and PCAs of their having armored scales in their groves were investigated and data recorded. We believe the general impression is that armored scales are rare. However, when we search groves we are working in for other purposes (avocado thrips, perseas mite), we often find low levels of armored scales. This is actually very good news – scales are present and appear to support low but persistent natural enemy populations, i.e. biological control is currently very good for the scale species we already have in California. The key question is whether the parasitoids we have would control the exotic Mexican scales or not. The average numbers of armored scales present on Mexican fruit was 0.71 live scales

and an additional 0.34 live eggs or crawlers per fruit (Morse et al. 2009). We don't know if this level of scales was present because biological control of armored scales in Mexico is poor or because pesticide use had excluded biological control agents.

We have not found any of the 7 species of exotic Mexican armored scales in California to date.

To date, we have found the following 18 parasitoid "species" in California (all are separate species unless noted; we list only Mexican parasitoids where they have genetic signatures close to CA parasitoids; note that the species are listed by their position top to bottom in a phylogenetic "tree" based on molecular software):

- *Plagiomerus diaspidis* and *Plagiomerus* nr. *diaspidis* (the two are close genetically and may be interbreeding some; both are common, together, they are the fourth most common group);
- Unknown species (6 times);
- *Aphytis melinus* (2);
- *Aphytis lignanensis* (once in CA; also 4 times from Mexican fruit) and a different species of *A.* nr. *lignanensis* (3 times in CA);
- *Aphytis* undetermined species (twice);
- *Aphytis* nr. *diaspidis* #1 and #2 (the two are different species; together third most common group);
- Seven different species of *Signiphora*, 2 only from Mexico and 5 different ones from CA; 3 of the CA species are relatively rare; "*Signiphora* sp. 2 from the *flavopallata* species group" is the most common parasitoid discovered in CA and a different species that is related to sp. 2 but is at the other end of the *Signiphora* tree is the second most common parasitoid in CA;
- Two unknown species, perhaps both *Encarsia* spp. (one 4 times, the other 3 times) – we are hampered in the identification of these because of a lack of matching genetic signatures in GenBank – this problem is solvable by sequencing known *Encarsia* or by rearing out a specimen to the adult stage (the latter is probably difficult due to their rarity).

We believe we now have a pretty good idea of what species of parasitoids are common in California. The nice thing about doing this work based on genetic signatures is that we have fairly good confidence regarding which are different species (standard taxonomy can be misleading) and once we have a genetic signature, even of immature stages, it is only a matter of time and effort before we identify the species.

## FUTURE RESEARCH PLANS

We will continue collecting information on the species of armored scales and parasitoids present on California avocados. Over the next year, our focus will shift in part to trying to rear the most common CA parasitoids. Ideally, we would like to start cultures of one of the species of *Plagiomerus diaspidis*, one of the more common *Signiphora* species, and one of the species of *Aphytis* nr. *diaspidis*. In order to rear these species effectively, we will need to study their basic biology to some degree and learn how to best rear their host scale, i.e. California latania scale. We will then initiate studies to determine which of these parasitoids will attack various species of exotic Mexican scales that we are rearing inside Quarantine. Given that this project ends 10-31-12, we will not be able to complete these objectives and a new research proposal will be submitted next year to extend this research. Should one of the species of Mexican armored scales establish in California (it is likely only a matter of time before this happens), we should initially try to eradicate the species if it is found early enough before it has spread widely. One problem is that little is known about the host range of many of these exotic armored scales – some are known to have quite broad host ranges whereas others may be confined mostly to plants in the Family Lauraceae like avocado. In the long term, should an exotic armored scale establish to the degree that eradication is no longer feasible, biological control may provide a

more practical method of management. We can only hope that one or several of the parasitoids we have present in California will attack and effectively control the exotic scale(s). If not, it may be necessary to see if other parasitoid species present in Mexico which have co-evolved with the exotic scale might be more effective and could be imported and released to provide effective biological control. Unfortunately, such importations can be done only via a federal permit and typically it takes up to two years or more to do the host specificity testing required to obtain release permits. We really do not need another exotic pest on California avocados that requires chemical control – biological control would be the preferred method of control if and when exotic scales are introduced.

#### SELECTED REFERENCES

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