An avocado grove with several different cultivars in Taiwan

PSHB Research Update

The Search for Biocontrol Agents

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During the end of April and first week of May, Drs. Richard Stouthamer and Akif Eskalen visited Taiwan and Vietnam to continue the search for potential biocontrol agents of the polyphagous shot hole borer (PSHB). This was the team's second visit to Vietnam, having previously visited in April 2014, and their first trip to Taiwan. Vietnam has been identified as the center of origin for the Los Angeles/Orange County population of PSHB and Taiwan is the apparent native range of the San Diego population.

Taiwan

In Taiwan, the beetle populations were found to be very low and the researchers were only able to capture a small number of beetles in avocado groves and none from the surrounding wild areas. In an infested avocado branch sample that was collected and dissected in a cooperator's lab, several wasp cocoons were found associated with the beetles. Samples of this wasp were sent back to the United States and DNA analysis indicated that it is a species of bethylid wasp.

Bethylid wasps are common parasitoids of Lepidoptera (butterflies and moths) and Coleoptera (beetles) species. A bethylid wasp has been used successfully as a biocontrol agent against another ambrosia beetle, the coffee bean borer beetle, widely considered one of the worst pests of coffee. Thus, finding one associated with PSHB samples is promising. A parasitoid would be an ideal candidate for in-

troduction as a biocontrol agent since parasitoids are generally highly host-specific.

It was also observed in Taiwan that the beetle, when present, did not appear to be as successful in establishing its fungal garden in the host tree as here in California. The mycangia (specialized mouth parts) of beetles collected in Taiwan were examined to determine what fungi they are carrying. Three different species of *Fusarium*, based on morphology, were found — one similar to the species in the San Diego beetle population and two other species. In addition, a *Graphium* species was found, but no *Acremonium* species, which is similar to the situation in San Diego. Genetic sequencing of all of the fungi found is ongoing to finalize their identification.

The researchers have developed several hypotheses to explain their observations in Taiwan. The low beetle populations may be the result of good biocontrol. Alternatively, the avocado groves in Taiwan are not monocultures like California groves. Instead, Taiwanese avocado groves consist of many different varieties and this diversity may affect the beetle's and fungi's ability to adapt to their host. With respect to the beetle's apparent poor ability to establish their fungal gardens, there may be antagonistic fungi or bacteria present that affect the beetle's fitness.

Drs. Stouthamer and Eskalen were very impressed with the quality of the scientists and their facilities — many of the scientists have been trained in the United States. They are optimistic that the Taiwanese researchers will be invaluable partners going forward and will be able to help answer many of the questions necessary to move these initial findings forward.

Vietnam

After two weeks in Taiwan, the researchers traveled to southern Vietnam, having visited northern Vietnam in 2014. No beetles were found in avocado groves in Vietnam, but the beetle is a major pest of acacia, which is grown in large plantations for timber. Richard Stouthamer noted that the avocado groves in Vietnam are very diverse, often interplanted with banana and other tropical fruits, whereas the acacia plantations are monocultures. What role this diversity plays in the beetle's apparent host preference is unknown. It is worth noting that the Vietnamese beetle is the same as the beetle in Los Angeles and Orange Counties, which also seems to have a greater affinity for non-avocado hosts in the environment, even though it can and does infest avocado.

During their visit to Vietnam in 2014, the researchers found a species of fly that appeared to be a predator of the beetle. Their Vietnamese cooperator, Dr. Thu, has been working on rearing beetles and the fly to conduct the necessary research to determine if it is, in fact, a predator of the beetle and, if so, how specific it is to the beetle. Dr. Thu's work is being supported by USDA Farm Bill funding that Dr. Stouthamer was successful in securing. Once that funding is in place, Dr. Thu's work will progress more quickly. He will also deploy traps to capture more beetles and potential biocontrol agents that will be sent to Dr. Stouthamer for identification.

A cocoon attached to the head of a female beetle

A pupae from cocoon

A Long Road Ahead

Finding a potential biocontrol agent is just the first step of a long process. Once a potential biocontrol agent is found, it must be proven to grow or feed upon PSHB. Following that, researchers will need to create a list of California native species to test the biocontrol agent against in order to demonstrate its specificity to PSHB. That list is submitted to the USDA who reviews it and makes additions or changes to it, before sending the list to a biocontrol committee for approval.

Once the list is approved, research is conducted to evaluate specificity. The research data is sent to the USDA for review by the committee, which then recommends approval to the USDA. Once the USDA approves the recommendation, it must be published in the Federal Register for public comment before any releases can be completed. This is likely a two-year process — possibly more. Despite the long and arduous path, a biocontrol agent may be our best long-term solution to PSHB.