FINAL REPORT

Project Title: Integrated Pest Management of Coconut Rhinoceros Beetle in Hawaii

Project Period: January 01, 2018 to March 31, 2019

Sponsor: Hawaii Invasive Species Council

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Project Directors: Zhiqiang Cheng and Michael Melzer

Affiliation: University of Hawaii
College of Tropical Agriculture and Human Resources
Dept. of Plant and Environmental Protection Sciences

Contact: Zhiqiang Cheng
(808) 956-6416
Cheng241@hawaii.edu

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Executive Summary

Coconut Rhinoceros Beetle (*Oryctes rhinoceros*, CRB) is a large scarab beetle native to southeast Asia and a damaging pest of palm species, most notably coconut palm (*Cocos nucifera*). In Hawaii, it was first confirmed on Oahu in 2013. CRB has been identified by USDA-APHIS as one of the most damaging invasive insect pests of coconut and other palm species whose introduction could result in significant economic losses to commercial coconut and palm nurseries, and Hawaii's residents and tourists who value palm trees for their aesthetic value. This HISC-funded project provided additional support to our on-going research on chemical, biological, and cultural control of CRB partially funded by USDA APHIS. The project summary presented in this final report described the integrated research and extension/outreach activities conducted by PI Z. Cheng's program during the reporting period.

Long-Term Field Experiment with Low-Risk Systemic Pesticides

The field experiment is the continuation from my USDA Farm Bill FY15 and FY16 projects. We started field experiment in May 2016. A total of 125 coconut palms in relative proximity to each other were selected and placed into blocks of five trees (25 total blocks). Each tree in a block was randomly designated a treatment type (control, acephate, emamectin benzoate, imidacloprid, and a combination of acephate and imidacloprid) with insecticides chosen based on lab assay results. Treatments were applied systemically through trunk injection according to label directions, while control palms received no injection. No insecticide was predicted to repel *O. rhinoceros* and so equal chance of feeding for each treatment was hypothesized. Initial ratings were taken on the overall tree health due to *O. rhinoceros* and the inner four frond health (0-5 scale with 0 being no damage and 5 being dead). After injections, observations were taken monthly to assess efficacy. Overall tree health and the inner four fronds were tested against initial conditions to determine area-wise efficacy of treatments as a whole. Acephate was applied every 6 months, and imidacloprid was applied every year.

Both the overall tree health and the inner four fronds were observed as the overall tree health shows how the tree appears as a whole while the inner four fronds show more recent attack as potentially how the tree will appear in the future. Over the 32 months post initial treatment, no month showed statistically significant scores compared to the initial month for overall frond damage, mainly due to overall low CRB infestation level on Oahu. However, acephate showed consistent overall frond condition improvement until eight months after initial treatment, and remained the lowest among all treatments and control up to 15 months post initial treatment (Figure 1). Starting from 16 months after initial treatment, imidacloprid and acephate+imidacloprid combo became the best treatments through month 32 post initial treatment (Figure 1). For inner four frond damage, acephate was the lowest among all treatments and control up to month 8 post initial treatment (Figure 2). Starting from month 9 post initial treatment, acephate+imidacloprid combo treatment generally resulted in lowest damage through month 26 post initial treatment (Figure 2). From month 27 post initial treatment onwards, imidacloprid treatment resulted in lowest damage to date (Figure 2).

Biological Control: Entomopathogenic Fungi

Entomopathogenic fungi lab assays are the continuation from my USDA Farm Bill FY15 and FY16 projects. Entomopathogenic Fungi, mainly *Beauveria bassiana* and *Metarhizium* spp., were collected from various locations on Oahu in our previous projects (Figure 3). Based on results of multiple lab assays in our previous projects, we focused on *Metarhizium* strains KO001, KO002, LA016, LA025, and LA026 in this project because they previously showed high mortality against CRB. In this project year, one lab assay was conducted without Epsom salt (Figure 4), and the other lab assay was conducted with Epsom salt (Figure 5). High total mortality was found in both trials, including the control without salt in the soil though (Figure 5). The substrate used for this study was gathered from mulch near UH Maona and sterilized. It was suspected that the mulch used in these assays could have caused some CRB mortality due to excessive moisture.

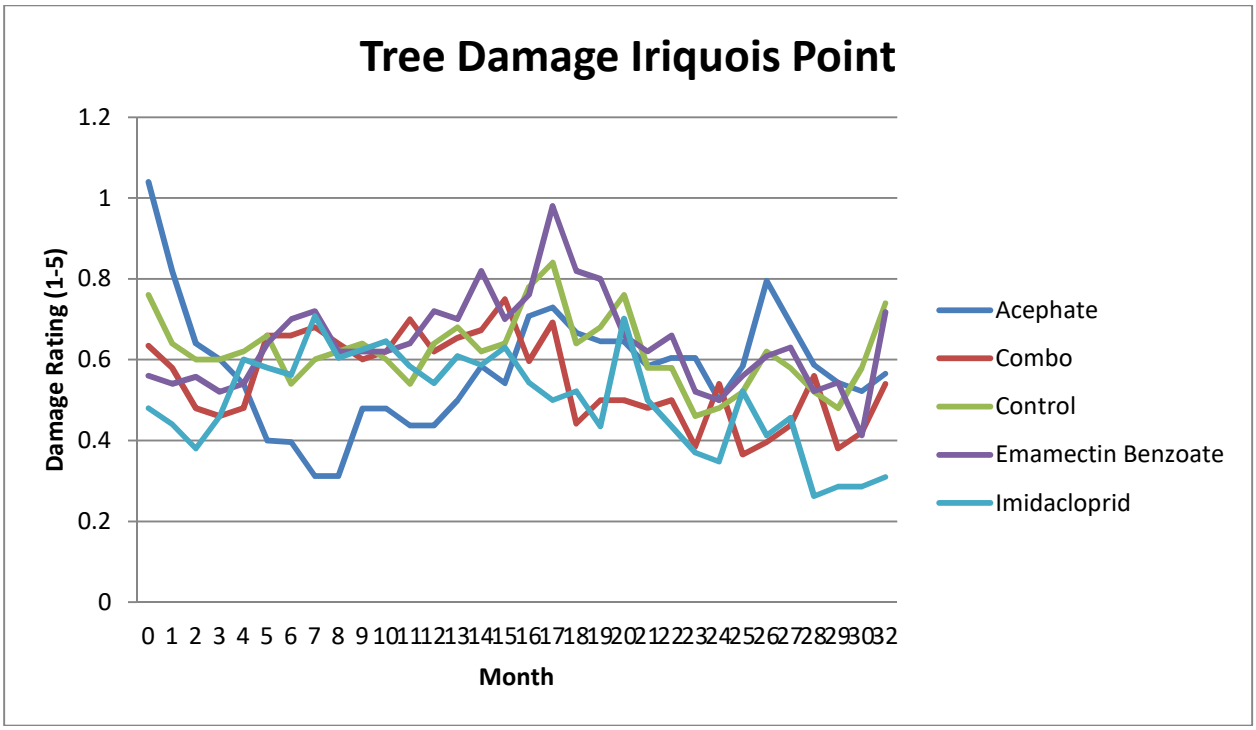

Figure 1. Average overall CRB damage over time for each treatment. Ranges of scores were 0-5 with 0 showing no damage and 5 being a dead tree.

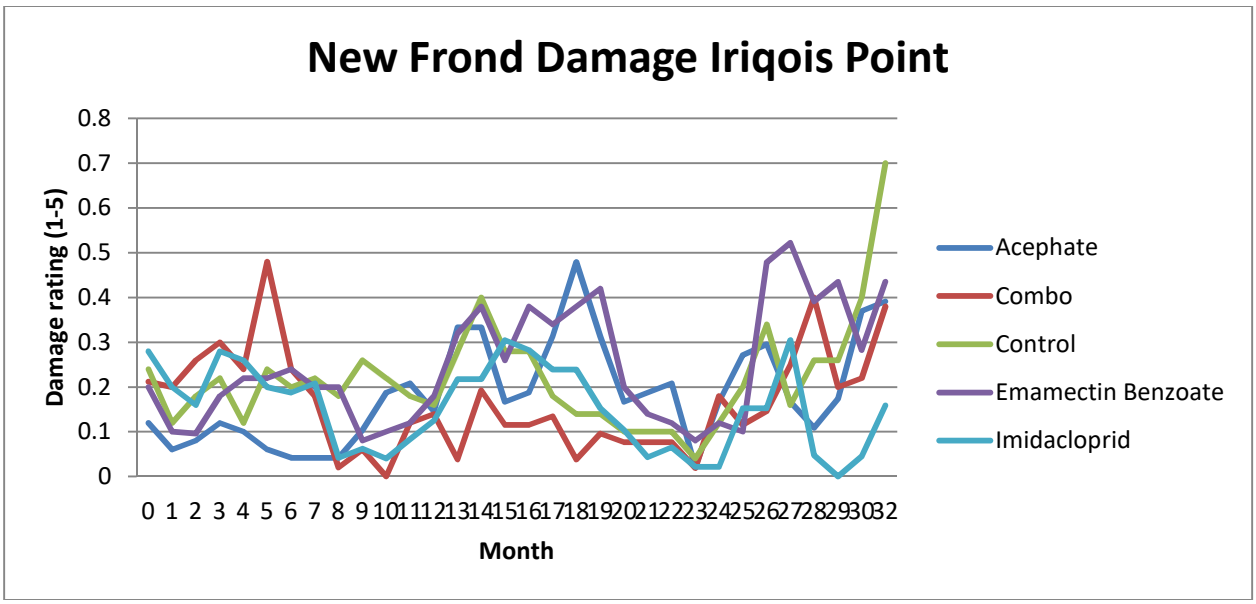

Figure 2. Average CRB damage on the inner most four fronds over time for each treatment. Ranges of scores were 0-5 with 0 showing no damage and 5 being a dead tree.

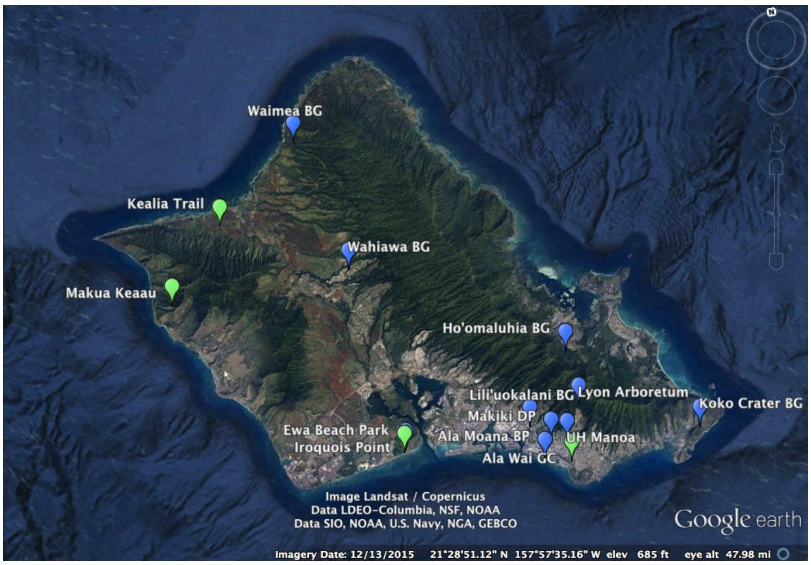

Figure 3. Map of collection sites for entomopathogenic fungi on Oahu.

Figure 4. Entomopathogenic fungi lab assay: 14-day post treatment CRB mortality.

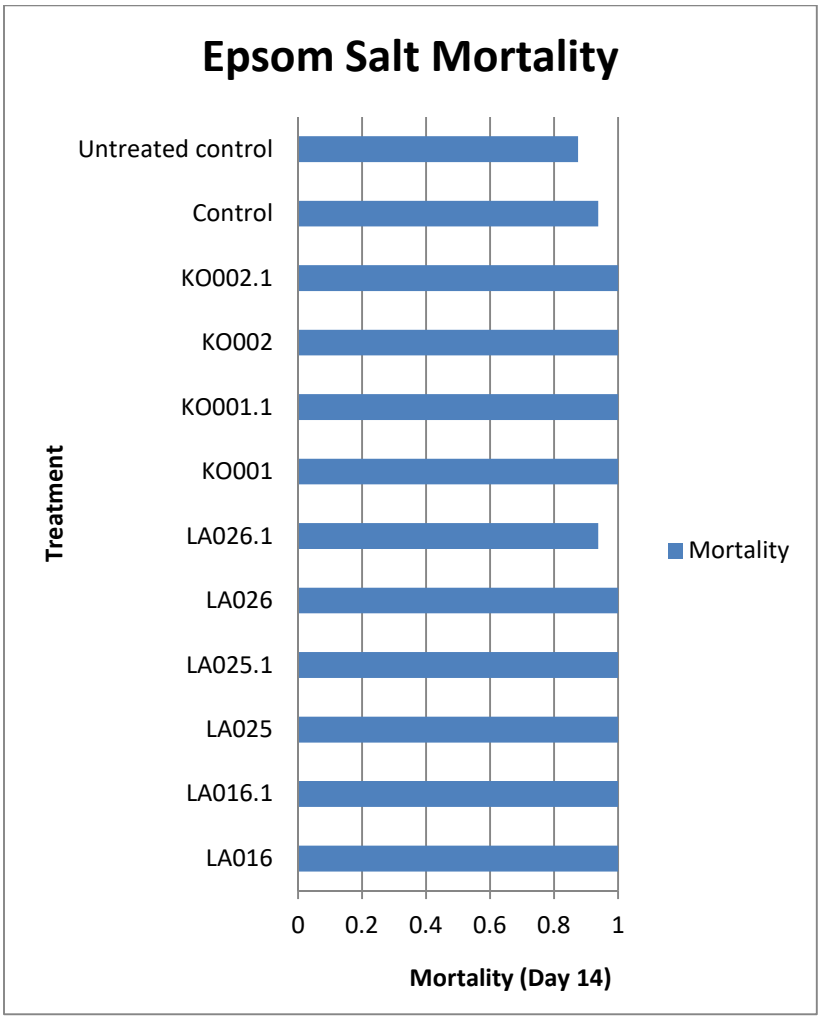

Figure 5. Entomopathogenic fungi lab assay with Epsom salt: 14-day post treatment CRB mortality.

We recently received permission from HDOA to test fungal strains in the field, when enough larvae were found for a statistically meaningful trial. In November 2018, the first field experiment was attempted in a large plastic tub similar to what is used for controlled CRB breeding sites on Oahu. Fungal strains were quantified in the lab and then appropriately distributed in bags of soil using 1 ml of solution for 25ml of soil. However, excessive rain during the first weekend of the trial drowned all CRB larvae. There was no more larvae found in this quantity in this project year to attempt a second field trial.

We recently started a dry granular approach to more efficiently rear *Metarhizium*. The goal is to produce large quantities of *Metarhizium* that can be dispersed in the field. We are currently fine-tuning the protocol/recipe for rearing *Metarhizium* on rice (Figure 6).

Biological Control: Entomopathogenic Nematodes

We recently started a wax moth colony to more efficiently rear entomopathogenic nematodes, specifically *Heterorhabditis indica* (Figure 7). A small-scale lab assay is underway to test if 880 IJ/ml is enough to cause CRB 1st instar mortality. Once wax moth numbers increase, we can rear larger quantities of EPNs for larger-scale lab assays. These will take place in the UH-ACL.

Figure 6. Dry granular approach to more efficiently rear *Metarhizium.*

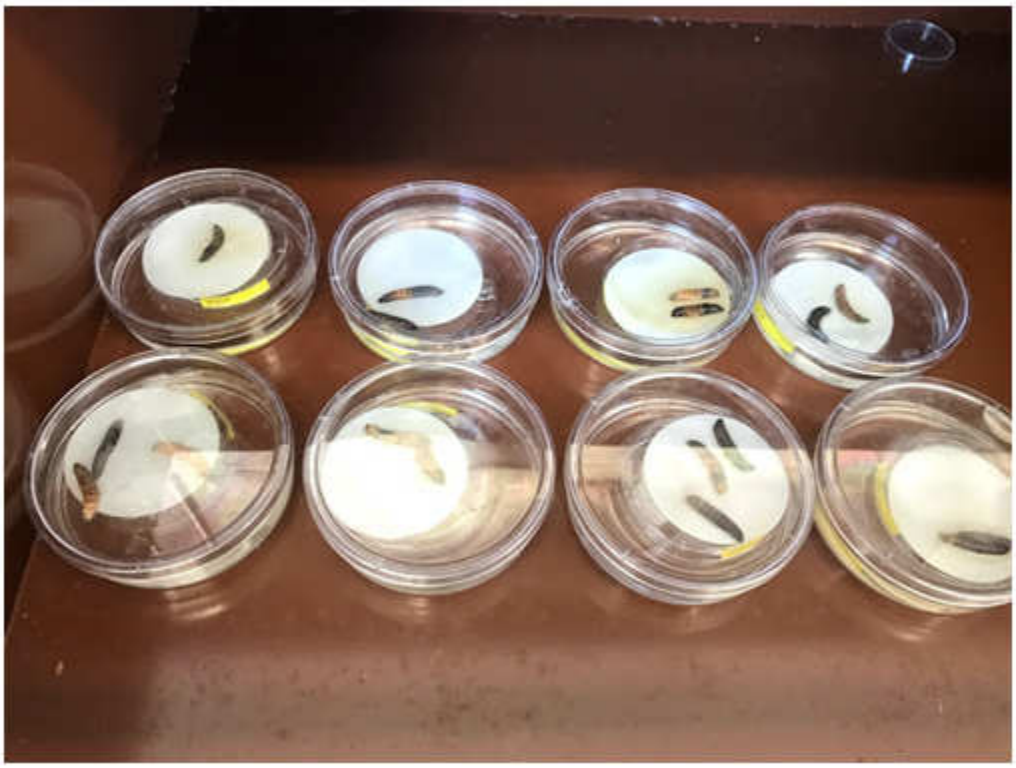

Figure 7. Wax moth in White Traps to rear entomopathogenic nematodes.

Dissemination of findings

During this project year, PI Z. Cheng and lab members made the following oral or poster presentations containing CRB research. HISC was acknowledged as a funding agency in all these presentations.

Cheng, Z. Management of several new invasive landscape pests in Hawaii: coconut rhinoceros beetle, lobate lac scale, *Ficus* stem and leaf gall wasps. 2018 Maui Turfgrass and Landscape Pest Management Workshop. December 13, 2018. Kahului, HI.

Russo, M., Z. Cheng, J. Li, M. Kellar, and K. Mitsuda. Potential use of local strains of entomopathogenic fungus to control the coconut rhinoceros beetle, *Oryctes rhinoceros*, on Oahu, Hawaii. 2018 Annual Entomological Society of America (ESA) meeting. November 11-14, 2018. Vancouver, BC, Canada.

Cheng, Z. Research updates on management of several important landscape and turfgrass pests in Hawaii. 2018 Annual Landscape Industry Council of Hawaii (LICH) Green Industry Conference and Trade Show. October 10, 2018. Honolulu, HI.

Cheng, Z. Research updates on control of several important landscape and turfgrass pests in Hawaii. 2018 Crop Production Services Annual Seminar and Trade Show. May 11, 2018. Honolulu, HI.

Russo, M., Z. Cheng, K. Mitsuda, J. Li, and M. Kellar. Potential use of local strains of entomopathogenic fungus to control the coconut rhinoceros beetle, *Oryctes rhinoceros* on Oahu, Hawaii (poster). 2018 CTAHR/COE Student Research Symposium. April 6-7, 2018. Honolulu, HI.