November 27, 2015

FINAL REPORT

Project Title:	Multi-Agency Proposal for Coconut Rhinoceros Beetle Response, Training, and Research
Project Period:	October 1, 2014 to September 30, 2015
Sponsor:	Hawaii Invasive Species Council
Funding Amount:	$389,253
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Executive Summary

The coconut rhinoceros beetle (CRB; *Oryctes rhinoceros*) was detected in December 2013 on Oahu at Joint Base Pearl Harbor-Hickam (JBPH-H). The United States Department of Agriculture (USDA) and Hawaii Department of Agriculture (HDOA) established a multi-agency response using the Incident Command system to eradicate incipient CRB populations. These populations are currently limited to Lualualei Valley and the southwestern coast of Oahu. With USDA and Hawaii Invasive Species Council (HISC) funding totaling $2.29 million, we employed 36 personnel and provided them with a 17 vehicle fleet to conduct survey, detection, trace, and control programs across Oahu under the direction of the Incident Commander. During the program period, these personnel deployed and/or serviced approximately 2700 traps across Oahu and removed close to 3000 CRB from the environment. These personnel have also identified numerous active breeding sites on Oahu, resulting in the incineration of 14,460 cubic yards of potential breeding substrate. Weekly interagency meetings that include representatives from USDA, HDOA, Hawaii Invasive Species Council, US Department of Defense, University of Hawaii, and other relevant stakeholders have been established to provide project updates and prioritize project goals and resources.

Introduction

Coconut rhinoceros beetle (CRB; *Oryctes rhinoceros*) is a large scarab beetle native to southeast Asia and a damaging pest of palm species, most notably coconut palm (*Cocos nucifera*). CRB has been identified by the United States Department of Agriculture-Animal & Plant Health Inspection Service (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, as well as Hawaii's residents and tourists who value palm trees for their aesthetic value. Adult CRBs were found at the Honolulu International Airport (HNL) and the adjacent Joint Base Pearl Harbor-Hickam (JBPHH) in December 2013. Further examination revealed CRB larvae in mulch at JBPHH, representing the first time a breeding population of CRB had been established in Hawaii. The objectives of this project were to i) provide staff support for field operations to conduct survey, detection, and control programs as needed by Incident Command, and ii) conduct research needed to develop strategies for the control of CRB.

Project Deliverables

1) *Increased inter-agency cooperation and camaraderie*

This project represents the largest acute response to a pest incursion in Hawaii's history. The agencies involved in the CRB response include, but are not limited to:

Hawaii Department of Agriculture (HDOA)
Hawaii Department of Land and Natural Resources (DLNR)
Hawaii Invasive Species Council (HISC)
Oahu Invasive Species Committee (OISC)
United States Department of Agriculture (USDA)
United States Department of Defense (DoD)
University of Hawaii

Weekly interagency meetings held at HDOA Plant Quarantine have established and strengthened the professional and social bonds between relevant agencies.

2) *Increased capacity for future inter-agency responses for other invasive species*

This project has established a scalable procedure for responses to future invasive species incursions. Personnel have been trained and a memory has been established with key personnel within each agency that will facilitate and expedite future responses.

3) *Experience in using incident command system for pest responses*

An incident command system was employed in this response, generating experience for the participating agencies and their personnel.

4) *Several effective biopesticides and reduced risk insecticides against CRB will be identified*

Seventeen fungal isolates collected from CRB cadavers have been cultured and stored for future bioassays to determine their pathogenicity. Acephate (ACE-jet) has emerged as a potential insecticide following preliminary trials.

5) *The minimum temperature and time needed to assure 100% mortality of all stages of CRB will be identified*

It was determined that immersion in water at temperatures $\geq$55 ^{o}C (131 ^{o}F) for a minimum of 5 min was 100% lethal to larval stages of CRB. Insufficient specimens were available to determine a minimum temperature and time needed to assure 100% mortality for CRB adults.

6) *The LD50 of ammonia gas on CRB will be identified*

CRB were exposed to ammonium nitrate to little or no effect. It was determined during the course of this project that an ammonia gas-based approach to CRB management was unfeasible.

7) *A more efficient/attractive trap for capturing CRB will be developed*

An alternative semiochemical trap lure is under evaluation in Guam. A more intense visual lure has been developed and will soon be deployed on Oahu for evaluation.

8) *At the end of this project, findings and results will be shared with government agencies, pest management professionals, peer scientists, and interested public through written (articles, brochures) and oral (presentations at meeting/seminar) communications.*

Findings and updates have been disseminated to stakeholders at interagency meetings, neighborhood board meetings, the local media, websites, and brochures. Scientific findings are currently being prepared for peer-reviewed publication. An Outreach Specialist position for the CRB program has been posted and candidate review is underway.

9) *Other Deliverables*

Although not part of our proposal, it was realized that assays designed to determine the effectiveness of chemical, biological, and physical control agents for CRB need adequate numbers of larvae and adults for statistical purposes. Although both larval and adult CRB are collected from the field, they do not provide sufficient numbers on a reliable basis to conduct robust experimentation. This has greatly hindered progress in evaluating control options. We have assumed control of the CRB colony at the Hawaii Department of Agriculture's Plant Quarantine facility and are maintaining this colony at this location until renovations on an insect rearing laboratory at the University of Hawaii are completed. This latter location will provide a secure, well-equipped laboratory for the rearing of CRB. CRB have a long larval stage that lasts up to 7 months. We have worked to optimize the rearing conditions (temperature, media composition, diet, and moisture content), to expedite the rearing process.

Project Milestones

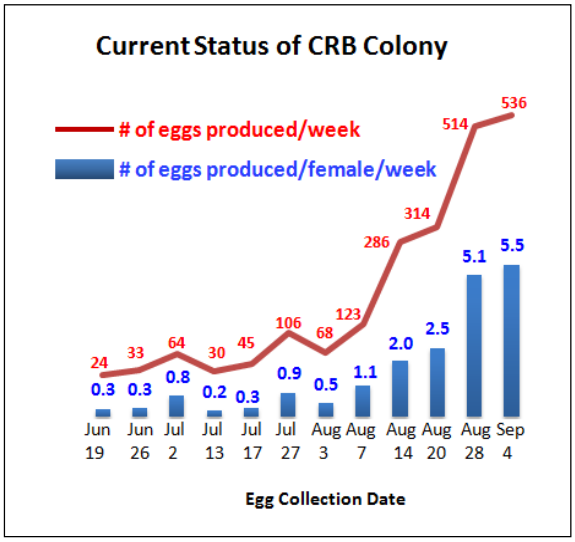
- Trap Deployment
    - Traps have been deployed on all major islands
    - 2691 traps have been deployed on Oahu
    - 2908 beetles have been caught in traps between July 1, 2014 and June 30, 2015
    - 3861 beetles have been caught since program inception
    - 445 of the traps deployed have caught beetles (none on other islands)

- Breeding sites destroyed:
    - Par 3 Golf Course (breeding site eliminated in April 2014 and no beetle activity detected since)
    - Mamala Bay Golf Course (Ground Zero; now a staging area for destruction of green waste)
    - Kuntz Gate (initial infested material destroyed; now a staging area for destruction of chipped and more mature compost through in-vessel composting)
    - Iroquois Point and Puuloa Rifle Range
    - Navy Marine Golf Course

- Destruction of infested material
    - 12,940 cubic yards of green waste has been burned using air-curtain burners
    - 1,520 cubic yards of infested green waste unsuitable for incineration treated through in-vessel composting and transferred to a high-temperature bio-solids processing facility

- CRB diagnostics
    - A PCR-based assay has been developed that can distinguish CRB larvae and frass from that of Oriental flower beetle (*Protaetia orientalis*), another scarab beetle commonly found in Oahu's compost

- University of Hawaii Rearing Laboratory
    - Three rearing chambers have been purchased and are under construction, with expected delivery in November 2015
    - Renovations on electrical (for rearing chambers), ceiling, and entry vestibules are underway to comply with insect containment guidelines
- CRB colony at HDOA Plant Quarantine
    - In July 2015, management of the colony was transferred to UH with continued assistance from HDOA
    - Introduction of new diets, feeding schedules, and rearing strategies
    - Since this transition, there has been:
        - a 10 fold increase in egg production
        - a 10 fold increase in female fecundity
        - improved hatching rate (previously <10%; now >50%)
    - Egg stage to 2nd instar larvae is completed in 28 days
    - Excess 1st instar larvae are now populating biological and chemical control experiments



Metrics of the CRB colony since UH assumed control in July 2015. Note: the colony became less productive after the reporting period of this project. The cause for this decrease in production is unclear.

- Entomopathogenic fungi have been isolated from CRB cadavers and other scarab/coleopteran insects
    - 17 isolates have been collected, including *Metarhizium*, *Beauveria*, and *Hirsutella* species
    - A lack of experimental insects has previously hindered evaluation of these fungal isolates as CRB pathogens

- Trials are underway with 1st instar CRB larvae using 5 fungal isolates

- Identification of other biological control agents (micro or macro fauna)
  We have detected CRB DNA in scat from Mamala Bay golf course providing evidence that the small Asian mongoose (*Herpestes javanicus)* is a predator of CRB in Hawaii

Other Project Impacts and Benefits

Coconut is an important component of urban forestry in Hawaii, grown primarily as an ornamental and is a symbolic tree for tourism in Hawaii. Elsewhere in the Pacific, the coconut is also a critical cultural resource for island communities as the fruit of the coconut also provides food, oil, coir, and charcoal for both subsistence and commercial production. In many Pacific Island nations where CRB has been introduced, a virus (*Oryctes rhinoceros nudivirus*) has been effective at reducing its impact. Preliminary studies conducted elsewhere indicate that the CRB genotype present in Guam and Hawaii are resistant to this virus. Therefore, if this CRB genotype were to invade other Pacific Island nations, its impact may be dramatic. Indeed, recent reports of increased CRB damage in Palau and Papua New Guinea appears to be associated with this virus-resistant CRB genotype.

Feeding damage observed in Hawaii and Guam indicates CRB poses a threat to native *Pandanus* (hala) and *Pritchardia* palms (loulu) in Hawaii's native forests. When population densities are high, CRB can also attack economically important plant species including areca and oil palms, sugar cane, pineapple, papaya, mango and banana. Should CRB be introduced to the Continental USA, it will also pose a threat to the $31.5 million date palm industry (located primarily in California, Arizona, and Florida). The presence of CRB in dry, arid environments on Oahu suggests it can survive in similar environments in California and Arizona. Historically, Hawaii has been a source of new quarantine pests for both California and Florida. The presence of CRB in Hawaii could therefore lead to domestic quarantines that will impact Hawaii's nursery industries should the infestation zone expand.

Knowledge gained in our efforts to eradicate CRB populations and control its spread in Hawaii is beneficial to the state and other locations where CRB is present or may become established. The development of procedures to efficiently rear CRB, and the development of biological control tools will aid in the battle against this important invasive insect, particularly for those regions who do not have the resources or expertise to develop these tools.