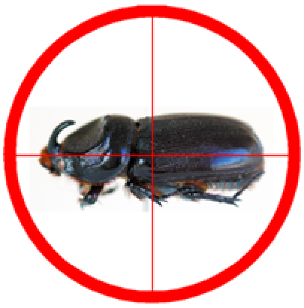
Preliminary Grant Proposal Prepared for the USDA Forest Service

Support for the Guam Coconut Rhinoceros Beetle Eradication Project



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This is a request to the USDA Forest Service for funds for continued support of the Guam Coconut Rhinoceros Eradication Project. We are asking for support to extend the work started in Agreement 11-DG-11052012-101.

1 Background

During September 2007, an infestation of the coconut rhinoceros beetle (CRB), *Oryctes rhinoceros*, was discovered along the beach of Tumon Bay. Adults of this large scarab kill coconuts and other palms when they bore into the crowns to feed on sap. Grubs feed on decaying coconut logs and stumps and they do no economic damage. Without significant control efforts, CRB can be expected to kill at least 50% of Guam's coconut palms and related plants, as it did within a few years of its arrival in Palau during the Second World War.

A thorough delimiting survey and risk assessment undertaken by the University of Guam (UOG), the Guam Department of Agriculture, and USDA-APHIS indicated that the population could be eradicated before it dispersed to other parts of the island. The Guam Coconut Rhinoceros Beetle Eradication Project has been in operation since late 2007. Although the ultimate goal is to eradicate CRB from Guam, our immediate goal is to develop and apply an integrated pest management program program to prevent any further increase in population and subsequent damage from the CRB infestation.

1.1 Funding

The project is currently supported by grants from USDA-APHIS, US Forest Service, and the Government of Guam (GovGuam). All project funds are administered by the University of Guam (UoG). Most of the money is used for temporary hires to staff the project, for pheromone lures, and for fuel and maintenance of project vehicles.

1.2 Project Management

The project is managed as an emergency Incident Command System (ICS) which is currently under the command of Michael (Troy) Brown, USDA-APHIS Plant Health Safeguarding Specialist, and Dr. Russell Campbell, Territorial Entomologist, Guam Department of Agriculture. Dr. Campbell and Dr. Aubrey Moore, UoG Extension Entomologist provide scientific/technical support for the project. UOG extension agent Roland Quitugua serves as Operations/Logistics Chief.

The ICS holds a planning meeting every Monday morning, prepares weekly situation reports, and participates in a monthly conference call with funding agencies and collaborators.

1.3 Staffing

A field crew of twelve temporary employees have been hired by the UOG to perform trapping and sanitation operations and to assist with applied research. Two members of our sanitation crew are certified pesticide applicators.

1.4 Eradication Activities

The eradication project employs two major tactics: sanitation and trapping. Sanitation is focused on detection and destruction of breeding sites. CRB breed mainly in dead coconut material. When a breeding site is detected, the area is sanitized by removing all CRB life stages along with all potential food. A network of about 1,000 pheromone traps is used to catch adult beetles to monitor changes in population levels and detect geographical spread of the infestation.

1.5 Data Collection and Record Keeping

A daily log of all activities is maintained and a weekly report is prepared and distributed as per ICS standard operating procedure. Trapping data from a network of 1,000 pheromone traps, detections of CRB grubs or adults at breeding sites, and observations of CRB defoliation and bore holes are entered daily into a web-based, georeferenced database. Project output including fact sheets, technical reports, media coverage, and images are publicly from a wiki page at http://tinyurl.com/Guam-CRB-info. More recent information is posted on a Drupal web site at http://www.guaminsects.net/anr.

1.6 Current Situation

About two years ago, CRB escaped from the original quarantine zone along the northeast coast of Guam and spread to inland areas where adults established breeding sites in large compost piles at municipal dumps and at golf courses, some of which exceed 200 cubic yards. These piles are now infested with large numbers of CRB grubs and which are generating large numbers of adults.

To date, no natural biocontrol of CRB has been observed on Guam. Without density-dependent, self propagating biocontrol, Guam is primed for a population explosion of CRB. Large numbers of adult beetles will initiate a positive feedback loop in which palms are killed, producing more food for grubs which will transform into ever increasing numbers of adults until food becomes limiting. If a CRB population occurs, risk of accidental export to other islands and elsewhere will increase.

Our plans to introduce a subfamily-specific virus into the population by autodissemination has failed. This virus has successfully suppressed CRB populations on other Pacific Islands. However, laboratory bioassays indicate that either our CRB population is resistant to the virus strains supplied to us by AgResearch, New Zealand, or the virus has lost its virulence and we are currently trying to define the cause of the failure in a collaborative project with AgResearch, funded by an APHIS biocontrol grant. We also continue to search for a virus strain which is pathogenic to our population.

As a second attempt at biocontrol, we have been importing and disseminating the entomopathogenic fungus, *Metarhizium majus*, formerly known as *Metarhizium anisopliae* (var. *majus*) as an alternative to the virus for biocontrol of CRB. This fungus, which is virulent to rhino beetles and other scarabs, is being used for CRB control by the Philippine Coconut Authority. USDA-APHIS has permitted us to use this biocontrol agent on Guam. We use the *Metarhizium* as a classical biocontrol agent rather than a microbial insecticide. Literature indicates that the fungus will persist and spread in the rhino beetle environment, providing sustained, density-dependent control and we have already seen evidence of natural spread on Guam. To date no natural occurring biological control has been observed on Guam. Vertebrate insectivores such as rats, shrews and birds are almost nonexistent on the island because of high predation by the introduced brown treesnake.

In the short term, it is critical that we develop extension recommendations for emergency treatment of the large, recently-infested compost piles. These piles are too far composted to burn and too large to be fumigated. To date, we have only found two insecticides for emergency treatment, cypermethrin, which kills all life stages, and an insect growth regulator, NYGUARD, which prevents pupation and generation of adults.

We also need to develop recommendations for home gardeners who are unintentionally producing CRB adults in garden compost piles.

2 Objectives: Development of an Integrated Pest Management Program for Coconut Rhinoceros Beetle on Guam

Eradication is the ultimate long-term objective of the Guam Coconut Rhinoceros Beetle Eradication Project. However, development and implementation of an integrated pest management (IPM) program to minimize damage by the current outbreak of CRB adults is our short-term objective. If we are successful, the Guam CRB IPM program will generate the following benefits:

- tree mortality and defoliation will be minimized
- control costs and use of pesticides will be minimized
- production of large numbers of adult CRB adults will be minimized, reducing the risk of accidentally exporting the CRB problem to neighboring islands or elsewhere
- development of detection, monitoring and control tactics on Guam will be useful in the event that this invasive species is inadvertently transported to neighboring islands or elsewhere

The University of Guam Agricultural Experiment Station at Yigo, Guam will be used as a large scale test facility for the Guam CRB IPM program. The station, which encompasses 40 acres in northern Guam, is currently badly infested with CRB, with most coconut palms showing signs of defoliation. We will protect most of the trees on the station by implementing CRB IPM. About 10-15 percent of coconut palms on the station will be left unmanaged to serve as an experimental control.

2.1 Public Workshops

Although we do not yet have all the answers, we have developed effective and appropriate tactics for CRB control on Guam during the past four years. In the light of the recent island-wide expansion of the CRB infestation, we feel that now is the right time to organize public workshops in order to share these tactics.

We are currently planning 2 types of workshops to begin in June, 2013. These workshops will be tailored for two types off clients:

- pest control operators, farmers, landscapers, plant nurseries, golf courses, government agencies, local and federal resource managers
- home-owners, gardeners

Depending on demand, we expect to have at least 2 sessions for each workshop.

Our sponsors (USFS, APHIS, and the Guam Legislature) will be credited on literature developed for the workshops and receive copes of the literature.

2.2 Integrated Pest Management Plan

A draft IPM plan for CRB on Guam is attached. If our proposal is approved, funding will be used to:

- put on public workshops (see above)
- continue sanitation and surveillance
- flesh out the draft IPM plan and publish this as an extension document
- perform applied research as required to improve the draft IPM plan

3 Budget

ITEM		FS FUNDS
Personnel		
4 sanitation crew laborers; $9 per hour; 1800 hours each		$57,600.00
2 trappers; $10 per hour; 1800 hours each		$36,000.00
Social security at 7.65%		$4,406.40
	Total Personnel	**$98,006.40**
Supplies		
Vehicle maintenance		$6,000.00
Public outreach material		$5,000.00
Hand tool replacement (sanitation)		$3,500.00
Vehicle fuel (sanitation and trapping)		$6,777.72
Office supplies, page charges, shipping, etc.		$2,000.00
	Total Supplies	**$23,277.72**
Indirect Costs (29.3% of hourly wages)		**$28,715.88**
	TOTAL	**$150,000.00**

3.1 Budget Notes

3.1.1 Matching Funds

We will use $150k from money allocated by the Government of Guam for support of the Guam Coconut Rhinoceros Eradication Project as matching funds.

3.1.2 Indirect Costs

The negotiated rate for indirect costs associated with federal funds administered by the University of Guam is 29.3% of hourly wages for off-campus activities.

4 ATTACHMENT: Draft IPM Plan for Coconut Rhinoceros Beetle on Guam

DRAFT
Integrated Pest Management of Coconut Rhinoceros Beetle on Guam

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May 22, 2013

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1 Tactics Aimed at Controlling All Life Stages

1.1 Sanitation

Sanitation is the most effective control tactic for CRB.

The objective of sanitation is to remove food material from active or potential breeding sites to prevent generation of adult beetles. Food material is commonly chipped and stockpiled at a location where it can be properly managed or converted into non-food (See subsections 1.3 and 1.4).

1.2 Biological Control

1.2.1 Virus

An insect virus attacking CRB has been used successfully for suppressing CRB populations on other Pacific Islands. We had planned to introduce this virus into the Guam population by autodissemination. However, several laboratory bioassays indicate that the Guam CRB are not susceptible to several strains of virus produced in insect cell culture by AgResearch New Zealand. These strains were imported into Guam under conditions of an APHIS import permit.

Applied Research Required:

- Identify a strain of Oryctes nudivirus which is pathogenic for the Guam CRB population and establish this strain as a biocontrol agent
- Use comparative bioassays with known susceptible strains of Oryctes nudivirus to prove conclusively that the Guam population is resistant

Note: A research proposal to address these two objectives has already been funded by APHIS and the work will be done in collaboration with AgResearch New Zealand.

1.2.2 Fungus

As an alternative to the virus as a biocontrol agent, we have implemented classical biological control using *Metarhizium majus*, also known as green muscardine fungus (GMF). Spores of this fungus are produced for the project by Dr. Ambrosio Alfiler of the Philippine Coconut Authority. It is imported and released under conditions of an APHIS import permit and use of this fungus was evaluated as part of the new environmental assessment document. *M. majus* pathogenicity is largely restricted to the genus *Oryctes*. Since CRB is the only insect in this genus that occurs on Guam, nontarget effects on other insects are not expected. The fungus did not attack other species of scarab beetles in laboratory bioassays.

To date, the project has imported eight 15 kg shipments of GMF. Spores are disseminated in two ways:

- adult males caught in traps are dusted with spores and released. These males will find breeding sites and infest these sites with GMF.
- Artificial breeding sites referred to as "sinks" have been set up. These sinks contain rotting coconut material infested with GMF. Adults are attracted to these sinks for mating and oviposition. Immatures and adults in the sinks are killed by GMF infection. Twenty-seven sinks are currently in existence and these are visited biweekly.
- More recently we have started using 55 gallon oil barrels as sinks. These barrels may be used as GMF autodissemination sources. We apply GMF to rotting coconut material. Adult beetles arrive, pick up fungal spores and leave. We have found the barrels be very efficient attraction traps when using rotting coconut material plus aggregation pheromone, thus simulating a breeding site. Very recently, we have discovered that hexagonal mesh chicken wire covers for the barrels allows adult beetles to enter but not leave. We are calling these "Hotel California Traps": beetles check in but can never leave.

Early results indicate that GMF is effectively limiting the Guam CRB population:

- GMF is spreading naturally. Infected grubs have been found at a distance from GMF spore release sites.

Applied Research Required:

- GMF has been applied to breeding sites in most parts of Guam and we have evidence that it is spreading naturally. However, we do not know how well GMF is suppressing the Guam CRB population. We need to measure the efficacy of GMF as a biocontrol agent. A life table approach may be one way of doing this.

1.3 Pesticide Treatment of Breeding Site Material

- CRB in breeding site material can be killed by fumigation with methyl bromide. However, this fumigant is only allowable for quarantine treatments.
- Cypermethrin (Demon Max), a pyrethroid, applied as a drench, has been successfully used as a nonpersistent treatment for piles of CRB food material in situ and for killing CRB in managed piles.
- The insect growth regulator NYGUARD has been used to prevent CRB grubs from transforming into adults. Third instar larvae do not pupate but continue feeding growing to about twice their normal size. Thus converting large quantities of CRB food to non-food.

Applied Research Required:

- We need to measure the persistence of NYGUARD IGR in terms of how often piles of CRB breeding material need to be treated in order to prevent generation of adults.

1.4 Physical Treatment of Breeding Site Material

1.4.1 Killing CRB with Heat and Water

- CRB grubs and adults are amazingly heat tolerant but can be killed by heating moist substrate to at least 150 degrees Fahrenheit for at least 2 hours. We determined that the 24 hour LT50 for third instar grubs in moist peet moss is 117 degrees F.
- Repeated attempts at raising the temperature of piles above th lethal threshold using solarization have failed.
- CRB grubs and adults can drowned, but this takes a long time: more than 50 hours completed submersion.

Applied Research Required:

- We may want to evaluate use of a steam generator as an alternative to pesticides for killing CRB infesting piles of breeding site material. The idea is to pile breeding site material on top of a series of perforated pipes. Steam would be pumped through these pipes to sanitize the pile.

1.4.2 Physical Barriers

Physical barriers can be erected to prevent infestation or re-infestation of breeding site material. CRB adults can be excluded from an area using half-inch metal hardware cloth. Beetles will easily make holes in plastic or metal insect screening.

We have recently discovered that a horizontal sheet of hexagonal chicken wire with one-inch holes acts as a “one-way entrance” for CRB adults. We have made chicken wire lids to cover 55 gallon oil barrels containing breeding site material and/or a pheromone lure. Beetles land on the chicken wire, crawl through it, and drop down into the barrel. Beetles are unable to fly out of the barrels because the holes in the chicken wire are much less than their wingspan. We consider this to be a significant discovery and have dubbed it the ’Hotel California’ concept ("We are programmed to receive. You can check-out any time you like, But you can never leave!").

We may be able to use chicken wire to enclose large piles of breeding site material so that adults can enter the pile, but none can leave. Thus, the pile would act as a large sink, capturing many CRB adults flying in the neighborhood before they can do damage, while preventing exit of any adults generated by the pile. The end product from the pile could be used as mulch or compost after physical or chemical treatment to ensure that all CRB are dead. Perhaps if left long enough, a pile of CRB food would be converted to nonfood with no risk of being reinfested by CRB.

Applied Research Required:

- Scale up the 'Hotel California' concept to enclose large piles.
- Determine how long it takes protected piles to degrade to a point where they are no longer useful as food or breeding sites for CRB.

2 Tactics Aimed at Controlling Adults

2.1 Pheromone Traps for Mass Trapping

When the CRB infestation first started on Guam in 2007, we were lead to believe that adults could be trapped out using massed trapping. It soon became evident that standard baffled bucket traps baited with Oryctalure were not efficacious for mass trapping because coconut palms within mass trapping areas were being heavily damaged. We gave up on using pheromone traps as a control method. However, we continue to use these traps for monitoring (See subsection 3.1).

Applied Research Required:

- We are currently doing trap improvement research (See subsection 3.1). If we can improve trap efficacy by an order of magnitude or more, mass trapping should be re-evaluated.

2.2 Artificial Breeding Sites (Sinks)

We set up our first artificial breeding sites for autodissemination of green muscardine fungus. These open sinks are essentially small piles of breeding material, mostly decaying coconut logs, enclosed by box made from coconut logs (about 2 meters square by 0.5 meters high). We soon realized that that these artificial breeding sites could be used as sinks to attract adults flying in the neighborhood.

More recently, we have developed barrel sinks. We shovel breeding material into surplus 55 gallon oil barrels and cover the top with chicken wire. Adult CRB flying in the neighborhood land on the chicken wire, crawl through the wire and drop into the breeding material. Adults are permanently trapped in the barrel sinks. The barrel sinks are seen as a way of managing green waste produced by small household gardens. Having a small open compost pile in the corner of the garden was good practice before the CRB arrived, but these piles are now generating adult beetles which attack nearby palms. We are currently developing recommendations for killing all life stages of CRB in the barrel sinks prior to using the material for mulch or compost.

In addition to allowing home gardeners to produce mulch and compost without generating adult CRB which will damage their palms, the barrel sinks attracts and traps beetles flying in the neighborhood reducing damage to nearby palms and reducing formation of unmanaged breeding sites.

Applied Research Required:

- Evaluate barrel sinks as traps
- Develop chemical and nonchemical methods for reliably killing all CRB life stages prior to use sink contents as mulch or compost.
- Determine how long it takes for barrel sink contents to be converted from CRB food to nonfood.

2.3 Pesticide Application to Tree Crowns

Recent research indicates that adult CRB actively attacking palms can be killed by application of cypermethrin to palm tree crowns. Moribund and dead CRB are found under treated trees for a few days following treatment. This suggests that applying a spray application of pesticide to palm crowns may be a useful emergency treatment. However, we do not yet know if this observed CRB mortality results in a reduction in damage (bore holes and defoliation).

Applied Research Required:

- Perform field trials to determine if pesticide application to palm tree crowns reduces damage (bore holes and defoliation).
- Determine persistence of cypermethrin in order to recommend a treatment interval.
- Identify and evaluate an active ingredient more persistent than cypermethrin.

3 Monitoring

3.1 Pheromone Traps for Monitoring

We know that the standard baffled bucket traps baited with oryctalure pheromone which are used by the project are inefficient from two lines of evidence. Firstly, coconut palms are repeatedly damaged in mass trapping areas, indicating that the palms are more attractive than the traps. Secondly, in a preliminary mark-release-recapture experiment in which 20 adult CRB were released in a mass trapping area, not a single beetle was recaptured.

We are currently doing research to find out how to improve trap performance. There is strong evidence that the release rate of commercially available lures may be too high for the Guam CRB population, either arresting or repelling beetles before they enter traps. In addition, work in collaboration with Matt Siderhurst and Eric Jang at USDA-ARS-PBARC suggests that CRB are attracted to ultraviolet light emitting diodes (UV LEDs). We have established replicated field trials to compare trap catch data from standard traps and those fitted with UV LEDs and/or reduced release rate lures. We will also test a new trap design and new lures produced by AlphaScents.

Applied Research Required:

- Complete trap improvement studies outlined above.
- Test new trap design and new lures from AlphaScents using our current baffled-bucket traps baited with Oryctalure as a standard.
- In an attempt to correlate trap catch with CRB flight activity, we will repeat mark-release-recapture experiments. We will use only male beetles which will be flight tested prior to release. Each beetle will be uniquely marked so that we can record data on longevity and distance traveled from release site to capture site.
- If field trials result in more attractive or cheaper traps, we will make changes to our island-wide trap network of about 1000 traps. Traps will be calibrated using mark-release-recapture experiments before and after application of these changes.
- We will observe motion of beetles in relation to pheromone traps using cameras and radio telemetry in an attempt to determine the active space of a trap.

3.2 Pan Traps

A pan trap is a simple modification to a barrel sink. A metal pan is placed directly beneath the chicken wire to prevent CRB adults from burrowing into the breeding material. Thus they can be quickly counted without having to dig through the breeding material.

Applied Research Required:

- Evaluate pan traps with and without Oryctalure as a surveillance device. Compare pan trap catch with those of standard baffled-bucket traps baited with Oryctalure.

3.3 Scouting for Breeding Sites

Wherever we find CRB damage, we do visual searches for breeding sites to local sources of adult beetles. Breeding sites are mapped and sanitized upon discovery. In the past we successfully used detector dogs to scout for CRB breeding sites but this part of our project was discontinued because it was too expensive.

During our workshops, we will train people how to survey for breeding sites.

Applied Research Required:

- None, at present.

3.4 Scouting for Adult Damage

Defoliation by CRB is very distinctive and proof that the defoliation was caused by CRB can be determined by presence of a bore hole.

During our workshops, we will train people how to detect CRB damage symptoms and determine conclusively if the observed damage was caused by a rhino beetle.

Applied Research Required:

- For research purposes, we need to develop a rating system for CRB damage to individual palms. For example, we will need to quantify damage reduction as a result of insecticide application to crowns of palms. A ranking system based on images may be sufficient.