

CFES Report

2020-06-15 to 2021-06-14

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Contents

Preface	4
Part I. Role Assignments	5
Part II. Extension and Community Activities (ECA) 51%	5
NIFA Classification	5
ECA-PA1 Insect Diagnostic Services	6
ECA-PA2 Detection and Documentation of Invasive Species	6
ECA-PA3 University of Guam Insect Collection	7
ECA-PA4 Mitigation of Damage to Guam's Ecosystems by Invasive Species	8
ECA-PA5 National Plant Diagnostic Network (NPDN)	8
ECA-PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Invasive Species Council (GISC)	9
ECA-PA7 Public Outreach: Internet	9
ECA-PA8 Public Outreach: Presentations	9
ECA-PA9 Public Outreach: Miscellaneous	10
ECA-PA10 Public Outreach: Public GitHub Repositories	10
Part II. Creative/Scholarly Activities or Research (CSR) 34%	13
NIFA Classification	13
CSR-PA1 Peer Reviewed Publications (N=4)	14
CSR-PA2 Publication submitted for Peer Review (N=1)	14

CSR-PA3 Journal Articles in Preparation (n=5)	15
CSR-PA4 Coconut Rhinoceros Beetle (CRB) Biocontrol	15
CSR-PA5 Guam Biodiversity Inventory	20
CSR-PA6 Cycad Aulacaspis Scale (CAS) Biocontrol	21
CSR-PA7 Eight Spot Butterfly (ESB) Conservation	22
Part II. University and Community Service (UCS) 15%	23
UCS-PA1 Undergraduate Instruction	23
UCS-PA2 Graduate Instruction	24
UCS-PA3 Faculty Committees	24
Grants which were active during the reporting period (n=8; \$742,812)	25
APHIS-CRB Biological Control of Coconut Rhinoceros Beetle Biotype-G \$200K .	27
OIA-CRB Biological Control of Coconut Rhinoceros Beetle Biotype-G in Microne-	
sia \$177K	28
BIODIVERSITY Guam Forest Biodiversity Inventory \$80K	29
8SPOT Eight Spot Butterfly Conservation \$20K	30
WPDN1 Western Plant Diagnostic Network 2016 \$63K	31
WPDN2 Western Plant Diagnostic Network FY2022 \$15K	32
FS-CRB-HR Harmonic Radar \$23K	33
FS-CRB CRB Biocontrol \$98K	34
Submitted Grant Proposals (n=1)	35
WPDN2 Western Plant Diagnostic Network FY2023-FY2026 \$60K	35
Part IV (Work Plan for 15JUN2021-14JUN2022): Extension and Community Activities (ECA) 51%	36
ECA-PA1 Insect Diagnostic Services	36
ECA-PA2 Detection and Documentation of Invasive Species	36
ECA-PA3 University of Guam Insect Collection	36
ECA-PA4 Mitigation of Damage to Guam's Ecosystems by Invasive Species	36
ECA-PA5 National Plant Diagnostic Network (NPDN)	36
ECA-PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Inva-	
sive Species Council (GISC)	36
ECA-PA7 Public Outreach: Internet	37
ECA-PA8 Public Outreach: Presentations	37
ECA-PA10 Public Outreach: Public GitHub Repositories	37
Part IV (Work Plan for 15JUN2021-14JUN2022): Creative/Scholarly Activities or Research (CSR) 34%	38
CSR-PA1 Peer Reviewed Publications	38
CSR-PA4 Coconut Rhinoceros Beetle (CRB) Biocontrol	38

CSR-PA5 Guam Biodiversity Inventory	38
CSR-PA6 Cycad Aulacaspis Scale (CAS) Biocontrol	38
CSR-PA7 Eight Spot Butterfly (ESB) Conservation	38
Part IV (Work Plan for 15JUN2021-14JUN2022): University and Community	
Service (UCS) 15%	39
UCS-PA1 Undergraduate Instruction	39
UCS-PA2 Graduate Instruction	39
UCS-PA3 Faculty Committees	39

Preface

I was hired by the University of Guam on October 1, 2003 under a limited-term, split appointment (50% extension and 50% research). On June 26, 2008, I started a tenure-track appointment as extension entomologist (100% extension) with the academic rank of assistant professor. At the end of the 2012 fall term I applied for tenure and promotion to associate professor and received both in 2013. At the end of 2018 fall term I applied for promotion to full professor and was promoted on July 11, 2019.

I work within the Agriculture and Natural Resources Unit of the University of Guam Cooperative Extension Service. I am a member of the Environmental Science Graduate Program Faculty and a member of the Western Pacific Tropical Research Center.

Note to Reader: If you are reading the PDF version of this report on a device connected to the internet, you will be able to follow hypertext links to documents I have referenced.

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Part I. Role Assignments

Time and Effort for Each Role

- 51% Extension and Community Activities (ECA)
- 34% Creative/Scholarly Activity or Research (CSR)
- 15% University and Community Service (UCS)

Part II. Extension and Community Activities (ECA) 51%

NIFA Classification

Critical Issues (CI)

- Sustained Agricultural Production Systems
- Plant Pest Efforts & Protect Resources of Guam

NIFA Science Emphasis Areas (SEA)

- **Sustainable Agricultural Production Systems** Addresses human interaction between science, technology, and agriculture. Integrates the biological, physical, and environmental and socioeconomic factors essential to successful production enterprises and viable rural communities.

NIFA Knowledge Areas (KA)

- KA 203 – Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- KA 211 – Insects, Mites and Other Anthropods Affecting Plants
- KA 215 – Biological Control of Pests Affecting Plants
- KA 216 – Integrated Pest Management Systems

Planned Activities (PA)

- PA1 Insect Diagnostic Services
- PA2 Detection and Documentation of Invasive Species
- PA3 University of Guam Insect Collection
- PA4 Mitigation of Damage to Guam's Ecosystems by Invasive Species

- PA5 National Plant Diagnostic Network (NPDN)
- PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Invasive Species Council (GISC)
- PA7 Public Outreach: Internet
- PA8 Public Outreach: Presentations
- PA9 Public Outreach: Miscellaneous
- PA10 Public Outreach: Public GitHub Repositories

ECA-PA1 Insect Diagnostic Services

Description As an extension entomologist, a major part of my job is providing insect identification and pest control recommendations to a diverse clientele including commercial growers, gardeners, householders, GovGuam agencies, federal agencies, and UOG colleagues. Most client contacts are initiated by a phone call or a visit by the client to the ANR office. In many cases identification and pest control recommendations require a site visit by me and/or extension associates to collect samples and define the problem.

Activities The number of extension calls requiring my assistance averaged approximately one per day during the reporting period. Many of these are documented as postings to iNaturalist [1].

- [1] Aubrey Moore. *Observations posted on iNaturalist by Aubrey Moore between June 15 2020 and June 15 2022*. 2022. URL: https://www.inaturalist.org/observations?d1=2020-06-15&place_id=any&user_id=aubreymoore&verifiable=any.

ECA-PA2 Detection and Documentation of Invasive Species

Description Invasive insects are arriving on Guam at a very high rate (estimates range as high as one new species per day). Very few of these are detected and even fewer are identified because Guam suffers from [the taxonomic impediment](#). Even when reliable species determinations are made, new island records are only rarely documented in the scientific press. Thus, impacts of invasive insects on Guam and elsewhere in Micronesia are grossly underestimated. One of my professional goals is to work towards solving this problem by increasing the detection rate, getting specimens identified by qualified taxonomists, and publishing new island records in the scientific literature.

Activities iNaturalist was used to document new records for insects detected in Guam and other Micronesian Islands [1]. Four new island records for insects in Micronesia were documented in iNaturalist posts during the reporting period [2, 3, 4, 5].

- [1] Aubrey Moore. *Search for new island records documented in iNaturalist since June 1, 2020 by Aubrey Moore*. 2022. URL: https://www.inaturalist.org/observations?created_d1=2020-06-01&place_id=any&q=new&user_id=aubreymoore&verifiable=any.
- [2] Aubrey Moore. *Suspected first island record for a whitefly infesting Euphorbia cyathophora on Guam*. Mar. 16, 2022. URL: <https://www.inaturalist.org/observations/108690775>.
- [3] Aubrey Moore. *First island record for a Icerya imperatae infesting napier grass on Guam*. Dec. 14, 2021. URL: <https://www.inaturalist.org/observations/103065598>.
- [4] Aubrey Moore. *First island record for Pericyma cruegeri attacking flame trees on Tinian*. Aug. 26, 2020. URL: <https://www.inaturalist.org/observations/57656025>.
- [5] Aubrey Moore. *First record for Xanthodes transversa attacking okra in Palau and Micronesia*. June 3, 2020. URL: <https://www.inaturalist.org/observations/48501627>.

ECA-PA3 University of Guam Insect Collection

Description The UOG insect collection is a valuable reference collection for extension entomology, teaching and research. I am a member of the board of directors for the collection and I work with Dr. Ross Miller to curate and catalog this collection.

In 2018 I ported the digital catalog for the UOG Insect Collection from a CSIRO BioLink database to a more modern web-based Symbiota database which is publicly available online [1]. I also established an internship to train entomology students how to curate an institutional insect collection and how to add specimen images to the digital catalog[2]. However, this work came to a halt because of space limitations.

Facilities provided for the UOG insect collection are very poor. It is literally *moth balled* in a small storage room which is too small for essential equipment such as microscopes and cameras. Curation and digitization necessitates removing specimens from the collection and transporting them outdoors to a lab where there is working space and equipment.

Activities In May 2022, I arranged for EPSCOR funding to have a door installed between the UOG insect collection and the adjacent ANR lab. Access to bench space in the lab will partially solve the space limitation problem described in the preceding section.

- [1] Aubrey Moore. *SCAN University of Guam Insect Collection Collection Profiles*. 2018.
URL: <http://scan-bugs.org/portal/collections/misc/collprofiles.php?collid=180> (visited on 08/23/2018).
- [2] Aubrey Moore. *Internship: University of Guam Insect Collection Technician*. 2018.
URL: <https://github.com/aubreymoore/Miscellaneous-Docs-for-CFES2018/raw/master/internship.pdf>.

ECA-PA4 Mitigation of Damage to Guam's Ecosystems by Invasive Species

Guam's ecosystems are rapidly being degraded by invasive species. These include:

- **Brown treesnake** which has extirpated Guam's forest birds, causing loss of ecosystem services they provided, such as seed dispersal, insect control and pollination.
- **Cycad aulacaspis scale insect**, ACS, which has killed more than 90% of Guam's endemic cycads, known locally as *fadang*. Fadang went from being the most abundant plant in Guam's forests in 2002 to being listed as an endangered species in 2015.
- **Coconut rhinoceros beetle**, CRB, which is killing coconut palms and palma brava throughout the island. These two palm species were the second and third most abundant trees in Guam's forest in 2002.

Clearly, an ecological disaster is happening on Guam, especially in forest ecosystems. As an extension entomologist, I am tasked with providing solutions to problems caused by insect pests. Unfortunately, there are no known methods for effectively controlling CAS and CRB on Guam. Therefore, I spend much of my time and effort performing applied research in an attempt to adequately control CAS and CRB so that restoration of Guam's forests can be attempted.

Activities Applied research is reported in the Creative/Research/Scholarly in a section for CRB and a section for CAS.

ECA-PA5 National Plant Diagnostic Network (NPDN)

Description I serve as the UOG Coordinator for the National Plant Diagnostic Network (NPDN). UOG receives about \$15K per year from NPDN as a subrecipient of the Western Plant Diagnostic Network administered by UC Davis. Grant details are in sections , and .

Activities

- Participated in monthly conference calls.
- Prepared and submitted annual reports.
- Prepared a [work plan and budget for FY2022](#).
- Prepared a [work plan and budget for FY2023-FY2026](#).
- Attended the WPDN Annual Meeting in April 2022 via Zoom and made a presentation entitled *The Invasive Species Problem on Guam* [1]

References

- [1] Aubrey Moore. “The Invasive Species Problem on Guam”. Western Plant Diagnostics Network Annual Meeting. Davis, California, Apr. 2022. URL: <https://aubreymoore.github.io/WPDN2022/>.

ECA-PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Invasive Species Council (GISC)

I am a founding member and regular participant in GISAC. President Underwood delegated me to represent UOG as a voting member of GISC and President Krise has reconfirmed my delegation.

Activities I participated in GISAC and GISC meetings.

On Wednesday, November 17, 2021, I participated in a Guam Legislature Public hearing concerning biosecurity issues. I provided both written and oral testimony.

ECA-PA7 Public Outreach: Internet

Since the 1990s, I have built and maintained web sites to facilitate sharing information about insects in Micronesia. I created a wiki site to serve as an index to web resources I have developed (Available at <https://guaminsects.net/aubwiki2020>). I will continue to use web sites to facilitate sharing information on Guam’s insects.

ECA-PA8 Public Outreach: Presentations

- [1] Aubrey Moore. “Biological Invasion of Guam’s Forests”. Guam Soil and Water Conservation Districts 2021 Educator’s Symposium: Healthy Forests, Healthy Communities. Guam, July 30, 2021. URL: <https://aubreymoore.github.io/albi345-slides/SWCD-2021-07-30/>.

- [2] Aubrey Moore. “How Bad is Guam’s Invasive Species Problem?: A Global Perspective”. Marianas Terrestrial Conservation Conference. Guam, 2021. URL: <https://aubreymoore.github.io/top-10-most-costly-ias-mtcc/>.
- [3] Aubrey Moore. “Presentation: Using harmonic radar to track the greater banded hornets to their nests so that they can be destroyed”. Guam Beekeepers Association Meeting. Jeff’s Pirates Cove, Ipan, Guam, Dec. 2021.
- [4] James J. Grasela and Aubrey Moore. “Preliminary efforts to establish a continuous coconut rhinoceros beetle (CRB) cell line (*Oryctes rhinoceros*) (Coleoptera: Scarabaeidae)”. 2022.
- [5] Aubrey Moore. “The Invasive Species Problem on Guam”. Western Plant Diagnostics Network Annual Meeting. Davis, California, Apr. 2022. URL: <https://aubreymoore.github.io/WPDN2022/>.

ECA-PA9 Public Outreach: Miscellaneous

References

- [1] Aubrey Moore. “What are the five worst invasive species on Guam that are likely to spread to other Micronesian islands? Submitted to the Micronesian Forester Newsletter.” Apr. 2, 2022. URL: <https://github.com/aubreymoore/guam-ias-bolo/raw/master/newsletter-submission.pdf>.

ECA-PA10 Public Outreach: Public GitHub Repositories

I attempt to provide access to as much of my work as possible using public GitHub repositories. GitHub is a free service for backing up and sharing documents on the web. Repositories which I have updated during the reporting period are listed in Table 1.

The document you are reading, all previous versions, and related data are stored in a public GitHub directory at <https://github.com/aubreymoore/CFES2020-22>. The document can be downloaded as a PDF from <https://aubreymoore.github.io/CFES2020-22/CFES2020-06-15to2021-06-14.pdf>.

I also use GitHub pages for serving static websites. A couple of good example sites are one which I created for my [ALBI345 General Entomology](#) course and one which is a [List of Insects and Mites Attacking Crops in Micronesia](#).

I will continue to create and maintain public GitHub repositories to provide access to my work as [open science](#).

Table 1: List of GitHub repositories created or pushed between 2020-06-15 and 2021-06-14. This list was generated by [code/repo-list-generator.ipynb](#).

n	repository
1	bts-mosquitoes
2	CRB-Action-Group-Webinar-2021-03-17
3	CRB-CNMI
4	CRB-Damage-Detection
5	CRB-Damage-Survey-Validation
6	CRB-PPA19-Report3
7	CRB-Project-Update-2021
8	crb-roadside-impact-report
9	crb-roadside-slides
10	CRB-trap-improvement
11	CRBG-action-group-webinar-20201209
12	GGI-Linux
13	GGI-odonata
14	Guam-Corona-Virus-Data
15	Guam-CRB-damage-map
16	Guam-CRB-damage-map-2020-10
17	Guam-CRB-damage-map-2020-12
18	Guam-CRB-Damage-Map-2021-03
19	Guam-CRB-Damage-Map-2021-05
20	Guam01
21	Leo-Palace-Traps
22	new-crb-damage-map
23	online-learning-course
24	PDF_to_Reveal
25	py4web-crb-app
26	qgiswebmap
27	roadside
28	roadside-article
29	roadside-spatialite
30	SUMMA21
31	temp
32	testhtml
33	top-10-most-costly-ias-mtcc
34	University-of-Guam-Insect-Collection
35	USAPI-Mosquito-ID
Continued on next page	

Table 1: List of GitHub repositories created or pushed between 2020-06-15 and 2021-06-14. This list was generated by [code/repo-list-generator.ipynb](#).

n	repository
36	worlds-most-costly-ias-on-guam
37	WPDN

Part II. Creative/Scholarly Activities or Research (CSR) 34%

NIFA Classification

Critical Issues (CI)

- Sustained Agricultural Production Systems
- Plant Pest Efforts & Protect Resources of Guam

NIFA Science Emphasis Areas (SEA)

- **Sustainable Agricultural Production Systems** Addresses human interaction between science, technology, and agriculture. Integrates the biological, physical, and environmental and socioeconomic factors essential to successful production enterprises and viable rural communities.

NIFA Knowledge Areas (KA)

- KA 203 – Plant Biological Efficiency and Abiotic Stresses Affecting
- KA 211 – Insects, Mites and Other Anthropods Affecting Plants
- KA 215 – Biological Control of Pests Affecting Plants
- KA 216 – Integrated Pest Management Systems
- KA 901 - Project, and Program Design, and Statistics
- KA 902 - Administration of Projects and Programs

Planned Activities (PA)

- PA1 Peer Reviewed Publications (N=4)
- PA2 Publications Submitted for Peer Review (N=1)
- PA3 Journal Articles in Preparation (N=4)
- PA4
- PA5 National Plant Diagnostic Network (NPDN)
- PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Invasive Species Council (GISC)
- PA7 Public Outreach: Internet

CSR-PA1 Peer Reviewed Publications (N=4)

- [1] Matthew S. Siderhurst, Aubrey Moore, Roland Quitugua, and Eric B. Chang. “Effects of Ultraviolet Light and Pheromone Release Rate in Trapping Coconut Rhinoceros Beetles, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae), on Guam”. In: (Dec. 31, 2021). Accepted: 2022-01-01T23:27:07Z Publisher: Hawaii Entomological Society. ISSN: 0073-134X. URL: <http://scholarspace.manoa.hawaii.edu/handle/10125/81413> (visited on 01/02/2022).
- [2] Gloria Barrera, Sean Marshall, Aubrey Moore, and Trevor Jackson. *Electron microscopy study confirms infection of coconut rhinoceros beetle (CRB-G) gut cells by OrNV - V23B. (Poster) Abstracts - 2021 International Congress on Invertebrate Pathology and Microbial Control & 53rd Annual Meeting of the Society for Invertebrate Pathology. Le Studium Conference (Virtual), Tours France. p 137.* July 21, 2021. URL: https://www.researchgate.net/publication/353356673_Electron_microscopy_study_confirms_infection_of_coconut_rhinoceros_beetle_CRB-G_gut_cells_by_OrNV-V23B_Poster_Abstracts_-_2021_International_Congress_on_Invertebrate_Pathology_and_Microbial_Control_5.
- [3] Sean D. G. Marshall, G. Barrera, Laura F. Villamizar, Gideon Suda, Aubrey Moore, James J. Grasela, P. D. Scotti, and Trevor A. Jackson. “Production of *Oryctes nudivirus* (OrNV) through the DSIR-Ha-1179 *Heteronychus arator* cell line. (Poster) Abstracts - 2021 International Congress on Invertebrate Pathology and Microbial Control & 53rd Annual Meeting of the Society for Invertebrate Pathology. Le Studium Conference (Virtual), Tours France.” In: (June 21, 2021). DOI: [10.13140/RG.2.2.30278.80963](https://doi.org/10.13140/RG.2.2.30278.80963).
- [4] Ronald D. Cave, Aubrey Moore, and Mark G. Wright. “Biological Control of the Cycad *Aulacaspis* Scale, *Aulacaspis yasumatsui*”. In: *Contributions of Classical Biological Control to U.S. Food Security, Forestry, and Biodiversity*. 2022. URL: https://github.com/aubreymoore/CAS/raw/main/CAS_Biocontrol.pdf.

Plans for 15JUN2021-14JUN2022 I plan to publish at least 1 peer reviewed publication as author or co-author.

Plans for 15JUN2022-14JUN2023 I plan to publish at least 1 peer reviewed publication as author or co-author.

CSR-PA2 Publication submitted for Peer Review (N=1)

- [1] Aubrey Moore and Matthew Siderhurst. “Detecting Coconut Rhinoceros Beetle Breeding Sites Using Harmonic Radar”. In: *ARPHA Preprints* 3 (2022), ARPHA Preprints. DOI: [10.3897/arphapreprints.e86423](https://doi.org/10.3897/arphapreprints.e86423). URL: <https://doi.org/10.3897/arphapreprints.e86423>.

Plans for 15JUN2021-14JUN2022 None.

Plans for 15JUN2022-14JUN2023 None.

CSR-PA3 Journal Articles in Preparation (n=5)

- [1] Aubrey Moore, N-Y Su, and Leonard Sigrah. "First Record of the Coconut Termite, *Neotermes Rainbowi* (Isoptera: Kalotermeae) from Micronesia". In: (In Preparation).
- [2] Aubrey Moore. *The Mariana Eight Spot Butterfly, Hypolimnas Octocula Marianensis*.
- [3] Aubrey Moore. "Three New Island Records for Bark Beetles (Curculionidae: Scolitinae) on Guam from a Single Coffee Berry Borer Trap". In: (In Preparation).
- [4] Aubrey Moore. *Change Analysis of Guam Forest Inventory Data*.
- [5] Aubrey Moore. *Coconut Rhinoceros Beetle Invasion History*. IN PREPARATION.

Plans for 15JUN2021-14JUN2022 None.

Plans for 15JUN2022-14JUN2023 None.

CSR-PA4 Coconut Rhinoceros Beetle (CRB) Biocontrol

Description A newly discovered biotype of coconut rhinoceros beetle (CRB-G) is rapidly killing coconuts and other palms on Guam and on other Pacific islands. Following a failed eradication attempt on Guam, CRB-G proved hard to control because it is resistant to *Oryctes rhinoceros* nudiviruses (OrNV), which was previously used as the preferred biological control agent for control of CRB outbreaks on Pacific Islands and elsewhere. Prior to the discovery of CRB-G, all OrNV releases on Pacific Islands resulted in immediate and sustained suppression of CRB damage to low levels and prevented tree mortality.

Guam is currently experiencing an uncontrolled and unmonitored island-wide CRB-G outbreak which was triggered by abundant CRB-G breeding sites in the form of dead and dying vegetation left in the wake of Typhoon Dolphin which occurred in May 2015. of a recent typhoon. Most of these breeding sites are inaccessible to sanitation efforts, being either in the jungle or on military land (which covers one third of Guam). A positive feedback cycle has begun whereby large numbers of adult beetles are killing large numbers of palms which become breeding sites which generate even higher numbers of adults. Severe damage to Guam's palms prompted the Governor of Guam to declare a state of emergency in July 2017.

The main objective of this project is to stop the uncontrolled outbreak on Guam. Entomologists working on the CRB-G problem on several Pacific islands agree that the most feasible tactic to halt tree mortality and suppress damage to tolerable levels is establishment

of biological control using an isolate of OrNV which is highly effective as a biological control agent for CRB-G. We are working with collaborators to identify populations of CRB-G throughout the Asia-Pacific region. We will sample these populations for biological control agent candidates which will be evaluated in laboratory bioassays performed at UOG. Promising candidates will be field released using autodissemination as per a USDA-APHIS import and release permit.

Concurrent with establishment of CRB-G biocontrol, success of the project will be monitored in a quarterly, island-wide tree health survey and incidence of OrNV infection will be monitored in a subsample of all field collected CRB-G.

If the Guam CRB-G infestation cannot be controlled, it is expected that most palms on the island will be killed and CRB-G will continue to spread to other islands and beyond. If CRB-G invades smaller islands and atolls where coconut is the tree of life, a human tragedy will ensue. On larger islands, coconut and oil palm industries will be severely impacted. Attempts to organize a well-funded, coordinated regional project in response to CRB-G have failed underway. However, UOG plays a major role in the *ad hoc* CRB-G Action Group which was established to facilitate sharing scientific/technical information among people working on the CRB-G problem.

Activities

Funding and Project Management This is my largest and most important project, requiring a lot of time and effort for project management including preparation of grant proposals and reports. During the reporting period, funding was provided by 4 grants totaling \$561,234: OIA-CRB [], APHIS-CRB [], FS-CRB [], and FS-CRB-HR []. Details, including links to project proposals, work plans and progress reports are available in the grants section of this report.

Staffing Department of the Interior Office of Insular Affairs grant (OIA-CRB) supports Dr. James Grasela, an insect pathologist, and Christian Cayanan, a technician.

Establishment of a CRB Rearing Facility and Rearing Protocol Development of biocontrol for CRB-G will require laboratory bioassays using standardized, healthy lab-reared beetles of equivalent age. Previously, we used beetles collected from pheromone traps for this purpose. However, mortality in experimental control groups was highly variable, yielding irreproducible results.

During the reporting period:

- We built and equipped a CRB rearing facility in a 40 foot shipping container.
- We developed and tested a natural larval diet by grinding dead standing coconut stems containing CRB breeding sites.

Establishment of an Island-wide CRB Damage Monitoring System We developed an island-wide roadside monitoring system to track spatial and temporal changes in CRB damage levels. Data are collected using a smart phone attached to a project vehicle. The phone continually records georeferenced roadside images as the vehicle is driven along all major results in both directions. Data are automatically analysed by an image analysis system which detects coconut palms in the images, calculates a damage index for each palm, and outputs results on a map of Guam. A nontechnical overview of this system was published in the 2020 WPTRC Impact Report [1].

To date, we have completed five surveys and data for a sixth have been recorded. Interactive damage maps are available on the web:

- October 2020 [2]
- December 2020 [3]
- March 2021 [4]
- May 2021 [5]
- August 2021 [6]

International collaboration will be essential for finding a way to halt massive ecological and economic damage to Pacific islands invaded by CRB-G. A CRB-G Action Group was formed to facilitate collaboration and cooperation. prior to COVID, this group met annually at international scientific meetings. During COVID, I helped to keep the group together by hosting Zoom webinars with assistance from the UOG Office of Information Technology. I created web pages to facilitate access recordings of these webinars:

- March 17, 2021 [7]
- December 9, 2020 [8]
- November 23, 2021 [9]

Outreach In an effort to facilitate technical and scientific information among people working on CRB, we have developed and maintain several online resources including a wiki [10], a Facebook site [11], an online interactive map of CRB invasion history [12] and a CRB reference library [13], and an online email discussion site [14].

Harmonic radar I am investigating the feasibility of using harmonic radar using funding from a US Forest Service grant []. Details of this applied research are available as a preprint journal article [15]. This work is being done in collaboration with Dr. Matt Siderhurst, a chemical ecologist at Eastern Mennonite University, Virginia. I am also collaborating with Dr. Glenn Dulla, Guam Department of Agriculture on the feasibility of using a harmonic radar unit attached to a drone.

CRB-G tissue culture The project’s insect pathologist has established a tissue culture of CRB-G cells [16]. This cell line may be useful for in vitro production of *Oryctes rhinoceros* nudivirus which is currently propagated in a cell line from a different scarab beetle.

Funding Three of the four grants supporting this project, terminate within calendar year 2022. The remaining grant, DOI-OIA [], terminates on September 30, 2023. I do not have plans to apply for additional grant funding for this project.

Staffing The project’s insect pathologist, Dr. Jim Grasela, is resigning on June 24, 2022. Recruitment of additional scientific/technical help will be required.

CRB-G biocontrol We will continue performing bioassays until a potential OrNV bio-control candidate is found. Once we have one, we will begin propagation *in vivo* and field releases via autodissemination. I already have a USDA-APHIS permit for field release of OrNV.

The current priority is to perform a critical laboratory bioassay to test for significant reduction in fecundity (egg laying) caused by OrNV isolate V23B. This isolate caused significant mortality in bioassays performed in our lab and also in the Solomon Islands. However, according to some of the literature, the main mode of action causing population reduction by OrNV is not mortality but reduction in fecundity. Given the long lifespan of CRB, this experiment will require at least a year (includes lab rearing of test insects).

Island-wide CRB Damage Surveys We will continue island-wide CRB damage surveys.

Harmonic radar The field trial detailed in the work plan for my grant [] will be done during the first two weeks of July 2022.

CRB-G tissue culture We will attempt to have another lab adopt the CRB-G cell line culture prior to Dr. Grasela’s departure from UOG.

Plans for 15JUN2021-14JUN2022

Plans for 15JUN2022-14JUN2023

References

- [1] Aubrey Moore. *Using a cell phone and artificial intelligence to map coconut rhinoceros beetle damage*. Mangilao, Guam: Western Pacific Tropical Research Center, College of Natural and Applied Sciences, University of Guam, 2020, pp. 7–10. URL: https://www.uog.edu/_resources/files/wptrc/2020WPTRCFinal.pdf (visited on 05/14/2022).

- [2] Aubrey Moore. *CRB damage webmap 2020-10*. Oct. 2020. URL: <https://aubreymoore.github.io/new-crb-damage-map/#11/13.4437/144.7861>.
- [3] Aubrey Moore. *CRB Damage Webmap 2020-12*. Dec. 2020. URL: <https://aubreymoore.github.io/Guam-CRB-damage-map-2020-12/webmap/v1/#11/13.4437/144.7861>.
- [4] Aubrey Moore. *CRB Damage Webmap 2021-03*. Mar. 2021. URL: <https://aubreymoore.github.io/Guam-CRB-Damage-Map-2021-03/#11/13.4437/144.7861>.
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- [7] Aubrey Moore. *Video recording of the CRBG Action Group Meeting: March 17, 2021 [conducted via Zoom]*. Mar. 17, 2021. URL: <https://aubreymoore.github.io/CRB-Action-Group-Webinar-2021-03-17/>.
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- [9] Aubrey Moore. *Video recording of the CRBG Action Group Meeting Webinar 3*. Nov. 23, 2021. URL: <https://aubreymoore.github.io/CRB-Action-Group-Webinar-2021-11-23/>.
- [10] Aubrey Moore. *CRB-G Wiki*. Oct. 13, 2019. URL: http://guaminsects.net/CRBG/index.php?title=CRB-G_Wiki.
- [11] Aubrey Moore and Ian R. Iriarte. *FaceBook Site: CRB-G*. Oct. 13, 2019. URL: <https://www.facebook.com/groups/crbg07/>.
- [12] Aubrey Moore. *Online interactive map of coconut rhinoceros beetle invasion history*. 2019. URL: <http://aubreymoore.github.io/crbdist/mymap.html> (visited on 05/28/2019).
- [13] Aubrey Moore and James J. Grasela. *An Online Reference Library for the CRB Action Group*. 2021. URL: <https://aubreymoore.pythonanywhere.com/crbllib>.
- [14] Aubrey Moore. *An Online Email Discussion Site (LISTSERV) for the Coconut Rhinoceros Beetle Action Group*. 2021. URL: <http://crbg.guaminsects.net/listinfo.cgi/crbg-guaminsects.net>.
- [15] Aubrey Moore and Matthew Siderhurst. "Detecting Coconut Rhinoceros Beetle Breeding Sites Using Harmonic Radar". In: *ARPHA Preprints* 3 (2022), ARPHA Preprints. DOI: 10.3897/arphapreprints.e86423. URL: <https://doi.org/10.3897/arphapreprints.e86423>.

- [16] James J. Grasela and Aubrey Moore. “Preliminary efforts to establish a continuous coconut rhinoceros beetle (CRB) cell line (*Oryctes rhinoceros*) (Coleoptera: Scarabaeidae)”. 2022.

CSR-PA5 Guam Biodiversity Inventory

Description I consider this to be my second most important project.

A biodiversity inventory is essentially a database containing a comprehensive check list of all taxa known occur within a defined area.

A terrestrial biodiversity inventory for Guam is needed to document rapid changes to Guam’s ecosystems, to provide free and open access to information on Guam’s flora and fauna, and to share Guam biodiversity information with the global scientific community, policy makers and the public.

The Guam Biodiversity Inventory will facilitate automatic generation and updates to lists such as: a list of all invasive species on Guam with year first recorded, a list of new species described from specimens collected on Guam, a list of observations for Guam’s endangered species, a list of Guam’s native plants with associated herbivores and pathogens, and a list of crops grown on Guam and pests and pathogens which attack them.

Activities

Funding This project is supported by my McIntire-Stennis grant which terminates on 2022-09-30.

Staffing I offered an internship to work on this project to Annette Kang, a graduate student from Guam currently working on a PhD in Entomology at Cornell University. Progress on this project was impeded because of a nine month delay in processing my interns stipend payment.

Data mining During the reporting period, the focus within this project was to extract data from legacy entomological literature for Guam, namely *Insects of Guam* I and II. This work was facilitated using a sophisticated workflow developed by [Plazi](#), a Swiss-based international non-profit association supporting and promoting the development of persistent and openly accessible digital biodiversity information. The Plazi office in Brazil kindly supported this project by provided online training sessions for myself and Annette. Data extracted from the literature are automatically published on the Global Biodiversity Information Facility as datasets and occurrence records. I wrote an [online dashboard to track our data-mining progress](#). More details are available in my 2021 annual report for this project [1]

References

- [1] Aubrey Moore. *Guam Forest Biodiversity Inventory: McIntire Stennis Annual Report for Period Ending 2021-09-30*. University of Guam, College of Agriculture and Life Sciences, Dec. 18, 2021. URL: https://github.com/aubreymoore/McIntire-Stennis/raw/master/2021%20Annual%20Report/submitted_for_review.pdf.

CSR-PA6 Cycad Aulacaspis Scale (CAS) Biocontrol

Description A US Forest Service survey published in 2002 reported that the most abundant tree in Guam’s forests (DBH > 5 inches) was Guam’s endemic cycad, *Cycas micronesica*. In 2003, an invasive scale insect, *Aulacaspis yasumatsui*, was detected on ornamental cycads but it soon infested wild cycads and started killing them. Within a decade, 90% of Guam’s endemic cycads have been killed by the scale and other invasive species. *Cycas micronesica* was placed on the US National Endangered Species List in 2015.

Mature plants are protected by a lady beetle I introduced, but no natural reproduction of the cycads is occurring because seeds and seedlings are still being killed by the scale insect. A likely solution to this problem is establishment of a small biocontrol agent, such as a miniature parasitic wasp, which will control scale insects infesting seeds and seedlings.

Activities I collaborated with Dr. Jim McConnell on insect pests impacting cycads on Tinian and Guam. I set up a pest monitoring of cycads in conservation plots on Tinian using leaf samples [1] and yellow sticky traps [2].

In March 2022, I hosted a visit from Dr. Ron Cave from the University of Florida. Ron is an expert on CAS biocontrol and I have been trying to get him out here on a consulting trip for several years. Some discussions with USFWS earlier this year led to them funding the trip.

During his trip, Ron and I hosted a Zoom seminar on CAS biocontrol. I put recordings of the presentations and discussion online [3]. After the trip, Dr. Cave provided [comprehensive consulting report complete with recommendations](#).

In addition, I coauthored a book chapter on CAS biocontrol with Ron Cave and Mark Wright, University of Hawaii.

Note that my work on CAS biocontrol is currently unfunded. [4].

References

- [1] Aubrey Moore and Jason Andrew. *Monitoring Aulacaspis yasumatsui on Cycas micronesica in the Tinian Conservation Plots using Leaf Samples*. 2022. URL: https://github.com/aubreymoore/Tinian-CAS/raw/main/reports/%20leaf_samples.pdf.

- [2] Aubrey Moore and Jason Andrew. *Monitoring Cycad Aulacaspis Scale (CAS), Aulacaspis yasumatsui, Infesting Cycas micronesica in the Tinian Conservation Plots using Sticky Traps*. 2022. URL: https://github.com/aubreymoore/Tinian-CAS/raw/main/reports/%20sticky_traps.pdf.
- [3] Ronald D. Cave and Aubrey Moore. “Biological control of cycad aulacaspis scale (webinar)”. University of Guam, Mangilao, Guam, Mar. 8, 2022. URL: <https://aubreymoore.github.io/CAS-biocontrol-seminar/>.
- [4] Ronald D. Cave, Aubrey Moore, and Mark G. Wright. “Biological Control of the Cycad Aulacaspis Scale, *Aulacaspis yasumatsui*”. In: *Contributions of Classical Biological Control to U.S. Food Security, Forestry, and Biodiversity*. 2022. URL: https://github.com/aubreymoore/CAS/raw/main/CAS_Biocontrol.pdf.

CSR-PA7 Eight Spot Butterfly (ESB) Conservation

Description The Guam Department of Agriculture Division of Aquatic and Wildlife Resources (GDOA-DAWR) requested assistance with conservation of the rare Mariana eight-spot butterfly, *Hypolimnas octocula marianensis*. I prepared a grant proposal and a permit application to do this work under a cooperative agreement with the GDOA-DAWR.

The objective of this project is to investigate the feasibility of captive rearing.

Activities I have partnered with Dr. Curt (George) Fiedler, Biology Department, and the Center for Island Sustainability to collaborate on this project.

A large field cage (20x20X10 feet) has been built in the UOG Center for Island Sustainability compound in Dean’s Circle and a shade house has been stocked with host plants.

On 2020-05-25, I organized a Zoom conference call with the US Fish and Wildlife Service to discuss conditions of a new permit which will allow UOG and the Guam Department of Agriculture - Division of Aquatic and Wildlife Resources to work on captive breeding of the Mariana eight-spot butterfly.

Part II. University and Community Service (UCS) 15%

UCS-PA1 Undergraduate Instruction

Description In addition to fulfilling my primary role as an extension entomologist, I am required to teach undergraduate courses.

Activities

AL/BI 345 General Entomology During Fall term 2021, I taught the lecture and laboratory sections of AL/BI 345 General Entomology.

I prepared a syllabus for this course [1]. I also built and maintained a web site [2] and populated this with lecture notes and other resources. My scores in the student evaluations for all 4 course sections were consistently higher than both university and college averages [3].

Special Project for Laura Caser, Biology I am currently supervising biology student Laura Caser on a special project. She is recording and analyzing coconut rhinoceros beetle feeding sounds using a new bioacoustics sensor called TreeVibes.

Summer Workshop on Mathematical Modelling During June and July 2021, I assisted in teaching undergraduates and high school students in a summer workshop on mathematical modeling of ecological systems. The program was coordinated by Dr. Hyunju Oh, UOG Mathematics, and funded by three of her grants: GECCO Summer Math Research Experience (SMRE), National Research Experience for Undergraduates Program (NREUP), and Young Scholars Research Experience in Mathematics (YSREM). I provided lectures and assistance to teams of students modelling *Invasion of the Coconut Rhinoceros Beetle (CRB) on Guam*.

My lectures and resource materials were made available in GitHub web page at <https://aubreymoore.github.io/SUMMA21/>.

References

- [1] Aubrey Moore. *Syllabus for ALBI 345, General Entomology, Fall 2021*. 2021. URL: <https://aubreymoore.github.io/ALBI-345/syllabus/ALBI345F21-syllabus.pdf>.
- [2] Aubrey Moore. *Web site for ALBI 345, General Entomology, Fall 2021*. 2021. URL: <https://aubreymoore.github.io/ALBI-345/>.
- [3] Aubrey Moore. *Instructor evaluation report for ALBI 345, General Entomology, Fall 2021*. 2021. URL: https://github.com/aubreymoore/CFES2020-22/raw/main/additional-docs/instructor_eval_fall21.pdf.

UCS-PA2 Graduate Instruction

I am a member of the Graduate Faculty of the Environmental Sciences Program. During the reporting period, I frequently presented guest lectures for EV courses. I also served as a member of Chris Rosario's masters committee and I have agreed to serve on the committee of a new masters student, Caylin McCormick.

I serve on the masters committee of Matt Putnam, a biology student working on captive breeding of the Marianas eight-spot butterfly.

UCS-PA3 Faculty Committees

Faculty Building Facilities Committee for the ALS This committee was formed by the Agriculture and Life Sciences Division to consult with the Dean on facilities problems within the Agriculture and Life Sciences Building. I was re-elected as chair of this committee, joined by Dr. Jim McConnell.

Activity

The committee's biggest accomplishment during the reporting period was installation of Prometheus smart screens in ALS 124 and ALS 127.

Search Committee: Restoration Ecologist I currently serve on a search committee for the new Restoration Ecologist position in the Biology department with Dr. Dan Lidstrom (Chair) and Dr. Frank Camacho.

Search Committee: Research Associates for RCUOG Brown Treesnake Grants I was a member of several search committees for BTS technicians. I was joined by Dr. Shane Siers (PI and Chair) and Dr. Dan Lindstrom.

- Feb 2021: Research Associate I
- Jun 2021: 2x Research Assistant I
- Jul 2021: Research Associate I
- Mar 2022: 2x Research Associate I

Grants which were active during the reporting period (n=8; \$742,812)

Note: Five grants terminate before the end of 2022.

Table 2: List of grants active during the reporting period (2020-06-15 through 2022-06-15).

code	title	funding
OIA-CRB ()	Establishment of Self-sustaining Biological Control of Coconut Rhinoceros Beetle Bio-type G in Micronesia	\$239,994
APHIS-CRB()	Biological Control of Coconut Rhinoceros Beetle Biotype G on Guam	\$200,000
FS-CRB ()	Establishment of Self-sustaining Biological Control of Coconut Rhinoceros Beetle Bio-type G in Micronesia	\$98,240
BIODIVERSITY ()	Guam Forest Biodiversity Inventory	\$80,000
WPDN1 ()	Western Plant Diagnostic Network	\$63,366
8SPOT ()	Captive Breeding of Eight-spot Butterfly	\$23,212
FS-CRB-HR ()	Improving Coconut Rhinoceros Beetle Breeding Site Detection Using Harmonic Radar	\$23,000
WPDN2 ()	Western Plant Diagnostic Network FY2022	\$15,000

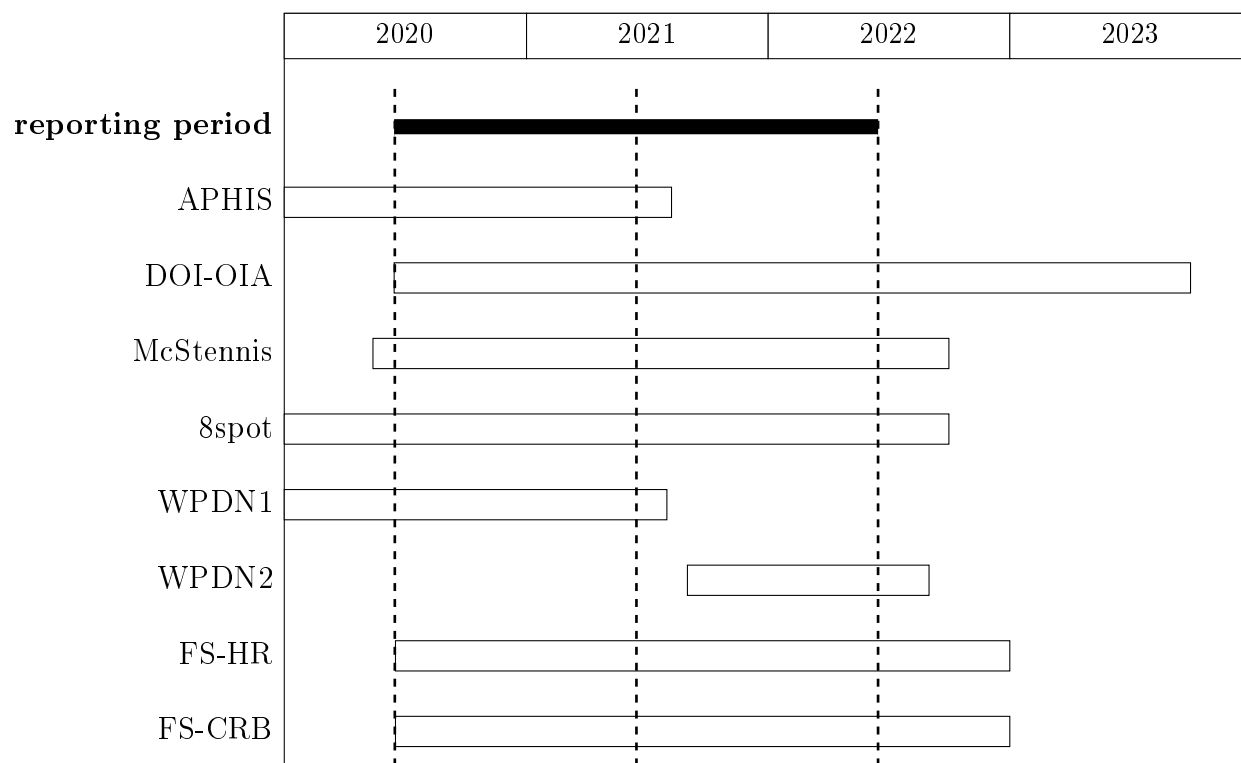


Figure 1: Performance periods for grants which were active during the reporting period (2020-06-15 through 2022-06-15).

APHIS-CRB Biological Control of Coconut Rhinoceros Beetle Biotype-G \$200K

Key data

- **Code:** APHIS-CRB
- **Long title:** Biological Control of Coconut Rhinoceros Beetle Biotype G on Guam
- **Start date:** 2019-08-08
- **End date:** 2021-08-07
- **Total budget:** \$200,000
- **Federal ID:** AP19PPQS&T00C168
- **UOG ID:** USDA Biocontrol 2019
- **UOG Account:** 30-2F-311117
- [GitHub repository](#)

Documents

- [Proposal](#)
- [Award letter](#)
- [Ammended work plan](#)
- [Report 1](#)
- [Report 2](#)
- [Report 3](#)
- [Final Report](#)

OIA-CRB Biological Control of Coconut Rhinoceros Beetle Biotype-G in Micronesia \$177K

Key data

- **Code:** OIA-CRB
- **Title:** Establishment of Self-sustaining Biological Control of Coconut Rhinoceros Beetle Biotype G in Micronesia
- **Start date:** 2020-05-14
- **End date:** 2023-09-30
- **Total budget:** \$239,994
- **Federal ID:** D20AP00060
- **UOG ID:** DOI Biocontrol CRB
- **UOG Account:** 30-2F-311150
- [GitHub repository](#)

Documents

- [Proposal](#)
- [Award letter](#)
- [Reporting requirements](#)
- [Report 1](#)

BIODIVERSITY Guam Forest Biodiversity Inventory \$80K

Key data

- **Code:** BIODIVERSITY
- **Title:** Guam Forest Biodiversity Inventory
- **Funding source:** McIntire-Stennis (administered by CNAS)
- **Reporting system:** [REReport](#)
- **Start date:** 2018-10-15
- **End date:** 2022-09-30
- **Total budget:** \$16,000 per year for each of 4 years
- **Federal ID:** GUA0930
- **UOG ID:**
- **UOG Account:**
- [GitHub repository](#)

Documents

- [2018-06-21 Proposal](#)
- [2018-10-08 Project initiation](#)
- [2020-01-02 2019 Annual report](#)
- [2020-12-28 2020 Annual report](#)
- [2021-12-18 2021 Annual report](#)
- Final report due 2022-12-31.

8SPOT Eight Spot Butterfly Conservation \$20K

Key data

- **Code:** 8SPOT
- **Title:** Captive Breeding of Eight-spot Butterfly
- **Start date:** 2013-10-01
- **End date:** 2022-09-30
- **Total budget:** \$23,212
- **Funding Agency:** DOI-FWS (via GDOA-DAWR)
- **Federal ID (FAIN):** F13AF01300
- **UOG ID:**
- **UOG Account:** 30-1F-315058-R
- [GitHub repository](#)

Documents

- [Award letter \(includes scope of work and budget\)](#)
- [Updated Award Letter](#)

WPDN1 Western Plant Diagnostic Network 2016 \$63K

Key data

- **Code:** WPDN1
- **Long title:** Western Plant Diagnostic Network
- **Start date:** 2016-09-01
- **End date:** 2021-07-31
- **Total budget:** \$63,366
- **Federal ID(FAIN):** 20163762025851
- **UOG ID:**
- **UOG Account:** 2F-243432R5
- [GitHub repository](#)

Documents

- [Proposal and Award Letter](#)

WPDN2 Western Plant Diagnostic Network FY2022 \$15K

Key data

- **Code:** WPDN2
- **Title:** Western Plant Diagnostic Network FY2022
- **Start date:** 2021-09-01
- **End date:** 2022-08-31
- **Total budget:** \$15,000
- **UOG ID:** WPTRC-UCDAVIS/USDA WPLANTDI
- **UOG Account:** 61-1F-243432
- [GitHub repository](#)

Documents

- [Work plan and budget](#)
- [Award letter](#)
- [UOG account setup](#)

FS-CRB-HR Harmonic Radar \$23K

Key data

- **Code:** FS-CRB-HR
- **Long title:** Improving Coconut Rhinoceros Beetle Breeding Site Detection Using Harmonic Radar
- **Start date:** 2020-06-17
- **End date:** 2022-12-31
- **Total budget:** \$23,000
- **Federal ID:** 20-DG-11052021-227
- **UOG ID:** CNAS-USDA-CRB Harmonic Radar
- **UG Account:** 30-2F-311144-R
- [GitHub repository](#)

Documents

- [Proposal](#)
- [Award letter](#)
- [Extension until 2022-12-31](#)
- [Report 1 \(2021-01-31\)](#)
- [Report 2 \(2021-07-31\)](#)
- [Final report \(90 days after expiration date\)](#)

FS-CRB CRB Biocontrol \$98K

Key data

- **Code:** FS-CRB
- **Long title:** Establishment of Self-sustaining Biological Control of Coconut Rhinoceros Beetle Biotype G in Micronesia
- **Start date:** 2020-06-17
- **End date:** 2022-12-31
- **Total budget:** \$98,240
- **Federal ID:** 20-DG-11052021-229
- **UOG ID:** CNAS-USDA Control of CRB
- **UG Account:** 30-2F-311143-R
- [GitHub repository](#)

Documents

- [Proposal](#)
- [Award letter](#)
- [Extension until 2022-12-31](#)
- [Report 1 \(2021-01-31\)](#)
- [Report 2 \(2021-07-31\)](#)
- [Final report](#)
- [2021-06-15 Amended agreement](#)

Submitted Grant Proposals (n=1)

WPDN2 Western Plant Diagnostic Network FY2023-FY2026 \$60K

Key data

- **Code:** WPDN-4YR
- **Title:** Western Plant Diagnostic Network FY2022-FY2026
- **Start date:**
- **End date:**
- **Total budget:** \$60,000
- **UOG ID:**
- **UOG Account:**
- [GitHub repository](#)

Documents

- [Work plan and budget](#)

Part IV (Work Plan for 15JUN2021-14JUN2022): Extension and Community Activities (ECA) 51%

ECA-PA1 Insect Diagnostic Services

I plan to continue providing insect diagnostic services.

ECA-PA2 Detection and Documentation of Invasive Species

I will continue to document new island records of insects detected in Micronesia. The International Union for Conservation of Nature (IUCN-ISSG) is building a Global Register of Introduced and Invasive Species. I have volunteered to coordinate building a check list for species on Guam.

The Guam Invasive Species Council is required to maintain a list on invasive species on Guam. I have volunteered to be “registrar” for this list.

ECA-PA3 University of Guam Insect Collection

I plan to request installation of a door between the UOG insect collection room and the adjacent ANR lab so that lab space, microscopes and cameras are available for working with specimens

ECA-PA4 Mitigation of Damage to Guam’s Ecosystems by Invasive Species

I plan to continue providing control recommendations for invasive insect species when control methods are available.

I will continue with applied research on CAS and CRB in an effort to mitigate the major damage being done by these pests.

ECA-PA5 National Plant Diagnostic Network (NPDN)

I will continue to act as UOG coordinator for NPDN.

ECA-PA6 Guam Invasive Species Advisory Committee (GISAC) and Guam Invasive Species Council (GISC)

I plan to continue as an active member of GISAC and GISC.

I plan to participate in a review of the Guam Invasive Species Management Plan.

ECA-PA7 Public Outreach: Internet

I will continue to create and maintain websites about insects in Micronesia.

ECA-PA8 Public Outreach: Presentations

I will continue to create and make presentations.

ECA-PA10 Public Outreach: Public GitHub Repositories

I will continue to create and maintain GitHub repositories to share my work.

Part IV (Work Plan for 15JUN2021-14JUN2022): Creative/Scholarly Activities or Research (CSR) 34%

CSR-PA1 Peer Reviewed Publications

I plan to publish at least 1 peer reviewed journal article as author or co-author.

CSR-PA4 Coconut Rhinoceros Beetle (CRB) Biocontrol

I will continue applied research with the goal of finding a solution to the CRB problem on Guam and elsewhere in Microneasia.

CSR-PA5 Guam Biodiversity Inventory

I am working to complete this project before the grant expires on 2022-09-30 and to complete a final report due 2022-12-31.

CSR-PA6 Cycad Aulacaspis Scale (CAS) Biocontrol

I am collaborating with the US Fish and Wildlife Service on prospects for CAS biocontrol. On my suggestion USFWS is considering funding a consulting trip to Guam by Dr. Ron Cave, a CAS biocontrol expert from the University of Florida.

CSR-PA7 Eight Spot Butterfly (ESB) Conservation

I will assist in requesting a new permit from USFWS to work with the eight-spot butterfly. Experimental facilities will be constructed at the Center for Island Sustainability compound on the UOG campus.

Part IV (Work Plan for 15JUN2021-14JUN2022): University and Community Service (UCS) 15%

UCS-PA1 Undergraduate Instruction

I will teach AL/BI 345, General Entomology, lecture and laboratory sections, during Fall Term 2021.

UCS-PA2 Graduate Instruction

As member of the Environmental Science graduate faculty, I will continue to serve on graduate committees and present guest lectures.

UCS-PA3 Faculty Committees

I will continue to serve on faculty committees.