UNIVERSITY OF GUAM
UNIBETSEDÅT GUÅHAN

COLLEGE OF NATURAL & APPLIED SCIENCES

WESTERN PACIFIC TROPICAL RESEARCH CENTER
2023 IMPACT REPORT

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Cover photo: *Hibiscus sabdariffa*
Photo by Mia Alvarez

UNIVERSITY OF GUAM
WESTERN PACIFIC TROPICAL RESEARCH CENTER

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Samoana fragilis, an endemic and endangered tree snail in Guam of the Partulidae family. *Photo by Curt Fiedler*

Buenas yan Håfa Adai!

I am honored and excited to have taken the helm late last year of the UOG College of Natural & Applied Sciences. With this role comes overseeing the important mission of Guam's Land Grant through both our Western Pacific Tropical Research Center and our Cooperative Extension programs.

WPTRC is one of 10 great research institutions at the University of Guam – all with the aim of improving life in our region. Funded primarily through the U.S. Department of Agriculture, WPTRC's research focuses specifically on improving agriculture, natural resources, and human health.

Our research faculty specialize in subject areas that are germane to this region, and we're pleased to have recently expanded our research portfolio with the addition of two new faculty members who specialize in ecosystem restoration and plant diseases. Last year, we added researchers who specialize in natural product chemistry/environmental technology and geospatial data and technology.

It's empowering to know that, here at WPTRC – with Guam's tropical climate and geographic isolation – we are able to produce unique research that not many other U.S. institutions can. And as several pieces in this report show, our findings can be of use to communities elsewhere in the world facing our same challenges – including the impact of tropical storms on the environment and overcoming a reliance on imported foods.

We believe in the Land Grant mission and are pleased to share this portfolio of work with you. Please reach out to our researchers at the emails provided if you're interested in knowing more.

Si Yu'os Ma'åse',

Rachael T. Leon Guerrero, Ph.D.
Dean, College of Natural & Applied Sciences
Director, Western Pacific Tropical Research Center
Director, Cooperative Extension & Outreach
University of Guam

Håfa Adai!

The year 2023 will be remembered for the occurrence of a major natural event, the Category 4 Typhoon Mawar that hit Guam in May. Two WPTRC units suffered the greatest harm of all College of Natural & Applied Sciences facilities. The Triton Farm experienced substantial damage to crops, buildings, and the hen flock. Physical damage on the Guam Aquaculture Development & Training Center was relatively minor, but mortality in the shrimp and seafood stocks was exceptionally large and amounted to hefty financial losses. Again, WPTRC personnel had to multiply efforts to dig out from a difficult scenario and the frustration of seeing multi-year efforts vanished.

It had been 21 years since a major typhoon landed in Guam. This timespan is similar to the period in which Dr. Lee Yudin served as Dean of CNAS before retiring in 2023. It is hard for me to find the words to properly express my gratitude to Dr. Yudin for his support to WPTRC and me. His greatest legacy was perhaps to create excellent STEM programs that diversify and invigorate the college under a scenario of declined enrollment and support for agriculture and related fields in Guam and elsewhere. From a WPTRC perspective, Dr. Yudin fully contributed to the developments at WPTRC that brought talented faculty on board, upgraded laboratories, created a private-public partnership, and improved other areas. On a personal note, I should say that he was one of the few people at UOG who laughed at my bad jokes.

Consistent with its recent progress, WPTRC welcomed Dr. Glenn Dulla, who is committed to creating a high-quality program in plant pathology and related topics. His transition was smooth as he was already teaching at CNAS and running projects at the Research Corporation of the University of Guam. Also on board is Dr. Rachel Jolley, who will work on restoration ecology, a topic of uttermost importance for Guam. The academic and personal profiles of these two highly qualified scientists are on page 7 of this report.

As always, on behalf of WPTRC, I would like to express deepest appreciation to a wide array of collaborators and the U.S. Department of Agriculture and other donors for their generous support.

Adrian Ares, Ph.D.
Interim Associate Director
Western Pacific Tropical Research Center
University of Guam

The Western Pacific Tropical Research Center is a Land Grant scientific research center. WPTRC is affiliated with agInnovation – the national parent organization for Agricultural Experiment Stations, which were established at Land Grant universities in every state by the Hatch Act of 1887.

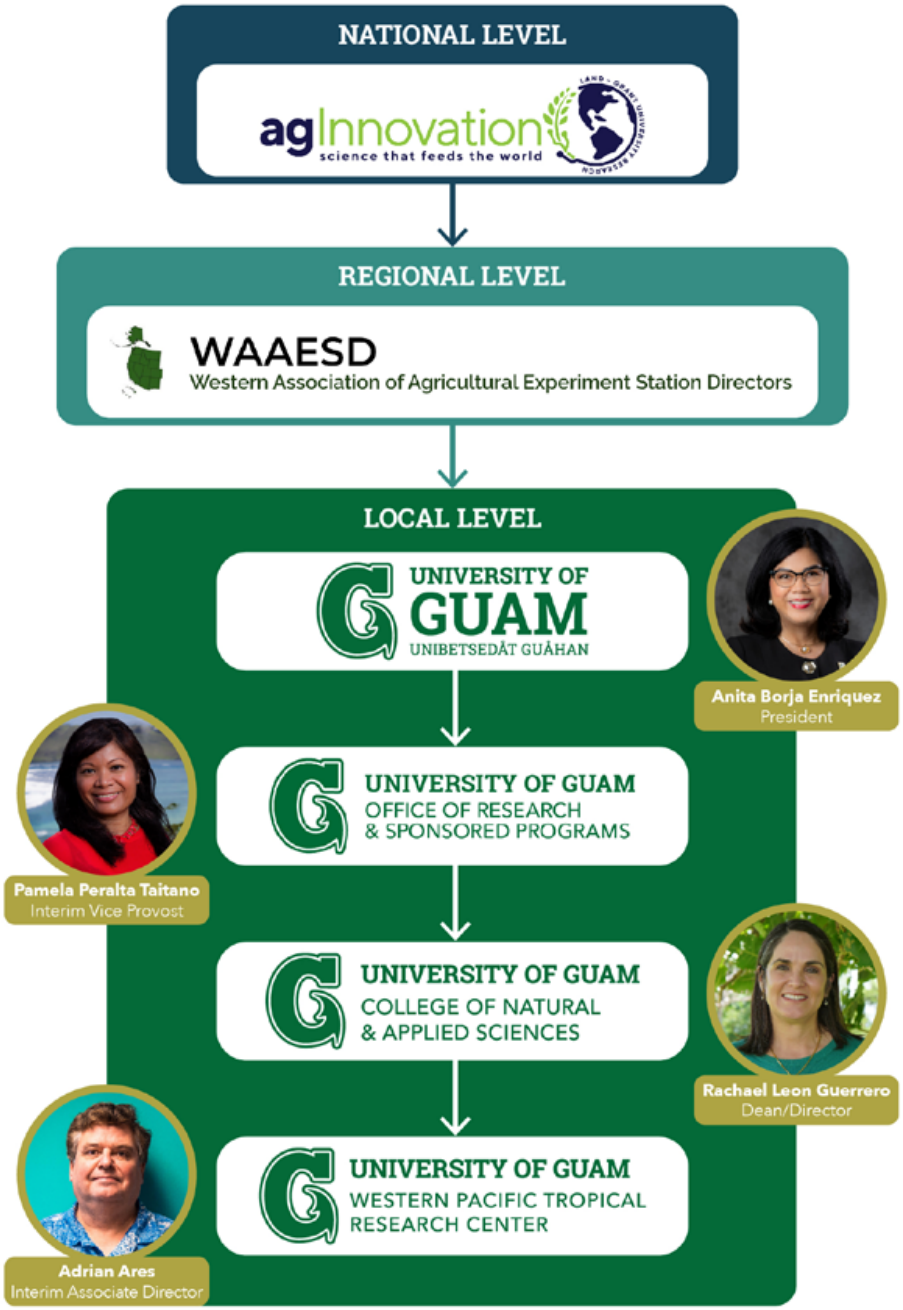
These stations are federally funded to investigate potential improvements to food production and agribusiness that will be of practical use to the local and regional populations.

Research under the Hatch Act can focus on any aspect of agriculture. The scientists at WPTRC specialize and produce research in:

- aquaculture
- locally grown and value-added food products
- soil science
- horticulture and crop variety testing
- plant diseases
- forest and savannah restoration
- pests and invasive species
- native species biodiversity
- natural product extraction
- human nutrition
- climate science and climate change adaptation
- technology to benefit agriculture and the environment

Agricultural Experiment Stations provide research and discoveries that fuel the work of Cooperative Extension in delivering hands-on education curriculum and assistance to farmers, ranchers, suppliers, processors, and others involved in food production and agriculture.

Major funding for WPTRC research is provided through the Hatch, Multistate Hatch, and McIntire Stennis programs administered by the USDA National Institute of Food & Agriculture.




USS ROBERT E. LEE
SSBN-601

Inarajan Research & Education Center
Est. 1975
10.6 acres

The Inarajan experiment station is the center's smallest station, representing the least common soil type in Guam. Bottomland, or strandline, soil is found in between the northern limestone soils and the southern volcanic soils of Guam and is deep, slow-draining, and silty or sandy in composition.

The station has a small plantation of 12 banana varieties, including some of the most popular varieties in Guam, used as a source of planting material for farmers and to teach students about plant propagation.

Ija Research & Education Center
Est. 1978
65 acres

With only rolling hills of red clay and wilderness in sight from the property, Ija station supports projects exploring agriculture techniques for the sloping, erosion-prone, and predominantly clay soil.

Ija station also has an orchard of mango trees that provides a valuable opportunity for improving mango fruit production on the island. The orchard includes 29 varieties from major mango-producing regions of the world and includes many of the most successful varieties in international commerce.

Yigo Research & Education Center
Est. 1986
47 acres

The Yigo station is located on the northern part of Guam on the soil type that covers approximately 30 percent of the island. The porous limestone in the north of Guam quickly absorbs water, and the shallow, "cobbly clay" soil tends to lack a good nutrient balance.

This makes the station ideal for research projects looking to make efficient and economical use of nutrients, such as the use of biochar and organic waste compost as soil amendments.

Glenn Dulla, Ph.D.
Assistant Professor of Plant Pathology

Dr. Glenn Dulla is a molecular microbiologist focused on studying plant-microbe interactions, specifically pathogenic associations on plants relevant to Guam's native and agricultural ecosystems. He joined UOG and WPTRC as an assistant professor of plant pathology in January 2023.

Dulla previously served a regulatory role as the invasive species coordinator for the Guam Department of Agriculture's Biosecurity Division to coordinate biosecurity initiatives and as the USDA Plant Pathology Area Identifier to determine pathogen identity on foreign and domestic imported agricultural commodities.

His current research focus is on developing a model bacterial system featuring a pathogen that is relevant to Guam. The objective is to investigate the interactions between microbes, the environment, and host plants in order to understand the mechanisms contributing to disease.

He holds a bachelor's in medical technology from Seattle University. He earned his doctorate in microbiology from the University of California at Berkeley studying the manipulation of plant pathogenic bacterial genetic regulatory networks that control virulence. He also completed a post-doctoral fellowship at the University of Washington studying colonization pathways of bacterial symbionts in composting earthworms.

Rachel Jolley, Ph.D.
Assistant Professor of Restoration Ecology

Dr. Rachel Jolley is a restoration ecologist focused on controlling invasive species and restoring Guam's native forests. She joined UOG and WPTRC as an assistant professor of restoration ecology in early 2023.

Jolley has worked in the natural resource management field for 30 years, including positions with the U.S. Forest Service, Utah Division of Wildlife Resources, Missouri Department of Conservation, environmental consulting firms, the Guam Plant Extinction Prevention Program, and the USDA Wildlife Research Center. She has also worked with online education development for 13 years.

Her current research is focused on controlling invasive vines, documenting forest recovery following ungulate removal, and planning large-scale restoration projects. In the future, she plans to research watershed restoration and native forest recovery.

She holds a bachelor's in wildlife conservation and a master's in botany and range sciences from Brigham Young University (Utah). Her doctorate is in forest ecology from Auburn University (Ala.). She completed a post-doctoral fellowship at Mississippi State University in habitat restoration.

IMMEDIATE OR GRADUAL? REMOVAL METHODS TESTED FOR INVASIVE MOLAVE TREES

Guam's limestone forests are being overtaken by an invasive overstory tree called *Vitex parviflora*, known commonly as the molave tree. Native to the Philippines, *Vitex* is now the most common invasive tree species in Guam, according to the 2013 Forest Inventory & Analysis. The tree tends to form a monoculture, driving out native species that are needed to balance and sustain Guam's ecosystem.

While the solution may seem as simple as cutting the invasive trees down, doing so may have the adverse effect of opening the canopy by bringing in light that could encourage further growth of invasive plants in the understory. Hawaii faced a similar problem, and clear-cutting opened large forest gaps where understory invasive species flourished. However, girdling the trees, a practice that removes a ring of bark and slowly starves the tree of nutrients, results in a gradual change in understory light and fewer invasive species.

To evaluate how forest understory species would react to the removal of *Vitex* trees, a study was conducted in the forests of UOG's agriculture experimental station in Yigo. Restoration ecologist Dr. Rachel Jolley and master's student Jonathan "Kawika" Davis randomly assigned one of three treatments to 48 plots of land with *Vitex* trees:

1) whole tree removal
2) girdling
3) no treatment (control)

Four one-square-meter subplots were used to record understory species composition in each plot. These subplots were evaluated prior to treatment applications and at three-month intervals following treatments. Researchers used a canopy analyzer to compare forest gap openings and light levels.

Upon comparing the three treatments, there were no differences in the understory species composition. When trees were first removed from the forest, it did create a gap and increase in light levels; however, the canopy of surrounding trees gradually filled in those gaps, dampening the increased light levels. Girdled trees lost their canopy several months into the study and started shedding small limbs toward the end of the study. However, the canopy of surrounding trees gradually filled in the gaps, leading to only minimal increases in light levels.

The results demonstrate that removing an invasive *V. parviflora* tree as a whole or gradually via girdling will have very little adverse impact on the forest understory if enough native forest trees are in the canopy to fill in the gaps. Girdling proved to be much faster and cheaper; however, as the tree begins to die, large falling branches can pose a hazard starting at the 14-month mark if people need to be in the area.

Land managers are encouraged to remove *V. parviflora* from native forests as early as possible – when there are still enough native species to buffer the canopy gaps. In forests that have become a monoculture of *V. parviflora*, however, it is likely that tree removal would create a clear-cut effect and could yield very different results. This study should be repeated in a monoculture stand of *V. parviflora* to explore how large gaps affect the forest understory community.

Project: "A comparison of *Vitex parviflora* removal methods on understory species composition in the degraded limestone forests of Guam"

Researchers: Dr. Rachel Jolley | *jollyr@triton.uog.edu*
Jonathan "Kawika" Davis | *jdavis@triton.uog.edu*
Dr. Jim McConnell | *mcconnell@triton.uog.edu*
Dr. Mari Marutani | *marutanim@triton.uog.edu*

Duration: August 2019 – November 2020

Funded by the U.S. Department of Defense

Researchers girdle invasive trees – a practice that removes a ring of bark and starves the tree of nutrients slowly, creating less impact on the understory.

Flowers and leaves of *Vitex parviflora*.
Photo by Forest & Kim Starr, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid=71851118

Graduate student Jonathan "Kawika" Davis uses a canopy analyzing instrument where invasive *Vitex parviflora* trees were removed in order to assess the change in light levels.

PIGS AND DEER SUPPRESS NATIVE PLANTS, AMONG OTHER NEGATIVE ECOLOGICAL IMPACTS

Feral pigs and deer have been a part of Guam's ecosystems since they were introduced to the island during the 17th and 18th centuries. As with many other tropical islands, Guam's ecosystems evolved in an environment devoid of large mammals. Thus, plants did not develop resiliency to grazing and trampling by ungulates as they do in habitats where grazers are part of the natural ecosystem.

Prior research suggests that the feral ungulates have substantially impacted Guam's forests by reducing native seedling survival, spreading disease, damaging root systems, and increasing erosion and runoff (Gawel et al., 2018; Schreiner, 1997). Native species recruitment has become further jeopardized in recent decades with the extirpation of forest birds, eliminating most of the island's native seed dispersers.

Restoration ecologist Dr. Rachel Jolley set out to compare the forest understory community composition prior to and two years following the removal of ungulates within a 33-hectare enclosure of native limestone forest. Her goal was to document changes in species composition, mainly species recruitment, with the removal of ungulate disturbances and ultimately be able to inform land management efforts regarding forest succession.

The 33-hectare site is commonly referred to as the "Tarague Triangle" on Andersen Air Force Base. Prior to ungulate removal, Jolley conducted a vegetation survey using 100 one-square-meter plots stratified across the study area. Data was collected on understory species frequency and cover, bare ground, moss, litter, and rock. Fencing and targeted ungulate removal were completed in December 2020. A follow-up survey was conducted in February 2023 and was ongoing as of January 2024.

Three years following ungulate removal, fewer non-native and early seral species – or a first phase of vegetation in a recovering forest – were found in the understory community, along with an increase in native and late seral species. Following Typhoon Mawar, vegetation

Two years following ungulate removal, fewer non-native and early seral species were found in the understory community, along with an increase in native and late seral species.

abundance was significantly higher in the areas where ungulates were excluded. Abundant native seedlings and saplings (including *Ochrosia oppositifolia* and *Macaranga thompsonii*) were found throughout the exclosure. Monitoring results suggest that the forest is showing signs of recovery with the absence of ungulate disturbance.

In a survey in January 2024, data shows a drastic change in understory vegetation caused by changes in forest overstory following Typhoon Mawar. Although this recent data will be more difficult to isolate the impact of feral ungulates, it will provide useful information in understanding the forest recovery process following a major typhoon.

As Guam continues to struggle with introduced species disrupting the balance and biodiversity in its ecosystems, these findings will help forest restoration managers prioritize the removal of ungulates to allow native plant species to recover.

Project: "Monitoring forest recovery following the removal of ungulates"
Researcher: Dr. Rachel Jolley | *jollyr@triton.uog.edu*
Duration: November 2021 – Ongoing

Gawel, A., Rogers, H., Miller, R., & Kerr, A. 2018. Contrasting ecological roles of non-native ungulates in a novel ecosystem. Royal Society Open Science. *5.*

Schreiner, IH. 1997. Demography and recruitment of selected trees in the limestone forest of Guam in relation to introduced ungulates. Micronesica *30(1): 169-181.*

A comparison of vegetation in an unfenced forest (left) and in an adjacent area fenced to exclude ungulates (right) on Andersen Air Force Base, Guam.

TESTING AQUAPONICS SYSTEMS FOR PROFITABILITY AND DURABILITY IN GUAM

The COVID pandemic and Typhoon Mawar have reminded the Guam community of its vulnerability to food security. Past experiences in aquaculture and agricultural production have proven that Guam is capable of producing much more food locally, but novel production strategies may be needed to overcome technical and economic barriers.

Aquaponics – a system that includes both plants and fish – is one food production strategy that makes practical sense for an isolated island like Guam. It makes smart use of space and resources by recirculating water and using organic waste from the fish to fertilize plants. The plants, in turn, remove these nutrients and return clean water to the fish. Aquaponics systems use 90% less water than traditional agriculture and also reduce the risk of pesticides leaching into aquifers.

Despite these benefits, the adoption rate of aquaponics systems on island – whether commercially or by private residents – has been very low, even with an increasing number of workshops and system demonstrations over the past 20 years.

Dr. Hui Gong Jiang, an aquaculture researcher with WPTRC, is working with aquaculture specialist David Crisostomo from the UOG Sea Grant program to look into several possible barriers: 1) production efficiency 2) cost of materials and 2) durability of the systems and materials in Guam's climate, which includes tropical storms and typhoons, harsh UV rays, and persistent heat.

They have designed and installed three different types of systems behidn the Agriculture & Life Sciences building on the University of Guam campus that could meet these pressing needs using affordable materials that can be sourced locally or from Asia.

1) Coupled (one-pass) system: This system pumps water from the fish tank to the filters, then to the plant trays. The water then returns directly to the fish tank.

2) Decoupled system: This system keeps the fish culture component separate from the plants. The solid waste from the fish tank is collected in the solids filter, then is periodically transferred to a biological aerobic digester. The digester utilizes bacteria and heavy aeration to break down the solid waste, releasing the nutrients. After three weeks the aeration in the digester is turned off and the solids are allowed to settle. The supernatant (clear water) is then delivered to the plant culture component.

Microbiome system: This system is basically the same as the coupled system with the addition of a bed of bamboo biochar as part of the filtration system. Biochar is thought to break down the organic waste compounds and allow more nutrients, such as iron, phosphorous, potassium and micro elements, to be available for the plants.

The three systems were stocked in January 2024 with tilapia raised at UOG WPTRC's Guam Aquaculture Development & Training Center while Crisostomo was supervising seed germination. Jiang and Crisostomo will be collecting data over the next year on the cost of production and rate of return on each of the three systems. They will also be trying out different crops and different species of fish to determine which combinations are most profitable.

This data will provide a financial analysis for building and operating an aquaponics system in Guam and will facilitate the retention of private farmers and small businesses in this growing practice. The researchers hope to present their findings at a national aquaponics conference later in 2024.

Project: "Comparison of production efficiency and costs in three styles of aquaponic systems: coupled, decoupled, and microbiome aquaponic systems"

Researchers: Dr. Hui Gong Jiang | *hgong@triton.uog.edu*
David Crisostomo | *crisostomod8562@triton.uog.edu*

Duration: March 1, 2023 – April 30, 2025

Funded by Hatch Grant, USDA NIFA

Aquaculture specialist David Crisostomo transfers seedlings to the newly designed aquaponics farm on the UOG campus. *Photo by Conrad Calma*

DA'OK: AN UNDERUTILIZED TREE IN GUAM WITH POTENTIAL HEALTH BENEFITS

Calophyllum inophyllum, a species of tree known as *da'ok* in Guam's native language of CHamoru, is a rich source of bioactive fatty acids, flavonoids, coumarins, and xanthones, which have been shown to have antioxidant, anti-inflammatory, anti-cancer, anti-microbial, and anti-HIV effects. The oil extracted from the seeds, called da'ok or tamanu oil, has been used by Pacific islanders for centuries, primarily as an external medicine for an assortment of skin issues, such as wounds, acne, arthritis, dry skin, skin wrinkles, and scalp psoriasis.

Da'ok trees grow prominently in Guam, but the fruit is largely underutilized. In other tropical locations, the tree has been reported to produce up to 10,000 seeds per season with a minimum of two seasons per year. The trees could be grown commercially for pharmaceutical and cosmeceutical products in Guam and used to treat skin-related issues, but no scientific research has been conducted on the bioactive properties or toxicity for the oil from Guam-grown da'ok.

Extracting the oils from the fruit is the first step in exploring what bioactive compounds are present. Natural product chemist Dr. Sahena Ferdosh set out to find the method that would extract the maximum amount of oil from the fruit while retaining the highest number of bioactive properties.

She utilized both the conventional method of screw press and Soxhlet and the nonconventional method of supercritical fluid extraction (SFE), which has gained popularity as one of the most effective green extraction techniques. The technique also allows for improved selectivity, higher extraction yields at low temperatures, shorter extraction times, and selective fractionation capabilities.

In Ferdosh's recently published review paper – "The extraction of bioactive agents from *Calophyllum inophyllum* L. and their pharmacological properties" – in the journal of Scientia Pharmaceutica, she reports that the conventional screw press method had a lower yield than chemical extraction. Moreover, conventional extraction carries impurities and toxic compounds, which require further purification to make the extract consumable. SFE, on the other hand, is a one-step method that also removes the impurities and toxicities from the extract to make them directly consumable without further purification.

She concluded that total phenolic content, total flavonoid content, antioxidant activity, and antibacterial activity of da'ok oil are higher when extracted via SFE than through conventional methods.

The enriched bioactive substance may potentially encourage a new agricultural commodity in da'ok tree farming in Guam and Micronesia and may lead to the development of cosmetic products. Ferdosh says the next step is to assess the da'ok oil for its anti-inflammatory and wound-healing properties, toxicity, and storage stability.

Project: "A miracle oil from underutilized da'ok (*Calophyllum inophyllum* L.) nut: Extraction and characterization"
Researcher: Dr. Sahena Ferdosh | *ferdoshs@triton.uog.edu*
Duration: June 2023 – June 2026

Funded by Hatch Grant, USDA NIFA

"The underutilized da'ok nut could help the Guam community by producing oil as pharmaceutical and cosmeceutical products, which could treat skin-related diseases as well as generate revenue."

– Dr. Sahena Ferdosh

Dr. Sahena Ferdosh places a tray of da'ok nuts in a drying oven to remove moisture. *Photo by Mia Alvarez*

UOG DRONE CORPS AND CLIMATE CENTER MAP AFTERMATH OF 2023'S STRONGEST STORM

In response to the devastation caused by Typhoon Mawar – the strongest storm worldwide in 2023, which struck Guam in May – the University of Guam and the National Weather Service Guam Forecast Office collaborated on a groundbreaking project three days after the storm to assess the aftermath using advanced drone technology. The initiative, led by a multi-agency team of remote pilots from programs led by WPTRC research faculty, such as the UOG Drone Corps, NASA Guam Space Grant, NASA Guam EPSCoR, and the Pacific Islands Climate Adaptation Science Center, aimed to address the urgent need for a timely and detailed damage assessment of coastal and urban areas.

From May 27 to June 8, the team deployed a fleet of DJI Matrice 300 drones equipped with Zenmuse P1 sensors to map eleven key sites from Ritidian to Agat. A special waiver from the Federal Aviation Administration permitted the pilots to operate above the usual 400-foot height restriction, allowing the team to cover extensive areas in a shorter amount of time. After approximately 60 hours spent on drone flight, set-up, and processing, the mission amassed a total of 11,758 photos that were stitched together to produce high precision orthomosaic maps of the observed sites.

The high-resolution imagery provided detailed visuals of damaged areas, showing fallen power lines, cracks on the road, and specific tree species prone to wind damage. This allowed meteorologists to analyze the storm's winds, structural damage, wave run-up, coastal inundation, and vegetation destruction, even in hard to access areas. The Guam Power Authority utilized the images to assess damages to solar panels. The maps will also serve as baseline datasets for comparative and longitudinal studies on recovery rates of conservation areas after the typhoon.

Considering that Guam has not faced any severe typhoons since the rise of drone technology, this post-storm mapping campaign presents a new frontier in disaster response capabilities. Moving forward, the UOG Drone Corps and NWS Guam Office will be working to ensure that the collected data is secure and accessible to relevant authorities and community partners.

The data collected from the mapping campaign is available upon request at bit.ly/nasagu2023data.

Researchers: Dr. Romina King | *roking@triton.uog.edu*
Brandon Aydlett, National Weather Service Guam | *william.aydlett@noaa.gov*
Landon Aydlett, National Weather Service Guam | *marcus.aydlett@noaa.gov*

Duration: May – July 2023

Funded by NASA Guam Space Grant, NASA Guam EPSCoR, UOG Drone Corps, Pacific Islands Climate Adaptation Science Center, and National Weather Service Guam.

Considering that Guam has not faced any severe typhoons since the rise of drone technology, this post-storm mapping campaign presents a new frontier in disaster response capabilities.

UOG Drone Corps member Kaya Taitano monitors a drone from afar during a mapping mission on May 27, 2023, at John F. Kennedy High School in Guam following Typhoon Mawar. *Photos by Keanno Fausto*

Co-remote-pilots-in-command Jonelle Sayama and Dong Won Lee prepare for a drone mapping mission following Typhoon Mawar.

DRONE MISSIONS IN PALAU PROVIDE MAPS TO MORE EFFICIENTLY MONITOR RHINO BEETLE

The Guam Department of Agriculture's Biosecurity Division estimates at least 25% of Guam's coconut trees have sustained damage from the invasive coconut rhinoceros beetle. Other islands of Micronesia are facing this threat as well – one being Palau. While Palau is not affected by the beetle as badly as it has been in the past, local natural resource managers are looking for more efficient ways to keep an eye on the CRB population and prevent a resurgence.

The coconut palm is a strong symbol of livelihood across the Pacific, and damage to the trees from the rhino beetles impacts those who rely on native coconut palms for sustenance and crafting resources and, consequently, the economy.

University of Guam graduate student Mira Mariur, who is originally from Palau and is studying sustainable agriculture and natural resources, wanted to see how advanced technology could help protect Palau from CRB damage. She made this the focus of her master's thesis and was able to make Palau-based research possible through a Climate Adaptation for Resource Management fellowship with the Pacific Islands Climate Adaptation Science Center (PI-CASC) under WPTRC.

While drone technology is not new to Palau, the concept of utilizing advanced technology to aid natural resource management is emerging across Micronesia, especially as climate change is starting to have a heavier impact on the Pacific islands.

Together with a team of UOG students and WPTRC research faculty involved with PI-CASC, NASA Guam Space Grant, and the NASA Guam Established Program to Stimulate Competitive Research (EPSCoR), Mariur embarked on remote piloting missions in Palau.

Mariur and her Palau-based supervisor – Dr. Christopher Kitalong with Palau Community College's extension service – picked out areas that would most likely have visible impacts to record. She then guided the UOG Drone Corps, a program of NASA Guam Space Grant, to six sites to deploy unmanned aerial vehicles and take imagery from Oct. 6 to Oct. 9, 2023.

Drone surveying and imagery captures a wide amount of data in a short amount of time – and often in places that cannot be reached on foot. The team's photos have since been processed and stitched together to create orthomosaic RGB maps.

These aerial imagery datasets are now available to view upon request at www.uog.edu/nasa-guam-space-grant/information#Resources. The maps produced from this mission will help Palau's officials and natural resource managers prioritize sites most vulnerable to CRB and will give them a baseline to see what control methods are effective.

With a connection now established between the University of Guam and the Palau Community College in the advanced technologies realm, more discussions are being held to further collaborate on other invasive species and environmental issues. This project also leads the way for more students from Micronesian islands outside of and including Guam to become PI-CASC CARM fellows and lead projects like this to benefit their islands.

Project: PI-CASC Climate Adaptation for Resource Management (CARM) Fellowship

Researchers: Dr. Romina King | *roking@triton.uog.edu*
Mira Mariur | *mariurm15447@gotritons.uog.edu*
Dr. Christopher Kitalong | *ckitalong@gmail.com*

Duration: August 2023 - Present

Funded by the U.S. Geological Survey, Pacific Islands Climate Adaptation Science Center; NASA Guam Space Grant; and NASA Guam EPSCoR.

(From left) Danielle Hagen, Mira Mariur, and Kaya Taitano during a drone flight mission in October 2023 at the Palau Community College's multi-species hatchery in Ngaremlengui State, Palau. *Photo by Keanno Fausto*

FIRST-TIME SURVEY TECHNIQUE FOR GUAM IMPROVES ACCURACY OF NATIVE SNAIL COUNT

Tree snails of the Partulidae family are endemic to tropical Western Pacific islands and an integral part of island ecosystems. Native tree snails may play important roles in nutrient recycling in native forests and are also a component of the cultural heritage of the Marianas.

While it is known that snail numbers are declining throughout their natural range, the method used to count them is not the most accurate or useful for comparative studies later on.

Four partulid species have been described in Guam: *Partula gibba, Partula radiolata, Samoana fragilis*, and the extinct *Partula salifana*. Across the other Mariana Islands, two more endemic partulid species are extinct, with a third – *Partula lutaensis* – remaining on the island of Rota. All four of the remaining Marianas tree snail species were listed as endangered in 2015 and are threatened by introduced predators and habitat destruction.

Direct population estimates of tree snails are difficult because visual surveys miss these small animals in their habitat of trees, shrubs, and plants. The traditional mark-recapture method of physically marking individuals with nail polish, permanent ink, or some sort of tag also requires handling the snails and risks accidental injury or substance transmission to the snails.

In seeking a more accurate and less invasive way to estimate populations, UOG biologist Dr. Curt Fiedler utilized a first-time method for Guam over a three-year population study. This "photo mark-capture," or PMR, method, has been used sporadically in Hawaii on endangered tree snails but not yet in Guam, and it has never been tested anywhere else on a long-term, large-scale basis.

The method uses software called HotSpotter to match photographs of snail shells. Photographs of snails were recorded along with their GPS coordinates, height from the ground, and plant species they are on. The software is able to distinguish individual snails by their specific color patterns, shell damage, and growth variations.

Straight counts of snails in forest habitats have been the norm, but they underestimate actual numbers. Photo mark-recapture gets closer to real numbers and provides a standard technique that can be used for comparative studies.

Fiedler surveyed the same plots repeatedly over three years with at least two-day intervals. His data revealed that all three species seem to undergo seasonal increases and decreases in population size. He was also able to – for the first time – survey the snails before and after a big storm. He found that Typhoon Mawar had an immediate negative impact on the endemic tree snail populations, with numbers declining further up to six months afterwards.

On Andersen Air Force Base, his long-term study on *P. radiolata* found a few individuals recaptured in subsequent seasons up to 11 months later, suggesting these snails can live up to one year in nature.

This study makes an important advancement for partulid snail research. Straight counts of snails in forest habitats have been the norm, but they underestimate actual numbers. PMR gets closer to real numbers and provides a standard technique that can be used for comparative studies.

Having a reliable count will be useful to agencies like the Guam Department of Agriculture and the U.S. Fish & Wildlife Service in Guam as well as to terrestrial ecologists who work to compare numbers over time and conserve the remaining Marianas snail species. NAVFAC Marianas is currently funding the use of this technique to assess snails at several installations in Guam.

A *Partula radiolata* tree snail feeding on the spores of a fern in Agat, Guam. *Photo by Curt Fiedler*

The study has implications beyond Guam as well. Thousands of snail images from this study are being used to train the A.I. engine on a software program that will be a tree snail–specific successor to HotSpotter for use in locations around the world.

Project: "Assessing populations of native tree snails and forest habitat requirements in the Mariana Islands"
Researcher: Dr. Curt Fiedler | *gcfiedler@triton.uog.edu*
Duration: January 2018 – September 2022

Funded by McIntire-Stennis Grant, USDA NIFA

POLLEN DNA SAMPLING REVEALS THE FOOD SOURCES OF GUAM HONEYBEES

Pollinators support healthy ecosystems needed for clean air, stable soils, and diverse wildlife. Honeybees, alone, pollinate 80 percent of all flowering plants and assist in pollinating crops worth billions of dollars each year. But pollinator populations are dropping alarmingly across North America creating a need to pay greater attention to what is essential for their success and survival.

The *Apis mellifera* species, or the Western honeybee, was first introduced from Hawaii to Guam in 1907. Since then, few honeybee-related studies have been conducted in Guam or even Micronesia. Researchers have determined that the Colony Collapse Disorder is likely attributable to a wide range of stressors, including pests, diseases, pesticides, pollutants/toxins, nutritional deficits, habitat loss, effects of climate variability, agricultural production intensification, reduced species or genetic diversity, and pollinator or crop management practices.

Biology graduate student Jonae Sayama – working with her supervisor UOG entomologist Dr. Ross Miller and UOG environmental science alumnus Christopher Rosario, who now heads the Guam Beekeepers Association – sought to better understand what floral sources Guam honeybees forage on. Knowing this would provide insight into whether the bees are experiencing nutritional deficiencies because of a lack of floral diversity. It would also indicate potential changes in pollinator and crop management practices to better support the honeybee colonies.

In a first of its kind study for Guam, Sayama sampled pollen grains from 10 randomly selected apiaries around the island over a year's time starting in January 2022. She sent the samples to Jonah Ventures Laboratory in Boulder, Colo., to be DNA metabarcoded and determine the plant source.

The lab found 139 plant taxa across all apiaries. Sayama said this seems to be a good number of food sources compared to studies in other locations, considering that many more pollen grains collected could not be identified.

Most common pollen types identified in Guam apiaries		
	Species	**Common (and Chamoru) name**
1.	*Leucaena leucocephala*	River tamarind (*tångantångan*)
2.	*Flagellaria indica*	False rattan
3.	*Casuarina equisetifolia*	Ironwood (*gagu*)
4.	*Muntingia calabura*	Cherry tree (*mansanita*)
5.	*Mesua ferrea*	Ironwood
6.	*Antigonon leptopus*	Chain of love
7.	*Rivina humilis*	Blood berry
8.	*Porana volubilis*	Bridal creeper
9.	*Jatropha integerrima*	Rose-flowered jatropha
10.	*Acacia crassicarpa*	Thick-podded salwood

Of the plants found, 39% are at the species level, while 61% were only able to be identified to the family or genus level due to an incomplete reference collection of plants in Guam.

The most abundant plant species present was *Leucaena leucocephala*, known locally as *tångantångan* (14.1%), followed by *Flagellaria indica*, or false rattan (4.2%), and *Casuarina equisetifolia*, or ironwood (2.7%). Among samples not identified to the species level, Fabaceae (flowering legume, pea, and bean plants) accounted for 50.6% of the remaining samples and Aracaceae (palm trees) for 4.2%. The remaining 6.3% were spread across 52 families and 49 genera.

The data supports that honeybees may serve as a pivotal pollinator for both native and introduced plants on Guam.

This study provides essential information for local beekeepers about the variety and type of floral sources honeybees prefer. It also informs the local environmental and agricultural communities about how to better support honeybees by providing the necessary plants

Biology graduate student Jonae Sayama takes pollen samples from a honeybee comb of a local apiary during her thesis research on pollen in 2022.

for healthy colonies and developing integrated weed and insect management strategies with minimal impact on domestic and feral honeybee hives.

Although the study determined many plants that honeybees forage on for resources, Sayama said it is not a complete list. She said an important next step would be getting more plants on Guam into sequence databases, like GenBank, so they can be identified in pollen samples.

Project: "Pollen identification in *Apis mellifera* L. (Hymenoptera: Apidae) apiaries on Guam using DNA metabarcoding"

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Dr. Ross Miller | *millerr@triton.uog.edu*

Duration: January 2022 – December 2022

Funded by Hatch Grant, USDA

PATHOLOGY STUDY PINPOINTS CAUSE OF MUSHY CANKER IN GUAM'S PAPAYA PLANTS

A "mushy canker" disease has been affecting papaya plants in the region since at least the 1980s, when it was first reported in the Northern Mariana Islands. Mushy canker causes soft rot symptoms and can occur in both agricultural fields and in wild jungle papaya trees. A bacterial pathogen called *Erwinia* has been suspected of causing the disease, but no research has confirmed it.

Papaya is an integral crop in Guam's agricultural economy. By learning about the cause of diseases that threaten Guam's papaya, growers can be better equipped to combat these diseases and, as a result, successfully grow plants and harvest beautiful, delicious fruits.

Plant pathologist Dr. Glenn Dulla and his research team sought to verify that the symptoms seen in Guam papaya plants associated with mushy canker disease are actually caused by *Erwinia sp.* If it was determined to be caused by *Erwinia sp.*, Dulla also sought to narrow identification to the species level.

The team tested nine bacterial isolates from naturally infected papaya plants on the UOG campus, finding that five of the nine wild-type strains caused mushy canker symptoms.

Genetic sequencing results for the five strains that showed greater than 98% similarity with strains called *Erwinia sp.* I-leaf and *Erwinia mallotivora* strain BT-MARDI. With these results, the researchers safely concluded that Guam's mushy canker disease is caused by *E. mallotivora*.

Papaya plants reinfected with Guam *E. mallotivora* were recovered on selective media, confirming the pathogen's ability to cause disease whereas the negative control plants did not display any disease symptoms nor show any growth on selective media.

Two possible mollusk vectors, the Cuban slug and giant African snail, were allowed to feed on *E. mallotivora*–infested plant material. The pathogen survived the gut system of both mollusks and was found in the Cuban slug feces up to four days post inoculation and six-plus days post inoculation in giant African snail feces. The duration of *E. mallotivora* colonization in giant African snail is undetermined.

This is the first report of *E. mallotivora* as a papaya pathogen in Guam and the region. Although *Erwinia sp.* was found to be the cause of papaya mushy canker in the Northern Mariana Islands in the '80s, the pathogen was confirmed to the species level.

This is the first observation of *E. mallotivora* being vectored in the giant African snail and possibly the first detection of the Cuban slug acting as vector for a plant pathogen.

With a definitive answer on what is causing Guam's papaya mushy canker disease, researchers can look further into how it is spread and potentially uncover ways it can be treated or managed. This could be vital information for Hawaii, where this disease has yet to be observed but could be devastating for papaya production, and for growers in the Micronesian region looking to start growing papaya trees or maintain the health of established trees.

Project: "Cell-cell communication and virulence factors in the *Erwinia sp.* papaya pathogen"

Researchers: Dr. Glenn Dulla | *dullag@triton.uog.edu*
Julia Delorm | *hudsonj13789@triton.uog.edu*
Zyrhese Santos, John F. Kennedy High School
Isaiah Moreno, Tiyan High School

Duration: January 2023 – Ongoing

Funded by Hatch Grant, USDA

Zyrhese Santos, a Pacific STEP-UP intern from John F. Kennedy High School, holds a Cuban slug, a vector of the pathogen that causes mushy canker in Guam papaya, in the UOG Plant Pathology Lab. *Photo by Jackie Hanson*

A papaya plant is shown over a two-week span after being inoculated with *E. mallotivora*. *Photos by Julia Delorm*





PATHOLOGY LAB IDENTIFIES AN ANTHRACNOSE-CAUSING PATHOGEN ON PEPPER PLANTS

Hot pepper (*Capsicum annum*), known locally as donne', grows well in Guam's climate and is a popular agricultural and gardening crop. However, the plant's leaves and fruit are subjected to multiple leaf-spotting or fruit pathogens that ultimately reduce the plant's marketable yield and devalue the quality of its fruit. It is believed that anthracnose is the most destructive disease to *C. annum*. The cause of this disease is presumed to be a fungal pathogen of *Colletotrichum sp.*

Donne' is an integral part of Guam's culture and has gained popularity in the agricultural economy for value-added products like hot sauce. By learning about the cause of diseases that threaten Guam's *donne'*, growers can be more equipped to combat these diseases and more successfully grow plants and harvest beautiful, delicious fruits.

Plant pathologist Dr. Glenn Dulla sought to verify that the symptoms seen in Guam's *donne'* plants that are associated with anthracnose disease are actually caused by a *Colletotrichum sp.* or by another organism, such as the bacterial pathogen *Pseudomonas syringae*. Dulla also sought to narrow the identification to the species level.

His research team attempted to isolate the pathogen by collecting samples from naturally infected hot pepper fruit (cv. *Guafi* and Manu) from local farmers. The peppers were incubated in humid chambers to allow potential fungal fruiting bodies to develop. They were also surface-sterilized and diseased tissue was placed on potato dextrose agar to grow out possible pathogens.

The team recorded the morphology of the fruiting bodies and conidia on the peppers and determined one pathogen to, in fact, be the fungus *Colletotrichum truncatum*.

This pepper pathogen has been documented in Guam in the past, but it may be the first time *C. truncatum* from hot pepper in Guam has been isolated and characterized in culture. It may also be the first time a causal relationship between anthracnose and *C. truncatum* on hot pepper in Guam has been established.

C. truncatum causes the disease symptoms of anthracnose: dark brown, water-soaked lesions and black fruiting bodies on the fruit as well as other parts of the plant. The development of this disease has been shown prior to and after harvest. Some cases have shown that this fungus can be transferred through abiotic and biotic factors. This fungal disease has been described to cause significant crop damage through defoliation, rotting, and wilting of the host. It has been observed on a variety of plant hosts, particularly on legumes and solanaceous plants like peppers.

Now, with at least one answer of what is causing Guam's anthracnose disease on hot pepper – with other pathogens still possible causes – producers can begin to apply successful management strategies. Next steps in research include variety trials to find out which varieties are more resistant to the *C. truncatum* fungus and also testing specific management approaches, such as antibiotics or biological controls.

Project: "Isolation and characterization of local hot pepper anthracnose pathogen"
Researchers: Dr. Glenn Dulla | *dullag@triton.uog.edu*
Stephenie Santos | *santoss11532@triton.uog.edu*
Duration: January 2023 – Ongoing

A microscopic image of black fruiting bodies and sunken lesions on a local hot pepper infected with the common fungal disease anthracnose. *Photo by Stephenie Andriana Santos*

Stephenie Andriana Santos, an undergraduate student studying agriculture and natural resources, inspects a *donne'* pepper plant for signs of anthracnose as part of her internship with the UOG Plant Pathology Lab.

A 'SMART IRRIGATION' APPROACH TO HELP FARMERS USE LESS WATER AND FERTILIZER

Agricultural producers account for 70% of all freshwater withdrawals worldwide. In the event of drought or a large increase in population, as Guam will be experiencing soon with the arrival of military personnel, water conservation, including watering efficiency in agriculture, becomes more important. Well-managed irrigation has benefits for farmers, too, saving them money on their water bill and potentially reducing the amount of fertilizer needed.

In California, to help growers and farmers conserve water in their arid climate, the University of California Cooperative Extension developed a smart-irrigation web application called CropManage (https://cropmanage.ucanr.edu). The application is populated with data from weather stations placed nearby that measure rainfall, temperature, wind speed, solar radiation, dew point, and relative humidity. Farmers can then log onto the application online to get daily water estimates for vegetable crops.

CropManage is capable of consistently reducing water and fertilizer use by 20% to 40% and, in many cases, improving crop yield. One test crop was shown to need 31% less fertilizer and improved its yield by 107%.

UOG's soil scientist Dr. Mohammad Golabi wanted to try the same smart-irrigation approach in Guam to see how much water could be saved by supplying farmers with a daily watering estimate based on weather data.

His research team set up weather stations on several participating farms, including UOG's agricultural experiment stations in Yigo and Ija. CropManage is not yet active in Guam, so the research team will be collecting data from the weather stations from November 2023 to February 2025 and calculating the amount of water needed depending on the crop being grown.

CropManage provides farmers and growers with daily water estimates for vegetable crops and is capable of consistently reducing 20% to 40% in water and fertilizer use and, in many cases, improving crop yield.

Simultaneously, the research team is tracking the water usage on the participating farms and will compare it to their calculated recommendations. Once these field trials are done in 2025, the CropManage app will be available to Guam farmers, who will be able to sign up for a login free of charge.

This study could ultimately show that large-scale farming in Guam is possible using less water and less fertilizer. It would be a tool that could reduce impact on the aquifer and environment as well as decrease costs for local farmers.

Project: "Improving water and nutrient efficiency for sustainable agriculture in Guam through smart irrigation scheduling"

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Duration: November 2023 – February 2025

Funded by Natural Resources Conservation Service, USDA

WPTRC Research Associate Katherine Perez, second from right, helps the Farm-to-Table Guam team install irrigation and a weather station on their farm to take part in a smart irrigation study. (From left) Dayamaya Calma, Joseph Campos, Niko Diego, Perez, and Roland Santos. *Photo by Ferdinand Galsim*

A weather station next to eggplant study plots at the University of Guam Yigo Research & Education Center.

HIBISCUS SABDARIFFA: A POTENTIAL NEW CROP TO BOOST HEALTH, FOOD SECURITY IN GUAM

Guam and the Micronesian Islands are limited in the variety of crops that grow well in the region's extreme climate. The islands also struggle to maintain genetic diversity, or available varieties, among the crops that are grown. This lack of agricultural diversity creates concern about food security as well as the crops' ability to adapt to diseases, pests, and other stressors, which is more likely with a broader gene pool.

The USDA Plant Genetic Resources Conservation Unit (PGRCU) is a multi-state project established to conserve plant genetic resources for future generations. Part of this effort involves distributing genetic resources of agronomic and horticultural crops. The Horticulture Lab at WPTRC acquired *Hibiscus sabdariffa*, or roselle – a potential new crop for Guam that could have broad use as a functional food source, medicinal plant, and value-added or export crop.

The calyces and leaves of *H. sabdariffa* are consumed in many countries and contain high amounts of bioactive compounds. Although there has been research that evaluates the phytochemical content and antioxidant capacities of roselle, very few studies explicitly describe the structural characteristics of specific accessions, which would help plant breeders and researchers select the most appropriate accessions for certain purposes.

The Horticulture Lab acquired nine *H. sabdariffa* accessions from the USDA PGRCU. Graduate student Maegan Delfin, under her supervisor Dr. Mari Marutani, introduced roselle to Guam on UOG's Agricultural Experiment Station in Yigo and conducted field evaluations from October 2021 to January 2022. They tracked and documented the plants' agronomic and horticultural traits and biochemical properties of the calyces and leaves, including the antioxidant, phenolic, flavonoid, and mineral content.

The phenolic compounds, mineral content, and antioxidant capacities found suggest that calyces of *H. sabdariffa* could, in fact, be a potential functional food for Guam and a good source of nutrients. The presence of antioxidants and the phenolic compound anthocyanin – commonly found in red, blue, and purple fruit and vegetables with a range of potential benefits for human health – were nearly absent in accessions with light green calyces and increased with increasing amounts of red-pigment. Therefore, the lab recommends the three accessions that produced red calyces as those that would have the best health benefits.

As this was the first time that roselle has been grown in Guam, Delfin said they hope to increase local interest and demand for the production for roselle calyces as a specialty crop that could be grown for its health benefits and also as an export. Future studies could explore the relationship between calyx color and anthocyanin content and could evaluate consumer acceptance toward roselle as a functional food.

The results from this study will soon be published in the journal HortTechology.

Project: "Plant genetic resources conservation and utilization"
Researchers: Dr. Mari Marutani | *marutanim@triton.uog.edu*
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Duration: November 2018 – September 2023

Funded by Multistate Hatch Grant: Plant Genetic Resources Conservation & Utilization, USDA NIFA

Research associate Maegan Delfin trims a *Hibiscus sabdariffa*, or roselle, calyx growing in Guam for the first time to test its biochemical properties. *Photos by Mia Alvarez*

STUDY IDENTIFIES BARRIERS TO FRESH LOCAL PRODUCE CONSUMPTION AMONG GUAM ADULTS

A shift in dietary patterns in the Pacific Islands since World War II has led to inadequate consumption of fruits and vegetables and excessive intake of processed, imported foods. Today, the majority of native CHamoru and Pacific Islander adults are not meeting the recommendations for fruits, vegetables, and whole grains. These dietary habits have contributed to the Western Pacific having the highest rates of diabetes per capita in the world as well as an increased risk for other non-communicable diseases. Improving the consumption of fresh local produce would allow Pacific Islanders to meet their nutritional needs and improve their health while also supporting local agricultural production and improving food systems and access to healthy foods.

Community-supported agriculture (CSA) programs, nutrition education, and the national Supplemental Nutrition Assistance Program (SNAP), both separately and combined, have been proven to improve fruit and vegetable intake. CSA-like programs in Guam offer subscription services to a weekly variety pack of seasonal local produce, but they are not widely utilized, particularly among lower income families.

Under the supervision of registered dietitian nutritionist Dr. Tanisha Aflague, graduate student Hope Evangelista designed a study to examine whether simply having produce more accessible and available would increase consumption and whether nutrition education would have any additional impact.

While the start of the COVID public health emergency greatly affected the recruitment approach for the study, a total of 53 adults completed the study.

Participants were assigned to one of three experiment arms:

1) those who received a variety pack of local produce
2) those who received nutrition education about the importance of eating fresh fruits and vegetables, and
3) those who received both on a weekly basis.

Improving the consumption of fresh local fruits and vegetables would allow Pacific Islanders to meet nutritional requirements while supporting local agricultural production and improving food systems and access to healthy foods.

At the end of the study, the researchers found that receiving the produce packs was effective in increasing consumption, but this was enhanced further when combined with nutrition education. They found that some of the common barriers to eating fruits and vegetables are high food costs, reliance on imported goods, and – in particular for SNAP recipients – unfamiliarity with how to handle and prepare local produce.

As the first study on this topic in Guam, it provides initial information on how to address barriers and capitalize on facilitators to CSA-like programs. It can inform the content of public nutrition education classes to help enhance the public's familiarity with different types of local season produce. Additionally, making local variety packs more readily available to SNAP recipients was shown to be feasible within the existing structure of SNAP-Ed.

Once feasibility is further examined, health care providers might be able to implement nutrition prescription programs, in which doctors could issue vouchers to CSA-like programs in the form of a prescription to SNAP recipients. In some states, SNAP-Ed programs have leveraged funding to implement a "Double-Up Bucks" program, which doubles a recipients' SNAP dollar value for fresh produce.

With the results of this study, the Guam SNAP-Ed program at UOG has plans to submit a proposal to the Gus Schumacher Nutrition Incentive Program to include Guam in the "Double Up Bucks" program.

Sharon Bidaure, office manager of the Farmers' Cooperative Association of Guam, and UOG research staff Gabrielle Quenga assemble variety packs of local produce at the Farmers' Co-op in Dededo. *Photo by Mia Alvarez*

Project: "An evaluation of community-supported agriculture (CSA) program in Guam: Perceived barriers and facilitators, impact on fruit and vegetable intake, and feasibility in Snap-Ed"

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Farmers' Cooperative Association of Guam

Duration: November 2020 – November 2023

Funded by Hatch Grant, USDA NIFA

EDUCATING GROWERS ON GRAFTING TO IMPROVE MANGO PRODUCTION IN GUAM

At present there are 220,000 mango trees in Guam – far more than the 150,000 people on the island – but very few of these trees are satisfactory fruit producers. Farmers are eager to grow mangos more successfully as there is a strong demand among consumers for the fruit.

A few barriers have prevented more robust mango production in Guam. First, the type of mango seed most commonly found throughout Guam is monoembryonic, which does not necessarily produce the same fruit quality or have the same appearance as its mother tree when people try to propagate by seed. Secondly, as growers have tried to import propagation materials for more desirable mango varieties, the Guam Department of Agriculture Biosecurity Division is imposing strict rules on the entry of mango.

A two-pronged effort was developed by WPTRC to improve mango production in Guam: 1) make improved varieties available to growers and 2) encourage and educate growers to adopt grafting as the recommended propagation technique. A key resource for this effort took root 30 years ago, when UOG imported 29 mango varieties from southern Florida and established them in an orchard at UOG's Ija Agricultural Experiment Station. The trees include some of the most important commercial and backyard varieties in the world. Eight of the varieties are polyembronic seed types, which produce seedlings that are genetically identical to the mother tree.

During the last three years, WPTRC has led an intense effort, made possible with 1,000 volunteer hours from agriculture students, to develop the orchard's trees as a local source of scions or budwood for grafting. Grafting is a horticultural technique where two trees are surgically spliced together to produce a tree with very desirable traits. Grafting is a reliable method for propagating trees that quickly and consistently produce large, sweet, fruit on compact trees with strongly anchored root systems.

Having received a grant award in 2020 from the USDA's Beginning Farmer and Rancher Development Program, WPRTC initiated a series of mango production workshops:

1) A field workshop in May 2022 that focused on identifying polyembryonic mangos for use as rootstocks in grafting.
2) An introductory mango grafting workshop in July 2023 that emphasized the advantages and challenges of adopting grafting.
3) An advanced workshop on mango grafting in November 2023 that explained the roles of the scion and rootstock in grafting and included demonstrations of the recommended grafting techniques, such as veneer and cleft grafts.

An average of 30 growers participated in each of the workshops and have recently received grafting kits to begin grafting on their own.

The availability of improved varieties and the adoption of grafting are opportunities to advance not only mango production, but agriculture in general in Guam as these techniques can be applied to other fruit crops. In an upcoming workshop in June, WPTRC will teach the grafting technique to beginning farmers looking to grow avocadoes.

Project: "Improving mango production in Guam"
Researchers: Dr. Adrian Ares | *adriana@triton.uog.edu*
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Duration: 2020 – 2023

Funded by Beginning Farmer & Rancher Development Program, USDA NIFA

A scion (top piece) of a desirable mango tree variety is grafted onto the rootstock (bottom piece) of another variety. The tree will ultimately grow to produce fruit that is genetically identical to the scion.

Christopher Leon Guerrero, nursery manager at the Guam Department of Agriculture, explains the role of rootstocks in the grafting of mango at a UOG workshop in July 2023. *Photos by Mia Alvarez*

GUAM MANGO LEAVES FOUND TO HAVE ANTIDIABETIC PROPERTIES

It is estimated that the population of adults with diabetes worldwide will reach 10.4%, or 642 million, by 2040. Diabetes and obesity are critical health issues in Guam as well – with diabetes mortality being one of the top 10 leading causes of death and with significantly higher negative impacts than in the mainland United States.

Many unique varieties of tropical plants, herbs, fruits, and vegetables grow naturally in Guam. Some of these plants contain various phytochemicals that could be beneficial to patients with diabetes. Certain plant properties can inhibit the breakdown of carbohydrates into glucose, reducing blood sugar. Extracts from many tropical plants also exhibit antioxidant, anticancer, and antimicrobial activity.

UOG food scientist Dr. Jian Yang wanted to find plants that grow locally in Guam that could potentially provide these type of health benefits and prevent diseases, especially degenerative illnesses, such as diabetes, cancer, and cardiovascular diseases.

His research team collected the leaves of 13 mango (*Mangifera indica*) varieties from the orchard on Ija Agricultural Experiment Station. The leaves were used to create extracts, which were then tested to determine antidiabetic activity, antioxidant activity, and total phenolics, which promote anti-inflammation.

They found that the mango leaf extracts of five varieties – Roposa, Vermillion, Bombay, Manalagi, and Palmer – showed antidiabetic activity, with 30%-90% inhibition of α-amylase activity.

The leaf extracts from the Palmer, Manalagi, and Raposa mango varieties exhibited antioxidant activity with 370-400 mg of Vitamin C – seven times the amount of in orange juice – as well as high phenolic content. Additionally, heat treatment, such as pasteurization, up to 85°C does not affect the beneficial bioactive components.

Leaf extracts from Palmer, Manalagi, and Raposa mango varieties exhibited antioxidant activity — seven times the amount of Vitamin C as orange juice — as well as high phenolic content.

In similar tests on other tropical plants, Yang's team also found that guava leaves, bitter melon flesh, and green and yellow calamansi peels exhibited antidiabetic activity.

With knowledge that some varieties of mango leaves grown in Guam do, in fact, have antidiabetic bioactive components, further studies can investigate how these components could be used as nutraceuticals or dietary supplements to provide health benefits to residents in Pacific Islands. Another future study could explore whether tropical plant extracts can be incorporated into processed food products and maintain their efficacy.

Project: "Biological properties of local mango leaves for health benefits"
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Duration: 2021 – 2023

Funded by Hatch Multistate Grant, USDA NIFA

The leaves of some mango varieties in Guam contain antidiabetic bioactive components that inhibit the breakdown of starch to glucose. *Photo by Luke Fernandez*

FIRST-TIME SURVEY FOR THE REGION DELIVERS DATA ON FARM WORKER STRESS

The 2016 National Violent Death Reporting System published by the Centers for Disease Control & Prevention placed agricultural workers among the top five occupational groups for suicides. Guam and Micronesia were not a part of this report, as no local data existed about occupational-related fatalities in the region's agriculture sector. National data could not supplement this lack of information because Guam's challenges and economic factors differ significantly from the mainland United States.

In a multidisciplinary effort, agricultural economist Dr. Kuan-Ju Chen and family and consumer sciences extension agent Dr. Tim de La Cruz established the Farmer Focus Project to gauge mental health decline at the local and regional levels in relation to the agriculture profession and to identify stressors that contribute to farm stress. The project is the first of its kind in the region, touching on both agricultural workers and mental health, which are not common research focuses due to stigma within Pacific cultures and economic shifts away from subsistence farming.

Last year, the project team completed an agricultural worker stress survey, which followed an agricultural producer stress survey the year before. They survey collected data from agricultural workers regarding their perceived stress level related to their occupation, frequency of certain stressors, health and wellness topics they would be interested to learn about, and they preferred ways in which they would like to receive this information.

The survey was conducted by visiting established farms and institutions frequented by farmers, such as the Dededo Farmers' Co-op. Planned gatherings were also utilized to meet with farmers at times that best fit their schedule. The survey received a total of 34 responses. Fifty-nine percent of participants indicated that they were experiencing medium levels of stress while 18% claimed they were undergoing high stress levels. The most frequent causes of stress included financial worries, lack of time, and crop/plant diseases.

The elevated stress of agricultural workers calls for an improvement in available services, the establishment of new resources and tools, and increased opportunities to learn how to maintain their farms and general well-being.

The elevated stress of agricultural workers calls for an improvement in available services, the establishment of new resources and tools, and increased opportunities to learn how to best maintain their farms and their general well-being. In response to these findings, the UOG Farmer Focus Project has hosted two regional conferences and several workshops that focused on topics related to top stress factors. The project has also successfully certified at least 36 individuals, including professionals who work directly with farmers, in adult Mental Health First Aid.

The data collected is being used by the project team to coordinate resources would be the most helpful and to determine steps to improve existing community services. Region-specific resources and outreach activities can now be curated that touch on topics like climate variations in the Pacific, tropical plant diseases, and pests.

Establishing new resources and providing opportunities for interactive learning through events like conferences, workshops, and trainings allows for sustainability in mental health and wellness service efforts and long-term capacity building of extension personnel and partner programs.

A Guam farmer clips a dragon fruit from the plant. *Photo by Luke Fernandez*

Future research possibilities might be investigating why certain stressors cause the corresponding effects in agriculture workers and how those stressors can be best addressed to alleviate farm stress in the region.

Project: Farmer Focus Project – Agriculture Workers Survey
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