State of Hawaii
Department of Agriculture
Agricultural Loan Division

April 25, 2023

Department of Agriculture
Honolulu, Hawaii

Subject: **Loan Presentation**

APPLICANT:

Rory James Souza
340 Burns Place
Makawao, HI 96768

CLASSIFICATION & ELIGIBILITY:

Rory James Souza operates his ranch as a sole proprietorship and meets the eligibility requirements as a qualified farmer as defined in Chapter 155, Hawaii Revised Statutes (HRS), subsections 155-1 and the general eligibility requirements cited in subsection 155-10. Mr. Souza has resided in the state for 31 years and operated his ranch since 2019.

COMMODITY: Cattle, goats

CREDIT HISTORY: SEE EXHIBIT A (CONFIDENTIAL)

OTHER STATE AGRICULTURAL LOANS: N/A

A2

LOAN REQUEST & PURPOSE:	Amount	Class D - Direct Emergency Loan
	$100,000	Operating expenses
	$100,000	Total Request

The emergency loan program was enacted to provide relief and rehabilitation without limitation as to purpose for qualified farmers affected by the impacts associated with the overpopulation of Axis deer, estimated at 60,000, in the County of Maui.

Deer droves continue to get into the applicant's pasture and cause damage throughout via overgrazing. The overgrazed forage has forced the applicant to reduce herd size because of poor forage quantity and quality.

Proceeds will be used for operating expenses associated with restoring the applicant's pasture/herd to the condition it was in prior to being damaged from overgrazing. This includes but is not limited to fencing, land clearing, machine work, feed, application of herbicide, and labor. Material cost for fencing an area of 8,300 linear feet is estimated at $12 per linear foot. Once installed, the fencing will prevent the deer from entering into the property.

TERMS:

Amount:	$100,000
Term:	(15) Fifteen years
Interest rate:	3.00%, fixed
Repayment:	Interest only payment due annually for the first 2 years. Thereafter, principal and interest payments of Nine thousand four hundred two and 95/100 ($9,402.95) due annually until loan maturity.

The interest only phase is designed to facilitate repayment and provide time necessary to complete improvements.

SECURITY:

The Class-D loan will be secured by the following:

- A second priority security interest in the ranch's accounts receivable, livestock, and farm equipment via a UCC Financing Statement and Security Agreement.

The proposed loan will be well-secured with a second security interest in the ranch's assets. As the livestock value provides sufficient collateral for the loan, the ranch's total asset value was not factored in.

GUARANTORS: Brendan L. Balthazar

FINANCIAL CONDITION: SEE EXHIBIT A (CONFIDENTIAL)

REPAYMENT ABILITY: SEE EXHIBIT A (CONFIDENTIAL)

INSURANCE: None

BACKGROUND/ MANAGEMENT ABILITY:

Rory J. Souza is a lifelong Maui native and assisted with his father's cattle operation from an early age. In 2019, he started ranching on his own. His 170-acre pasture is located in the mauka area of Haiku on the rural northwest slope of Haleakala on East Maui. Lease terms are very favorable since the Lessor is the applicant's sister. No compensation is required, and the lease matures on 01/01/ 2041.

Mr. Souza's herd consists of more than a hundred cows, several bulls, and Boer goats. He also owns working horses and a few cattle dogs. Most of the cattle (cows and bulls) are Angus Plus, considered one of the more popular breeds of beef cattle. Calves are typically weaned for 8 to 9 months and shipped at 300 to 450 lbs. to a Texas buyer. Goats are typically weened for 3 months.

Besides running his own ranch, the applicant serves as Brendan Balthazar's right-hand man by managing Diamond B Ranch's pastures and herd, upkeeping irrigation systems, and processing calves from local ranchers prior to shipping.

A few of Mr. Souza's bulls are featured at the Makawao Rodeo. The affair first started in 1956 and is held yearly on the fourth of July. It is Hawaii's largest paniolo competition. Weekend events include a parade and traditional rodeo competitions such as barrel racing, calf roping, and bareback bronco riding, all with a few Hawaiian twists. The rodeo today seeks to perpetuate the history of the ranching era, while showcasing new generations of riders and ropers.

SUMMARY:

Mr. Souza has been involved with ranching since his youth. He is active in community events and has competed in the Makawao rodeo's roping competition for the last 15 years. He possesses the requisite experience to successfully operate his own ranch as evidenced by its financial performance which has improved over the prior 2-year period. The proposed loan is further strengthened by the guarantee of Brendan L. Balthazar whose personal financial condition remains solid.

The proposed loan will assist the ranch by allowing the ranch to get back to the condition it was prior to overgrazing caused by the influx of axis deer.

Benefits to the State include supporting cattle production which is a key contributor to the local economy. Based on cash receipts, beef currently ranks as one of Hawaii's top agricultural commodities. Maui counts about 140 working cattle operations and its beef is said to belong to the best-tasting in the world. It should also be noted ranching represents an important aspect of Maui's cultural heritage as the industry dates back to 1793.

TURNDOWNS:

Loan declinations from other lenders have been waived for emergency loans under $100,000 per the emergency loan parameters approved by the Board of Agriculture on August 23, 2022.

RECOMMENDATIONS: The loan is recommended for approval based on Mr. Souza's ranching experience, history of profitable operations, collateral offered, and guarantee of Brendan L. Balthazar.

Date	Recommended by:
3/29/23	Gareth Mendonsa Business Loan Officer

Date	Reviewed and concurred by:
4/10/23	Morris M. Atta Acting Administrator

Date	Approved for submission
4/10/23	Sharon Hurd Chairperson, Board of Agriculture

A5

State of Hawaii
Department of Agriculture
Agricultural Loan Division

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject: **Loan Presentation**

APPLICANT:

Ink Farm
P.O. Box 93
Hoolehua. HI 96729

Kathereen Kaai
Lloyd Inouye
P.O. Box 93
Hoolehua. HI 96729

CLASSIFICATION & ELIGIBILITY

The applicants meet the eligibility requirements of Hawaii Revised Statutes Chapter 155 as a "Qualified Farmer." Ink Farm was established in 2019. Mrs. Kaai and Mr. Inouye have been farming full time for four years and are life-long Hawaii resident.

COMMODITY: Native Plants and Fruits

CREDIT HISTORY: SEE EXHIBIT A (CONFIDENTIAL)

A10

LOAN REQUEST & PURPOSE:

Amount	Class
$100,000	Direct Class D Operating Loan

Shown below is a breakdown of the loan request.

$59,276	Materials
$19,000	Labor
$12,144	Equipment Rental & Hauling
$90,420	**Total Loan Request**

The loan funds will be used to build a Deer Proof fence around the 35 acre farm which includes approximately 9,200 feet of fence, 10 feet gates, and 10 feet posts. The installation is critical to protect the plants from the deer.

TERMS:

Amount:	$90,420.00
Term:	Ten (10) years
Interest rate:	3.00% per annum, fixed.
Repayment:	No payments for six (6) months, then interest payments of $452.10 per month for six (6) months. Followed by monthly principal and interest of $956.37 until maturity.

The no payment and interest payments are scheduled to assist with cash flow during the installation and regrowth of the plants.

SECURITY:

This loan will be secured as follows:

- First Position Financing statement on all crops, inventory, and accounts receivable.
- First position lien on farm equipment specific interest in the Skytrack forklift 6036, John Deere 2755, Bobcat excavator 331, Case backhoe Super E 580, Kioti CK20 and Kubota tractor B7100. With an estimated value of $83,000.

GUARANTORS: None

FINANCIAL CONDITION: SEE EXHIBIT A (CONFIDENTIAL)

REPAYMENT ABILITY: SEE EXHIBIT A (CONFIDENTIAL)

INSURANCE: Liability

BACKGROUND/ MANAGEMENT ABILITY:

Kathereen Kaai and Lloyd Inouye have been together for 37 years. Mrs. Kaai grew up on Molokai and Mr. Inouye on Maui on his family's farm until relocating to Molokai. They have raised a family and ran a construction company for most of the years following.

In 2018 they turned their attention to building a farm that raises nursery plants on 35 acres in Hoolehua. Installing farm infrastructure such as water lines that dissect the acreage and planted an orchard. The water line gives access throughout the entire property. They planted ulu, kou, pines, citrus, papaya, and avocados. Their markets are direct to consumer and wholesale to a local market.

When the drought began, they were regularly irrigating which attracted the deer. They have tried a variety of fencing solutions to shield their plants against the deer. Under the guidance of NRCS, Mr. Inouye installed an 8-foot fence around a 5.5-acre field for the native plants. The deer have broken part of the fence where the sea spray weakened the wire. They plan to fix this with a stronger material.

Before becoming a full-time farmer, Mr. Inouye owned and managed a construction company. His son has since taken over the day-to-day. After the years of repeated destruction from deer, their plant inventory is low. To stabilize their farm income, they offer farm service and equipment rentals. Mr. Inouye has returned to working for his family's construction company and will continue until the farm income improves. Their lifestyle is modest, and his extra income will sufficiently cover living expenses.

SUMMARY:

Mrs. Kaai and Mr. Inouye are experienced farmers with years of experience beyond that of Ink farm. As seasoned business operators they are agile problem solvers.

The farm has suffered from significant damage from the over population of Axis deer in combination with drought conditions. During my farm inspection deer crossed our path twice. The 5.5-acre fenced area has some survivor stock however most of the plants have been pulled closer to their home. The equipment appeared well maintained.

The proposed loan will fund the installation of 9,200 feet fencing and gates to protect their plants. The loan will be secured with a first position lien on farm equipment, accounts, and inventory. The farm has sufficient historical cash flow to service the proposed debt. Mr. Inouye additional off farm income alleviates some risk for HDOA.

TURNDOWNS:

Turndowns for emergency loans $100,000 and under have been waived by the board of Agriculture.

RECOMMENDATIONS: Approval of this request is recommended based on their farming experience, the historical year over year growth in revenues of the farm, collateral offered, and good credit rating.

Date

4/5/23

Recommended by:

Jillian C. Scheibe
Agricultural Loan Officer I

Date

4/6/23

Reviewed and concurred by:

Morris Atta
Acting Division Administrator

Date

4/10/23

Approved for submission:

Sharon Hurd
Chairperson, Board of Agriculture

A13

State of Hawaii
Department of Agriculture
Agricultural Loan Division

April 25, 2023

Department of Agriculture
Honolulu, Hawaii

Subject: **Loan Presentation**

APPLICANT:

Douglas Clive Drew & Pearl Garcia Drew, Trustees of the Douglas Clive Drew and Pearl Garcia Drew Living Trust dated February 27, 2015.

2211 Omaopio Rd.
Kula, HI 96790

CLASSIFICATION & ELIGIBILITY

The applicant meets the general eligibility requirements of section 155-10 and as a "qualified farmer" as cited in 155-1 of the Hawaii Revised Statutes. Douglas "Clive" Drew is a qualified farmer and a Hawaii resident for 22-years since 2000. Pearl Garcia Drew (spouse) has been a Hawaii resident for 22-years since 2000.

Clive currently serves as an elected board member of the Maui Coffee Association. His international agricultural experiences in Africa as plantation farm manager with crops including coffee, tropical fruits, livestock, and various value chains are shared with over a dozen local coffee farmers engaged in the UH Cooperative Extension programs.

COMMODITY: Coffee, Fruit Trees, Sheep and Goats

CREDIT HISTORY: SEE EXHIBIT A (CONFIDENTIAL)

OTHER STATE AGRICULTURAL LOANS: None

A17

LOAN REQUEST & PURPOSE:	AMOUNT	CLASS D
	$100,000	Axis Deer Emergency

This request will allow the borrowers emergency axis deer funding to purchase fencing materials and labor to build deer fencing around the 13.987-acres of farmland at 2211 Omaopio Rd in Kula, Maui.

$33,000	Farm Down Payment to Miranda Fencing
$ 8,000	Farm Labor and Equipment Contribution
$33,500	This Request 1st Disbursement to Miranda Fencing
$66,500	This Request 2nd Disbursement to Miranda Fencing
$141.000	EM Deer Fencing Omaopio Farm

TERMS:

Amount	Class D – Emergency Operating Loan
Amount:	$100,000
Term:	10 years
Interest:	3.0%

Repayment: Monthly principal, and interest payments of $956 will be required till maturity.

SECURITY:

The Douglas Clive Drew and Pearl Garcia Drew Living Trust dated 2/27/2015 defines "Trust Property" as follows:

1. Personal Property
   All of Douglas Clive Drew's and Pearl Garcia Drew's right, title, and interest in and to all tangible personal property now and hereafter acquired, of whatever kind and wherever situated.

2. Real Property
   An interest in the following real property:

   TMK: (2) 2-3-003-174
   2211 Omaopio Rd
   Kula Hawaii 96790

This request is secured by personal property including farm and farming assets withing the Douglas Clive Drew and Pearl Garcia Drew Living Trust dated 2/27/2015 as follows:

- First Position UCC blanket security interest in all accounts receivables, chattel paper, documents, instruments, money deposit accounts, contract rights, goods, aquatic plants and animal life now growing or grown, or which are hereafter acquired by stocking, natural increase, substitution, replacement, or addition from and after the date of this agreement in ponds or other bodies of water. interest and financing statement in accounts receivable, livestock, inventory, and farm equipment.

GUARANTORS: None

FINANCIAL CONDITION: SEE EXHIBIT A (CONFIDENTIAL)

REPAYMENT ABILITY: SEE EXHIBIT A (CONFIDENTIAL)

INSURANCE: Liability Insurance.

BACKGROUND: Douglas "Clive" Drew is an agribusiness specialist with more than 40 years of experience in farm, cattle range, livestock management, agricultural production, post-harvest handling, agro-processing, and marketing. He graduated in 1970 from the College of Tropical Agriculture at UH Manoa in Agriculture & Resource Economics and completed his PhD coursework and dissertation in 1973.

In 1994, Clive prepared a Strategic Plan for the Ulupalakua Ranch, Inc that included a succession plan and ranch management restructuring. Clive said his experience at Ulupalakua Ranch and Haleakala Dairy helped him to develop a vision of becoming a farmer on Maui.

In 2008, Clive and Pearl owned a 2-acre farm on Kekaulike Ave in Kula that included several mature fruit trees with avocado, mango, banana, papaya, and lychee. The farm regularly sold fresh fruits at the local farmer's markets. When the couple took an assignment in East and Southern Africa, the farm was tended by a tenant who continued to maintain the fruit trees and sell the fruits on behalf of the owners. In Africa, Clive worked as a contractor to manage agricultural development projects for USAID, World Bank, UN, Danish, Netherlands, and UK donor programs. Pearl worked as a diplomat with the U.S. State Department.

In 2014, the couple returned to the Kekaulike farm with Clive resuming his agricultural consulting services by providing technical input on agricultural project bid proposals, market systems and value-added products. Clive and Pearl also worked to build their new residence and farm on 13.987-acres of farmland situated at 2211 Omaopio Rd in Kula. The main dwelling and residence was completed in October 2021 and the couple moved in soon after. In 2022, Clive and Pearl sold their former Kekaulike farm and residence.

At the new Omaopio residence, Clive began farm activities by fast-tracking permanent tree crops, removing 3-acres of rocks and stumps, ripping plant lines, soil testing for basal fertilizer application and installing a drip irrigation/fertigation system. Plans were made to raise "low maintenance" grazing meat goats with a caretaker friend doing the handling and marketing activities. Then came the explosion of axis deer that wrecked the fences and allowed the goats to escape onto Omaopio road and neighboring properties. This created a liability hazard, so the goat meat enterprise was abandoned. The deer problem also forced the farm's mauka neighbor to abandon his crops, turning both farms into a daytime deer refuge. To combat the deer, Clive has acquired a colleague to harvest the deer via bow hunting to reduce liability.

The axis deer population has expanded at an exponential rate, and they are physically present 24/7 consuming the coffee and wrecking the fruit trees with bucks rubbing the tree bark with their antlers. The farm is also unable to plant edible landscaping and a vegetable garden until the farm is secured with fencing enclosures to harvest any axis deer intruders that breach the fence. With the current severe drought conditions, the farm has become a refuge for the axis deer since there is no barriers for the permanent grazing herds of 50-170 axis deer that are also denuding the gulch area and exposing it to erosion when it rains. Clive's neighbors becoming are concerned that the farm is harboring the axis deer and that are introducing invasive weed species.

Clive discovered the cost for deer fencing is a real shock and it's a "take it or leave it" proposition with fencing contractors. Miranda Fence Company quoted $133,000 for (materials & labor) plus and estimated $8,000 for fence line that includes uprooting and disposal of the old fencing and clearing the fence line that we can also maintain through mowing and weed whacking as a firebreak and as a deterrent to axis deer busting through the deer fence for a total estimated cost of $141,000. Clive will contribute his efforts to "make-ready" by using the farm's John Deere backhoe, chain saw and his sweat equity. They intend to hire a contractor with an excavator for the more challenging portions.

SUMMARY:

The current plan once the deer fence is installed, is to undertake perennial cropping of coffee intercropped with sweet banana with adjacent areas devoted to a cornucopia of tropical fruits and nuts. The farm has propagated 1,100 coffee seedlings and have booked another 1,100 coffee seedlings from neighboring Howard's nursery. Clive said these crops require daily hands-on husbandry and has chosen not to place the seedlings in the fields until the fences are in place and with all the boots on the ground to act.

With complete boundary fencing, cross-fencing, regular surveillance, repair, and invasive axis deer harvesting the farm will be able to mitigate the axis deer problem. Cross-fencing into three paddocks will divide the farm into a central portion to the coffee, fruit trees and the forever farm dwelling, the northern portion to bore goat raising and the southern portion to dorper sheep raising.

From a climate change perspective, the farm will maintain the savannah keawe/grassland landscape utilizing responsible stocking rates, mitigate the erosion hazard caused by axis deer that are using the gulch as a refuge, and the permanent tree crops shall preserve carbon sequestration and CO_2 utilization through plant photosynthesis. The farming enterprise represents both economic diversity and biodiversity. Two beehives shall also be introduced once the coffee and fruit trees reach flowering maturity.

TURNDOWNS:

This $100,000 Axis Deer Emergency Loan Program request does not require a commercial loan denial(s).

A20

A 21

RECOMMENDATIONS: Approval of this request is recommended due to the strong financial position of the borrowers and their exemplary agricultural education, background, and experiences. Secondary sources of repayment that includes a first position UCC blanket security on farm assets. The borrowers also possess excellent credit scores sufficient to support this emergency loan.

Date

4/10/2023

Recommended by:

Wayne S. Takamine
Business Loan Officer I

Date

4/10/23

Reviewed and concurred by:

Morris Atta
Acting Division Administrator

Date

4/10/23

Approved for Submission

Sharon Hurd
Chairperson, Board of Agriculture

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject:	REQUEST FOR ACCEPTANCE OF ANNUAL LEASE RENT AS DETERMINED BY INDEPENDENT APPRAISAL AND CONSENT TO ASSIGNMENT OF GENERAL LEASE, RONALD P. WEIDENBACH DBA HAWAII FISH COMPANY, ASSIGNOR, TO HAWAII FISH COMPANY INC., ASSIGNEE; TMKS: (1) 6-9-001:002, 003 AND 036; KAENA, WAIALUA, ISLAND OF OAHU, HAWAII
Authority:	Sections 166E-6 and 8, Hawaii Revised Statutes (HRS), and Sections 4-158-19(3), (4) & (5), Hawaii Administrative Rules (HAR)
Lessee/Assignor:	Ronald P. Weidenbach DBA Hawaii Fish Company
Assignee:	Hawaii Fish Company Inc.
Land Area:	147.464 Acres
Tax Map Key:	(1) 6-9-001:002, 003 and 036 (Exhibit "A")
Land Status:	Management Jurisdiction transferred by Governor's Executive Order No. 4682 to the Department of Agriculture for Non-Agricultural Park Lands purposes in 2022
Lease Term:	65 years
Appraised Rent:	$2,419.00 per year
Character of Use:	Diversified Agriculture

REMARKS:

Ronald P. Weidenbach DBA Hawaii Fish Company was issued Revocable Permit No. S-6814 by the Board of Land and Natural Resources in 1992. On September 14, 2022, Revocable Permit No. S-6814 was set aside to the Department of Agriculture for management purposes via Governor's Executive Order No. 4682. At its November 29, 2022 meeting, the Board of Agriculture approved the conversion of Revocable Permit No. S-6814 to a new sixty-five (65) year lease with the character of use as Diversified Agriculture, subject to approval of the annual lease rent appraisal.

B-1

B-2

An appraisal was done pursuant to Section 4-158-21, HAR, for the purpose of determining the fair market rental for the subject parcels for the converted lease. The Department of Agriculture contracted ACM Consultants, Inc., to determine the fair market annual base rental and additional rents for the initial fifteen (15) year term of the new lease. The appraised annual rental for the new lease is $2,419.00 per year or 1.5% of gross sales, whichever is greater. The appraised annual rental for this lease will be applied to the effective date of the lease. In accordance with Section 4-158-8(b)(4), the lessee shall also pay an annual premium equal to 25% of the annual base rental for a period not to exceed seven (7) years.

Mr. Weidenbach requests consent to assign the new lease to Hawaii Fish Company Inc., a domestic corporation, as the business form changed from a sole proprietorship to an incorporated company. The provisions of Section 166E-8(b)(5), HRS, and Section 4-158-19(a)(3), HAR, require Board approval for assignments or other transfers of interest. The applicant meets the farming experience and residency requirements pursuant to Sections 4-158-1 and 4-158-27, HAR.

There is no consideration for the assignment of the new lease.

RECOMMENDATION:

That the Board of Agriculture accept the fair market rental of $2,419.00 per year for TMK: (1) 6-9-001:002, 003 and 036 for a new lease, and consent to assign the new lease to Hawaii Fish Company Inc. All documents are subject to the approval as to form by the Department of the Attorney General, and such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

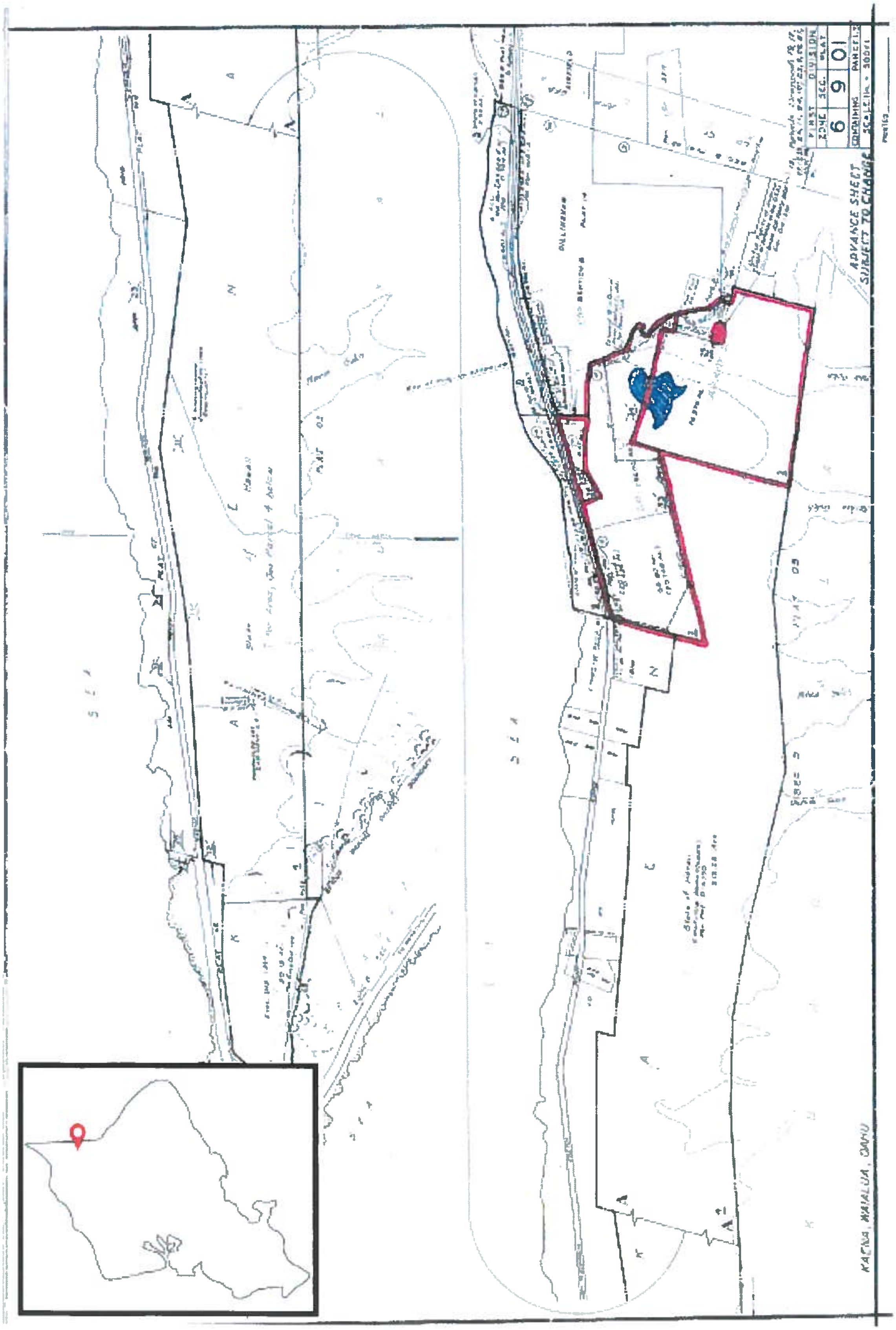
BRIAN KAU, P.E.
Administrator and Chief Engineer
Agricultural Resource Management Division

Attachments - Exhibit "A"

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

EXHIBIT "A"



B-3

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject:	REQUEST FOR CONSENT TO AMEND GENERAL LEASE NO. S-3138; HAWAII LAND & LIVESTOCK, LLC, LESSEE; TMK: (1) 9-1-031:001, HONOULIULI, EWA, ISLAND OF OAHU, HAWAII
Authority:	Section 166E-6, Hawaii Revised Statutes (HRS) as amended, and Section 4-158-2(a)(2), Hawaii Administrative Rules (HAR), as amended
Lessee:	Hawaii Land & Livestock, LLC
Land Area:	110.016 acres
Tax Map Key:	(1) 9-1-031:001 (see Exhibit "A")
Land Status:	Encumbered by Governor's Executive Order No. 4584 to the Department of Agriculture for agricultural park land purposes dated May 15, 2019
Lease Term:	January 1, 2020 through December 31, 2055
Current Rent:	$18,300.00 per year until the rental reopening on 1/1/2035
Permitted Use:	Diversified Agriculture including feed lot purposes

BACKGROUND:

General Lease No. S-3138 (the Lease) was awarded by direct negotiation to Hawaii Land & Livestock, LLC (HLL) commencing January 1, 2020 for diversified agricultural, which included feedlot use. The HLL parcels are located adjacent to each other and the feedlot parcel supports the harvest facility and is also crucial for water allocation purposes. The harvest facility is the only USDA certified facility on Oahu.

B-4

B-5

HLL is requesting an amendment to paragraph 7 of the Lease to give them three additional years to complete development of the parcel pursuant to a revised Plan of Utilization to be approved by the Department of Agriculture.

Approximately two months after the Lease was executed, the negative impacts of the COVID-19 pandemic drastically altered daily life activities worldwide. In the State of Hawaii, Federal and State government COVID-19 restrictions and regulations forced the closures of schools, restaurants, retail stores, other business establishments. These new government restrictions severely impacted businesses and forced owners to redirect their priorities to remain profitable. Many of the businesses who survived the several years of the pandemic shut down used alternative business practices that aided in their financial survival.

Since the Lease commencement date of January 1, 2020, HLL also had to pivot and find resourceful ways to continue business endeavors to remain viable as a business entity. HLL encountered the following obstacles that have impeded their efforts in the development of the feedlot, in accordance with their current lease agreement.

1. Due to the impact of the COVID pandemic government restrictions, HLL had to redirect and reorganize business priorities away from the feedlot and postpone its development schedule. All HLL finances and efforts were then focused on (1) increasing the harvesting and processing operations located on the adjacent harvest facility lot, under General Lease No. S-8500, to benefit the public need for food and (2) keeping its employees safe. HLL believed that the development of its new project, the Feedlot, was not wise with all the uncertainty in the marketplace at that time. Ramping up the harvest facility operations were essential to the public food supply and supporting the ranching community in Hawaii. The Hawaii Cattle Industry, with guidance from Hawaii Cattlemen's Council, requested that HLL focus on the expansion of the harvest and processing build out area. During this pandemic period, the community voiced concerns on the shortage of critical food supply chains and it was imperative that Hawaii food producers needed to get local products out to the community, due to the high dependence of imported food products. The harvest facility doubled its harvest numbers to feed the public and help maintain income for the ranchers of the Hawaii cattle industry.
2. COVID-19 government restrictions on transportation and shipping limited the amount of available cattle feed to support a feeding operation for cattle. Hawaii is heavily dependent on imported livestock feed for its animals. Additionally, these restrictions halted the shipment of calves to the mainland which ranchers depend on as a primary source of income, therefore increasing the need for local slaughter of the mature animals. Due to these restrictions, HLL prioritized local slaughter initiatives to ensure the livelihood of the cattle industry.
3. When HLL was informed of DLNR's interest in developing an agreement with a solar energy company (Eurus Energy) to lease portions of the feedlot, HLL cautiously halted development in fears that the lease could be cancelled.

HLL kept DOA informed about the various obstacles that delayed the development of the feedlot.

In 2022, HLL felt confident to move ahead with developing the feedlot with revised plans to bring the property back to a positive agricultural site. HLL had the property surveyed and commenced with clearing the premises of invasive vegetation, abandoned derelict vehicles and heavy equipment, rusting metal from the previous feedlot use, and various other debris that had accumulated during its many years of remaining vacant. Approximately 60% of the premises has been cleared. HLL has submitted an updated plan of utilization and development (PUD) to more efficiently utilize the premises for various agricultural activities taking into consideration various lessons learned as a result of the COVID-19 pandemic crisis.

During the COVID-19 crisis the harvest facility significantly increased its output capacity to meet the demand for local products. This increased activity by the harvest facility impacted and required revisions to the planned use for the feed lot. It was calculated that portions of the entire 110 acres could be used for agricultural activities other than feedlot purposes. Consequently, HLL has submitted a revised PUD. In addition to cattle holding corrals, alternative agricultural activities will be developed to include farming of feed for livestock (BanaGrass and layered sprouted grains) and development of a hog harvesting facility to assist the struggling hog industry in Hawaii. Should the hog harvesting facility not receive adequate support, however, the backup plan is to expand the farming of livestock feed areas. The proposed activities of farming feed for livestock and development of the hog havesting facility would both be documented through subleases, subject to approval by the BOA in separate submittals and subject to approval of this request to amend the lease. Any change in use may not violate DLNR's right to utilize the parcel for solar power.

The COVID-19 pandemic has severely impacted businesses in Hawaii, resulting in development setbacks and requiring revisions to operations to survive and move forward towards success. HLL has had to reorganize and redirect the focus of its business operations resulting in delays related to development of the feedlot as originally planned. Staff believes there have been reasons for the delay in development outside the control of HHL, that HHL has made good faith efforts to begin development, and that HHL has a practical plan to complete development within a reasonable period of time

Consequently, staff is recommending that paragraph "7. *Utilization and development of the demised premises*" of the Lease be amended as follows:

7. Utilization and development of the demised premises. The development of the demised premises shall be completed within six years from the commencement date of this lease, in accordance with a Plan of Utilization and Development (P.U.D.) and schedule therein which shall be prepared by the Lessee and approved by the Department of Agriculture before the execution of this lease. Any modification or deviation from the plan or the schedule, without the prior written approval of the Department of Agriculture, may constitute a breach of this lease

B-6

B-7

and cause for the termination thereof. Agricultural activity modifications and deviations from the plan may be made by the Lessee provided that such modifications and deviations are within the definition of Diversified Agriculture and in compliance with the provisions of the Lease.

RECOMMENDATION:

That the Board of Agriculture approve amending General Lease No. S-3138, Hawaii Land & Livestock, LLC, Lessee, Paragraph *7. Utilization and development of the demised premises*, due to extenuating circumstances that prevented the Lessee from performing in accordance with the original lease provisions, as follows:

7. Utilization and development of the demised premises. The development of the demised premises shall be completed within six years from the commencement date of this lease, in accordance with a Plan of Utilization and Development (P.U.D.) and schedule therein which shall be prepared by the Lessee and approved by the Department of Agriculture before the execution of this lease. Any modification or deviation from the plan or the schedule, without the prior written approval of the Department of Agriculture, may constitute a breach of this lease and cause for the termination thereof. Agricultural activity modifications and deviations from the plan may be made by the Lessee provided that such modifications and deviations are within the definition of Diversified Agriculture and in compliance with the provisions of the Lease.

All documents shall be subject to review and approval as to form by the Department of the Attorney General.

Respectfully submitted,

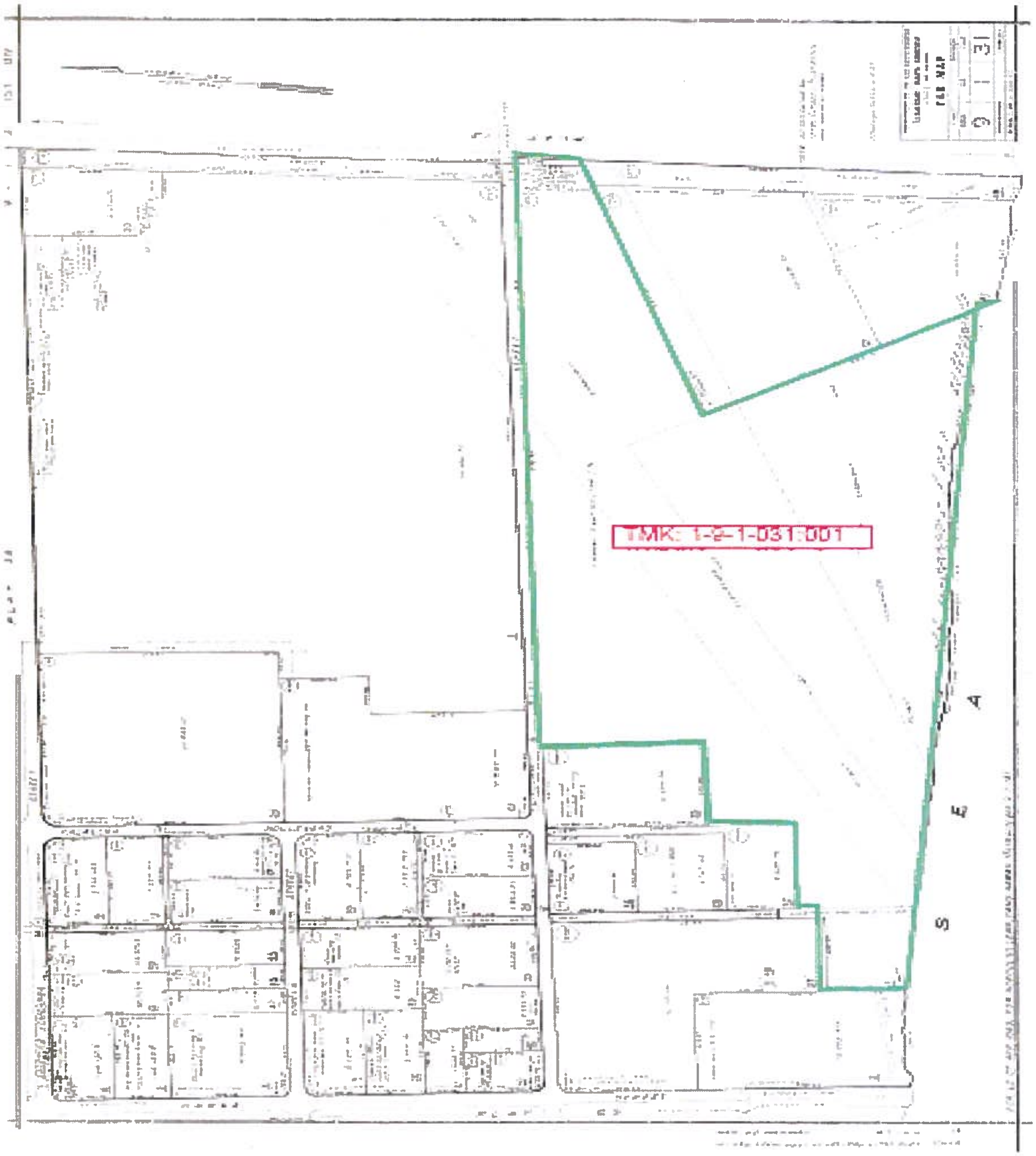
BRIAN KAU, P.E.
Administrator,
Agricultural Resource Management Division

Attachment – Exhibit "A"

APPROVED FOR SUBMISSION

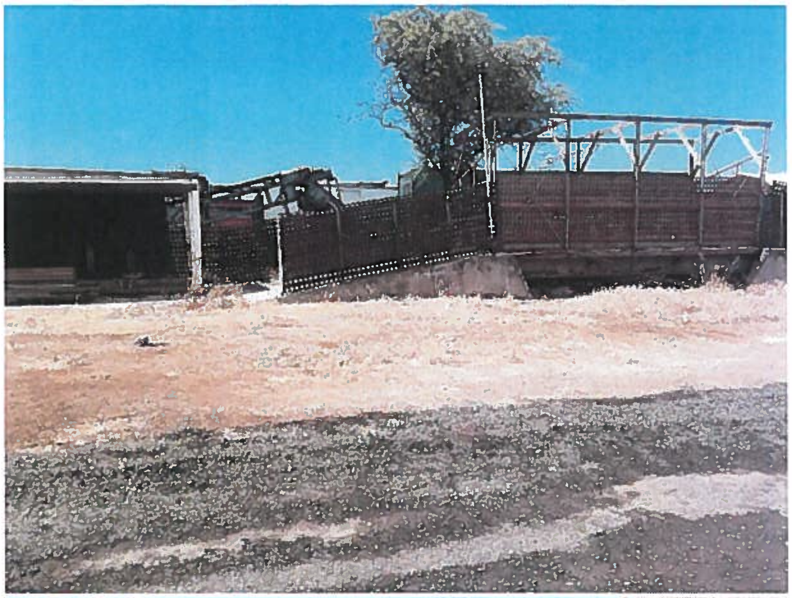
SHARON HURD
Chairperson, Board of Agriculture

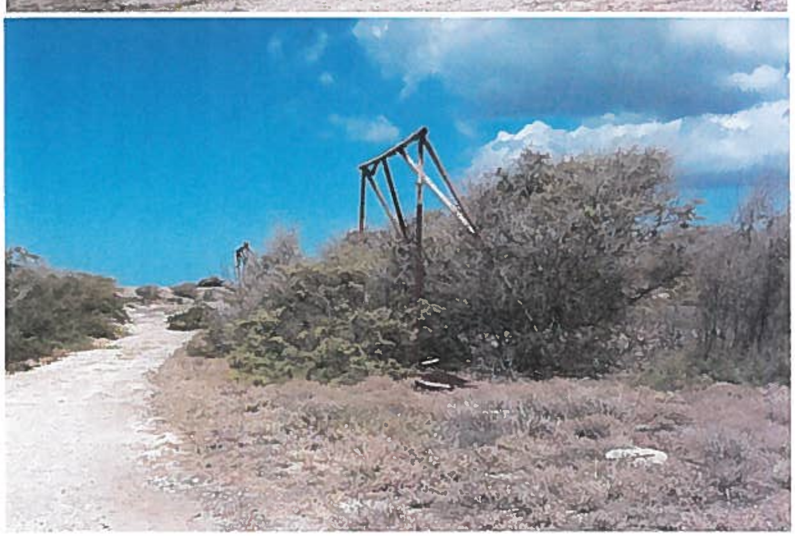
EXHIBIT "A"



B-8

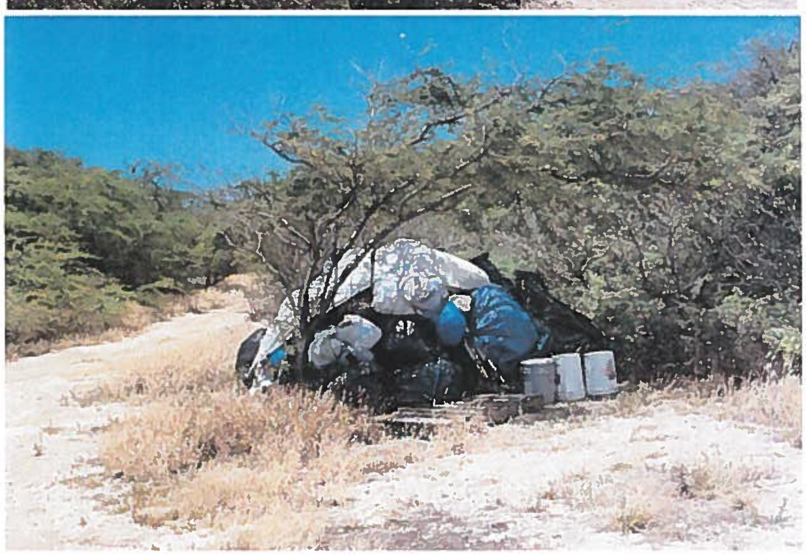
B-9





B-10

B-11



STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject: REQUEST TO 1) TERMINATE GENERAL LEASE NO. S-9001, JANE KELLY LAVOIE, LESSEE; ISSUE CANCELLATION DOCUMENT, AND DISPOSITION OF LOT; AND (2) RESCIND APPROVAL OF FARM DWELLING; TMK: (2) 5-2-001:011, LOT NO. 2, MOLOKAI AGRICULTURAL PARK, HOOLEHUA, ISLAND OF MOLOKAI, HAWAII

Authority: Section 166-6(b), Hawaii Revised Statutes (HRS), and Sections 4-153-3(b)(3) and 34, Hawaii Administrative Rules (HAR)

Lessee: Jane Kelly Lavoie

Land Area: Approximately 25.304 acres

Tax Map Key: (2) 5-2-001:011 (Exhibit "A")

Land Status: Encumbered by Governor's Executive Order No. 3696 to the Department of Agriculture for agricultural park land purposes in 1996

Lease Term: 35 years, October 1, 1998 to September 3, 2033

Current Rent: $1,900.00 per year

Character of Use: Diversified Agriculture

BACKGROUND:

General Lease No. S-9001 (the Lease) was originally awarded to Jerome J. Kennedy aka Joe Kennedy in 1998. At a meeting held on August 27, 2019, the Board approved an assignment of lease to Jane Lavoie who planned to produce lilikoi and asparagus. Lilikoi is used in her value-added product called Passion Pudding for which she has a patent.

The Lessee currently is in default with a lease rent balance due of $4,378.00, owing delinquent real property taxes of $4,466.85, as of this date, and expired general liability insurance coverage. Numerous notices have been sent to the Lessee demanding payment to remedy the delinquencies including issuance of monthly lease rent invoices showing accumulating balances due with interest fees. Letters demanding remedy of various lease violations have been sent. All efforts to work with the Lessee have been exhausted and no lease rent payments have been received from Ms. LaVoie since January 2021.

B-12

B-13

Staff deems the Lessee to be in breach and default of this lease due to numerous violations of the lease. The account is uneconomical and impractical to remedy and collect and recommends referral of the account to the Office of the AG to expedite resolution of the outstanding lease rent balance due.

Additionally, Staff recommends rescinding prior Board approval of a farm dwelling on the premises that was granted at a meeting held on August 12, 2020. The lessee was to repair and renovate an existing, County permitted farm dwelling on the premises. It was reported by the Lessee's representative that, over time, illegal trespassers stripped the dwelling of all its exterior and interior doors, all windows including any frames, kitchen and bathroom fixtures, plumbing, etc. and anything that could be removed from the dwelling rendering it a safety hazard. The lessee will be required to demolish the dwelling.

RECOMMENDATIONS:

That the Board of Agriculture:

1. Approve the cancellation of General Lease S-9001, pursuant to Sections 4-153-3(b)(3) and 34, HAR, and cancellation of all right, title, and interest granted to the Lessee therein effective as of the date of approval of this submittal.
2. Authorize issuance of a lease cancellation document to be executed by the chairperson and recorded at the Bureau of Conveyances;
3. Rescind the prior Board approval of the farm dwelling at a meeting held on August 12, 2020;
4. Authorize staff to prepare TMK: (2) 5-2-001:011 for disposition by public notice, pursuant to Sections 4-153-19 and 22, HAR; and
5. Approve the request to refer General Lease No. S-9001 as a delinquent account to the Office of the Attorney General for review and disposition in accordance with Section 40-82, Hawaii Revised Statutes.

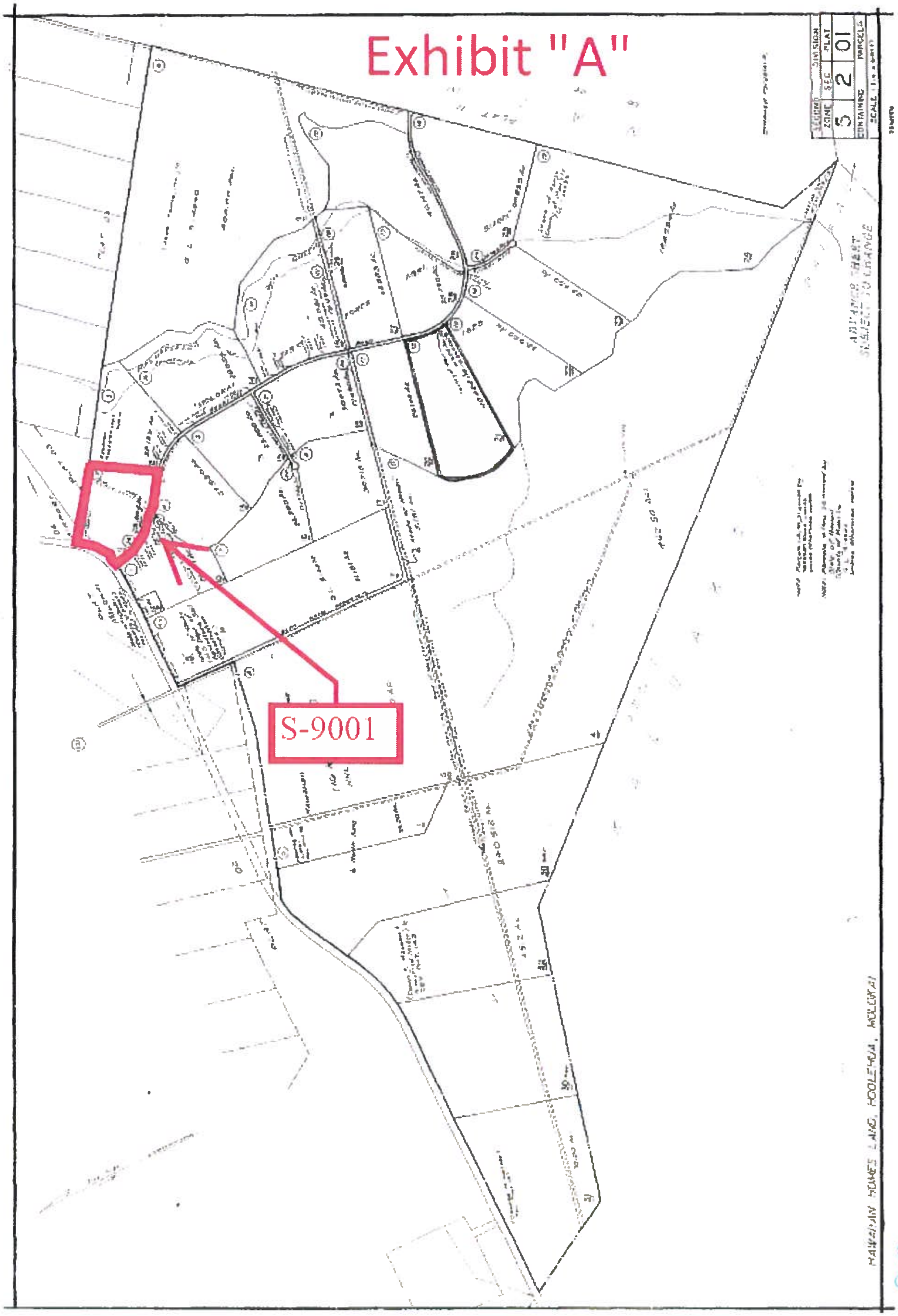
All documents are subject to the approval as to form by the Office of the Attorney General, and such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

BRIAN KAU, P.E.
Administrator and Chief Engineer
Agricultural Resource Management Division

Attachment - Exhibits "A" and "B"
APPROVED FOR SUBMISSION:

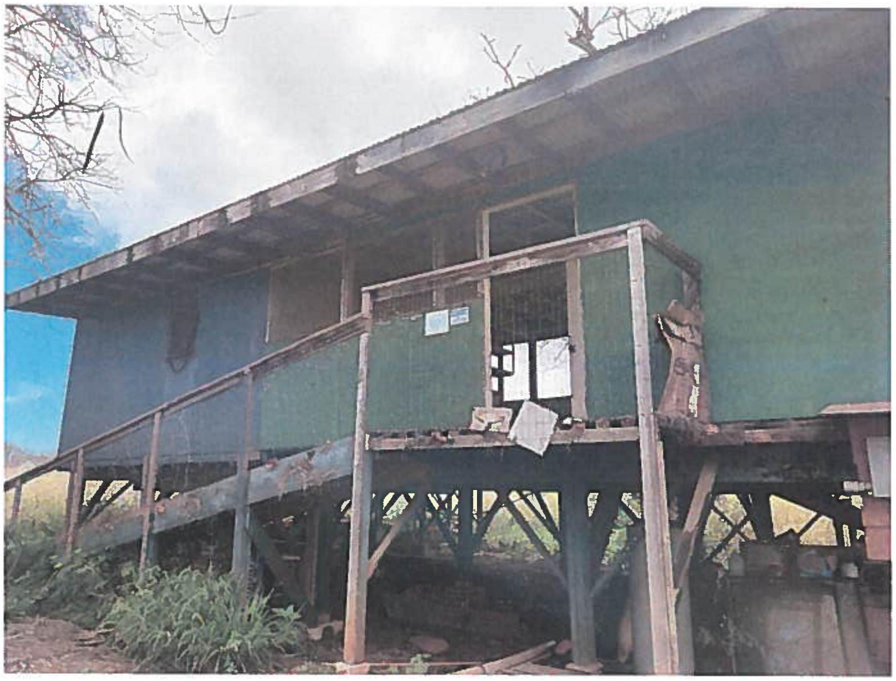
SHARON HURD
Chairperson, Board of Agriculture



B-14

B-15

Exhibit "B"



STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject:	REQUEST FOR CONSENT TO ASSIGNMENT OF GENERAL LEASE NO. S-4829; WILLIAM HANSON AND HENRIETTA HANSON, LESSEE/ASSIGNOR; JUNGLE MIST ORCHIDS, LLC, ASSIGNEE; TMK: 3rd DIV/1-5-116:034, LOT 7, PAHOA AGRICULTURAL PARK, PUNA DISTRICT, ISLAND OF HAWAII, HAWAII
Authority:	Section 166-7 Hawaii Revised Statutes, (HRS), and Section 4-153-33(a)(6)(B), Hawaii Administrative Rules (HAR)
Lessee/Assignor:	William Hanson and Henrietta Hanson
Assignee:	Jungle Mist Orchids, LLC
Land Area:	5.002 acres
Tax Map Key:	3rdDiv/1-5-116:034 (Exhibit "A")
Lease Term:	45-years, July 1, 2004, through June 30, 2049
Land Status:	Encumbered by Governor's Executive Order No. 3380, dated February 26, 1988, to the Department of Agriculture for Agricultural Park Purposes
Annual Base Rent:	$700.00 per year (until 7/1/2029 re-opening)
Character of Use:	Diversified Agriculture or Aquaculture purposes
Consideration:	$20,000.00

BACKGROUND:

The Board of Agriculture (BOA) awarded General Lease No. S-4829 to William Hanson and Henrietta Hanson commencing on July 1, 2004.

Since the execution of General Lease S-4829, William and Henrietta grubbed and cleared the subject property and planted mango, avocado, and Samoan coconut trees. In 2018, the Kilauea eruption caused major disruption in the Lessee's ability to maintain the subject property and on August 23, 2021, Henrietta Hanson passed away.

Due to an unforeseen disability, William Hanson is no longer physically able to farm the property and is therefore, requesting the assignment of General Lease S-4829 to Jungle Mist Orchids, LLC.

B-16

B-17

Pursuant to the terms of General Lease No. S-4829 and Section 4-153-33(a)(6)(B), HAR, an assignment of lease is permitted due to physical disability.

Caleb Houck is the sole owner and operator of Jungle Mist Orchids, LLC, since its inception in August 2007, where he grows a variety of orchids. Prior to opening his business, Mr. Houck spent 3 years as a farm laborer for Kalapana Tropicals, Inc.

Mr. Houck would like to utilize the subject property to expand on his current orchid nursery. Additionally, he plans to cultivate various fruit trees, such as, mango, avocados, coconuts, lychee, cacao, breadfruit, peach palms, bananas and coffee.

Jungle Mist Orchids, LLC qualifies as an agricultural company with more than 75 percent of its officers qualifying as a Bona fide farmer. Caleb Houck, the sole owner of Jungle Mist Orchids, LLC, qualifies as a Bona Fide Farmer with more than two (2) years of full-time farming experience and satisfies the eligibility requirements pursuant to Sections 4-153-1 and 13, HAR.

There is a consideration of $20,000.00 for the assignment of lease. This consideration includes 6 mature fruit-bearing mango trees, 14 mature fruit-bearing avocado trees and 26 mature fruit-bearing Samoan coconut trees. The value of these trees is estimated at $30,700.00. In accordance with Paragraph 16. Assignments of lease, lease interest, etc., of General Lease S-4829, any net proceeds are subject to a premium percentage charge benefitting the lessor. In this case, calculations in accordance with this provision net $0.00 to the Lessor (see attached Exhibit "B").

RECOMMENDATION:

That the Board of Agriculture approve the assignment of General Lease S-4829 from William Hanson and Henrietta Hanson, Lessee/Assignor, to Jungle Mist Orchids, LLC, Assignee. All related documents are subject to the review and approval as to form by the Department of the Attorney General, and such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

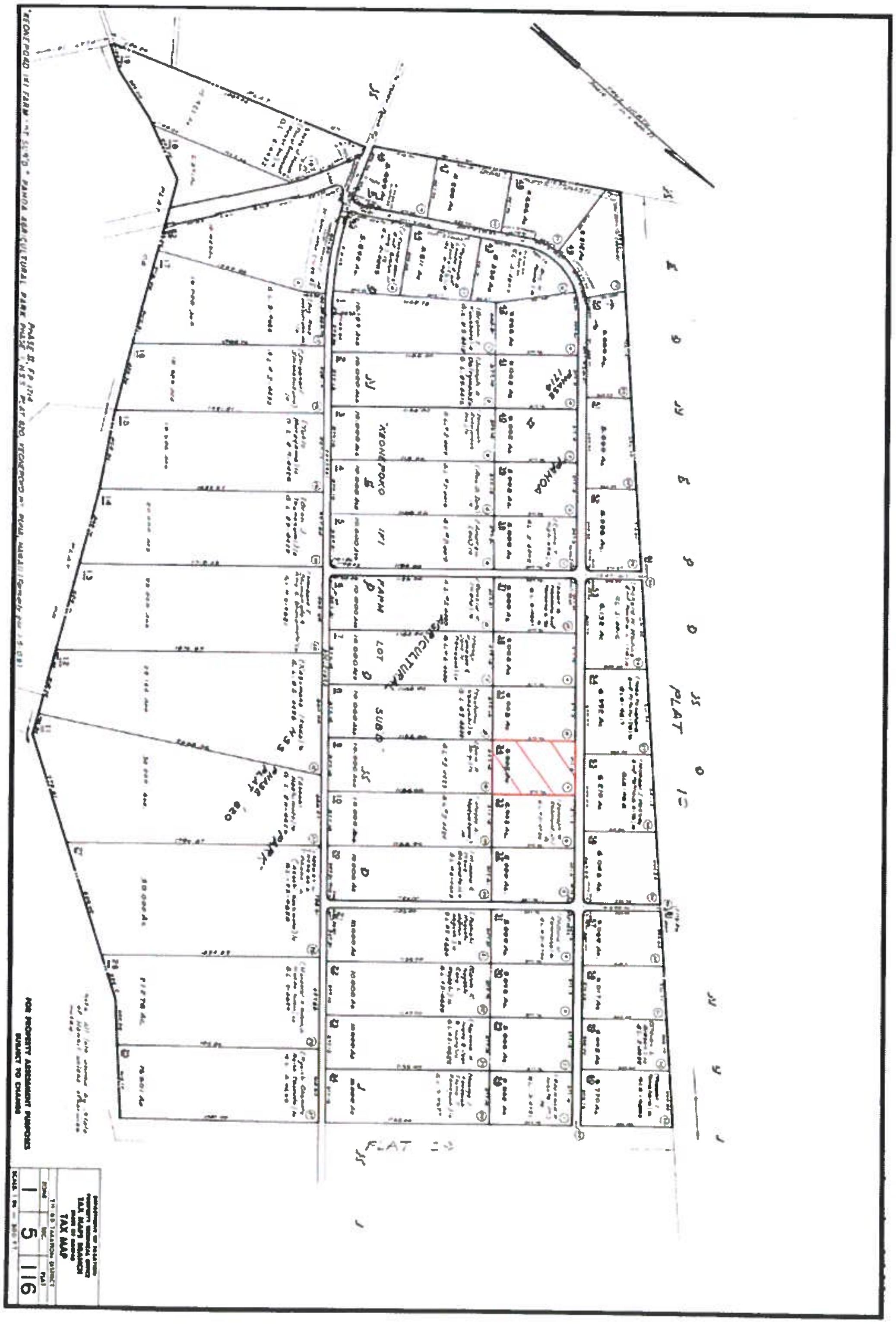
BRIAN KAU, P.E.
Administrator and Chief Engineer
Agricultural Resource Management Division

Attachments - Exhibits "A" and "B"

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

EXHIBIT "A"



B-19

EXHIBIT "B"

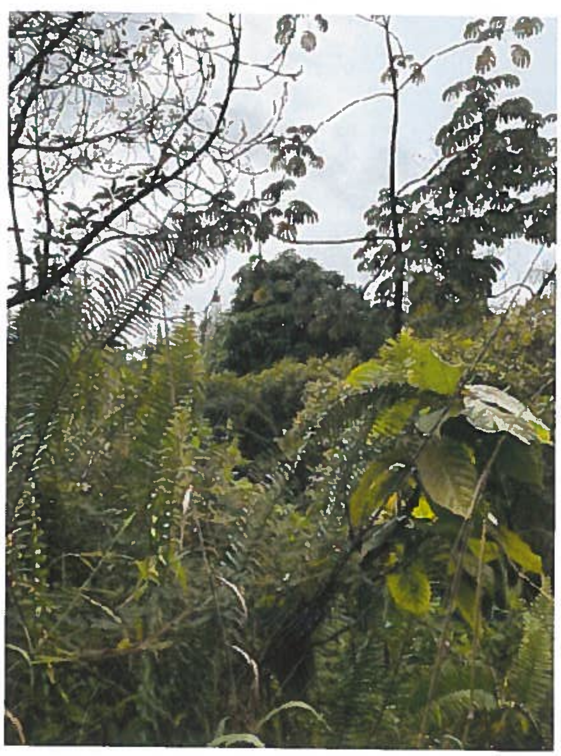
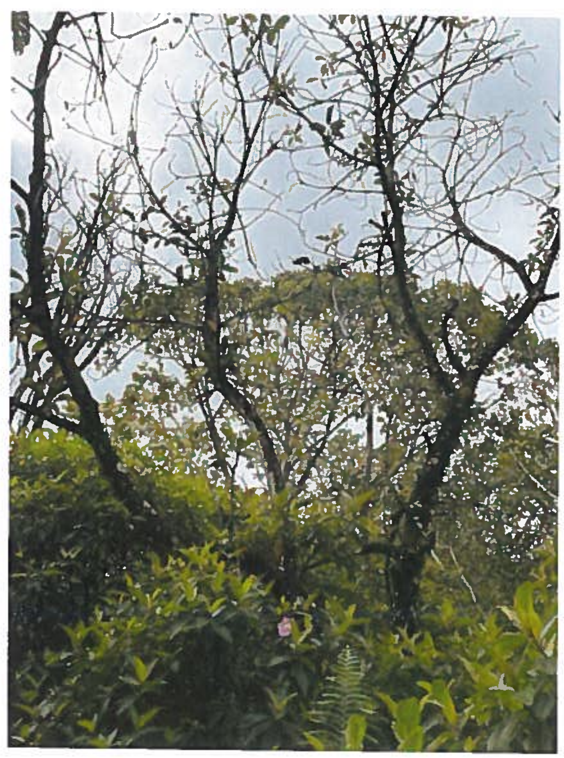
ASSIGNMENT OF LEASE CALCULATIONS FOR
GENERAL LEASE NO. S-4829

Adjusted Depreciation Cost of Improvements or Renovations

Total Consideration:	$ 20,000.00			
Less: Inventory	$ 30,700.00			
Net Consideration:	$ (10,700.00)			
Actual Cost:	$0.00			
CCI (most recent):	n/a			
CCI (base):	n/a			
Expired Term:	266			
Whole Term:	540			
1. Adjusted Cost of Improvments or Renovations:				
	Actual Cost x CCI (most recent)/CCI (Base)			
	CCI (recent)	n/a		
	CCI (base)	n/a		
	CCIR/CCIB			
	Actual Cost x CCI(R)/CCI(B) =			
	$0.00	0.00	$0.00	
2. Depreciation:				
	Adjust. Cost Impr./Whole Term x Expired Term =			
	$0.00	540	266	$0.00
3. Adjusted Depreciated Cost of Improvements:				
	Adjust cost - Depreciated cost =			
	$ -	$ -		$ -
1. TOTAL NET CONSIDERATION				$ (10,700.00)
2. Adj Cost of Imp/Renov		$ -		
		$ -		$ -
3. Adj. cost of Trade Fixtures		$ -		
		$ -		
4. Excess				$0.00
5. Premium		Percentage: 30%		$0.00

Photos
General Lease S-4829



B-21

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject:	REQUEST FOR APPROVAL TO SUBLEASE BETWEEN THE HAMAKUA AGRICULTURAL COOPERATIVE, LESSEE/SUBLESSOR, AND ROSE CYPRET, SUBLESSEE; GENERAL LEASE NO. S-5551, TMK: (3) 4-6-003:001, 002 and 020 (por), LOT NO. 4, HONOKAIA, HAMAKUA, ISLAND OF HAWAII, HAWAII
Authority:	Section 166E-6 Hawaii Revised Statutes, (HRS), and Section 4-158-19(a)(6), Hawaii Administrative Rules (HAR)
Lessee/Sublessor:	Hamakua Agricultural Cooperative
Sublessee:	Rose Cypret
Land Area:	Approximately 10.577 acres
Tax Map Key:	3rdDiv/4-6-003:001, 002 and 020 (por) (Exhibit "A")
Land Status:	The Hamakua lands were transferred to the Department of Agriculture by Governor's Executive Order No. 4250, dated October 22, 2008, pursuant to Act 90, SLH 2003
Lease Term:	35-years, June 30, 1998 through June 29, 2033
Sub-Lease Term:	March 15, 2023 to June 29, 2033
Annual Base Rent:	$1,161.79/year
Character of Use:	General Agricultural Purposes in accordance with a Plan of Utilization and Development approved by the Department

BACKGROUND:

Rose Cypret is requesting to sublease Lot 4, under General Lease S-5551, consisting of approximately 10.577 acres. Ms. Cypret has previously been approved by the Board of Agriculture and is currently sub-leasing lots 11 and 26 under General Lease S-5551, where she grows a variety of organic fruits and vegetables. Ms. Cypret is requesting to sublease Lot 4 to expand on her current operation. Lot 4 serves as a better growing space for long-term Malaysian Dwarf coconut trees. She also plans to utilize a section of the property to raise lambs.

B-22

B-23

Rose Cypret is a sub-lessee in good standing and qualifies as a bona fide farmer with more than 2 years of full-time farming experience and meets the application and eligibility requirements in accordance with sections 4-158-1 and 27, HAR.

RECOMMENDATION:

That the Board of Agriculture approve the Sublease between the Hamakua Agricultural Cooperative, Lessee/Sublessor, and Rose Cypret, Sublessee, for Lot No. 4 in Honokaia, under General Lease S-5551, through the expiration date of June 29, 2033. Further, all documents are subject to the review and approval as to form by the Office of the Attorney General, and such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

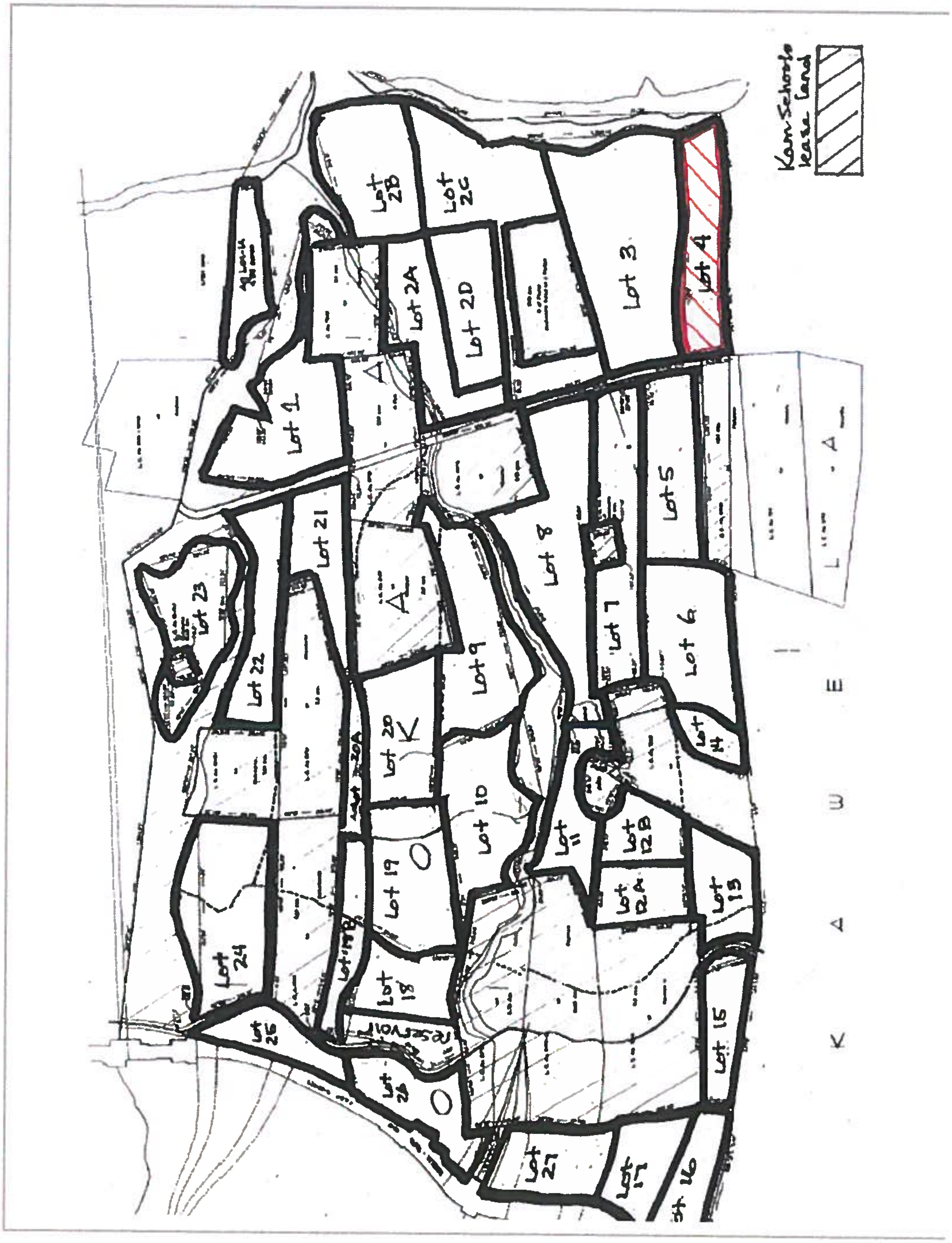
BRIAN KAU, P.E.
Administrator and Chief Engineer,
Agricultural Resource Management Division

Attachment - Exhibit "A"

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

EXHIBIT "A"


Kam Schools lease land
Lot 1
Lot 2A
Lot 2B
Lot 2C
Lot 2D
Lot 3
Lot 4
Lot 5
Lot 6
Lot 7
Lot 8
Lot 9
Lot 10
Lot 11
Lot 12A
Lot 12B
Lot 13
Lot 14
Lot 15
Lot 16
Lot 17
Lot 18
Lot 19
Lot 20
Lot 21
Lot 22
Lot 23
Lot 24
Lot 25
Lot 26
Lot 27
Reservoir
K A W E L A

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII 96814

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject:	REQUEST FOR ACCEPTANCE OF ANNUAL LEASE RENT AS DETERMINED BY INDEPENDENT APPRAISAL FOR GENERAL LEASE NO. S-4205; KOHALA PLANTS INC., LESSEE; TMK: 3RD DIV/2-4-049:031; LOT 31, PANAEWA FARM LOTS, WAIAKEA, SOUTH HILO, ISLAND OF HAWAII, HAWAII
Authority:	Section 166E-6, Hawaii Revised Statutes, (HRS), and Sections 4-158-2(a)(11) and 4-158-10 (b), Hawaii Administrative Rules (HAR)
Lessee:	Kohala Plants, Inc.
Land Area:	Approximately 60.000 acres
Tax Map Key:	(3) 2-4-049:031 (Exhibit "A")
Lease Term:	55 years, September 26, 1968, through September 25, 2023
Land Status:	Encumbered by Governor's Executive Order No. 4300 dated October 14, 2009, to the Department of Agriculture for agricultural purposes
Annual Base Rent:	$14,700.00 per year
Character of Use:	Cultivation, wholesaling, retailing and packing of nursery products and related uses

<u>BACKGROUND</u>:

On September 26, 1968, the Board of Land and Natural Resources (BLNR) awarded General Lease S-4205 to Shinobu Oshima. At its meeting held on October 26, 1979, the BLNR approved the Assignment of General Lease S-4205 from Shinobu Oshima to Flowers Incorporated. In 2009, Governor's Executive Order No. 4300 transferred General Lease No. S-4205 to the Department of Agriculture for management purposes. On January 25, 2022, the Board of Agriculture consented to the Assignment of General Lease S-4205 from Flowers Incorporated to Kohala Plants, Inc., who has continued to successfully produce anthuriums, coconuts, papaya, breadfruit, citrus fruits, and landscaping plants.

On August 22, 2022, on behalf of the Board of Agriculture, the Chairperson approved the extension of General Lease No. S-4205 for an additional ten (10) years commencing from September 26, 2023, through September 25, 2033, subject to approval of the annual lease rent appraisal.

B-25

B-26

An appraisal was done pursuant to Section 4-158-10(b), HAR, by ACM Consultants, Inc. for the purpose of determining the fair market rental for the subject parcel for the extension period. The appraised annual rental for the extension period is $14,700.00 per year or 1.5% of gross sales, whichever is greater.

RECOMMENDATION:

That the Board of Agriculture accept the fair market rental of $14,700.00 per year for General Lease No. S-4205, commencing from September 26, 2023, through September 25, 2033. All documents are subject to the approval as to form by the Department of the Attorney General, and such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

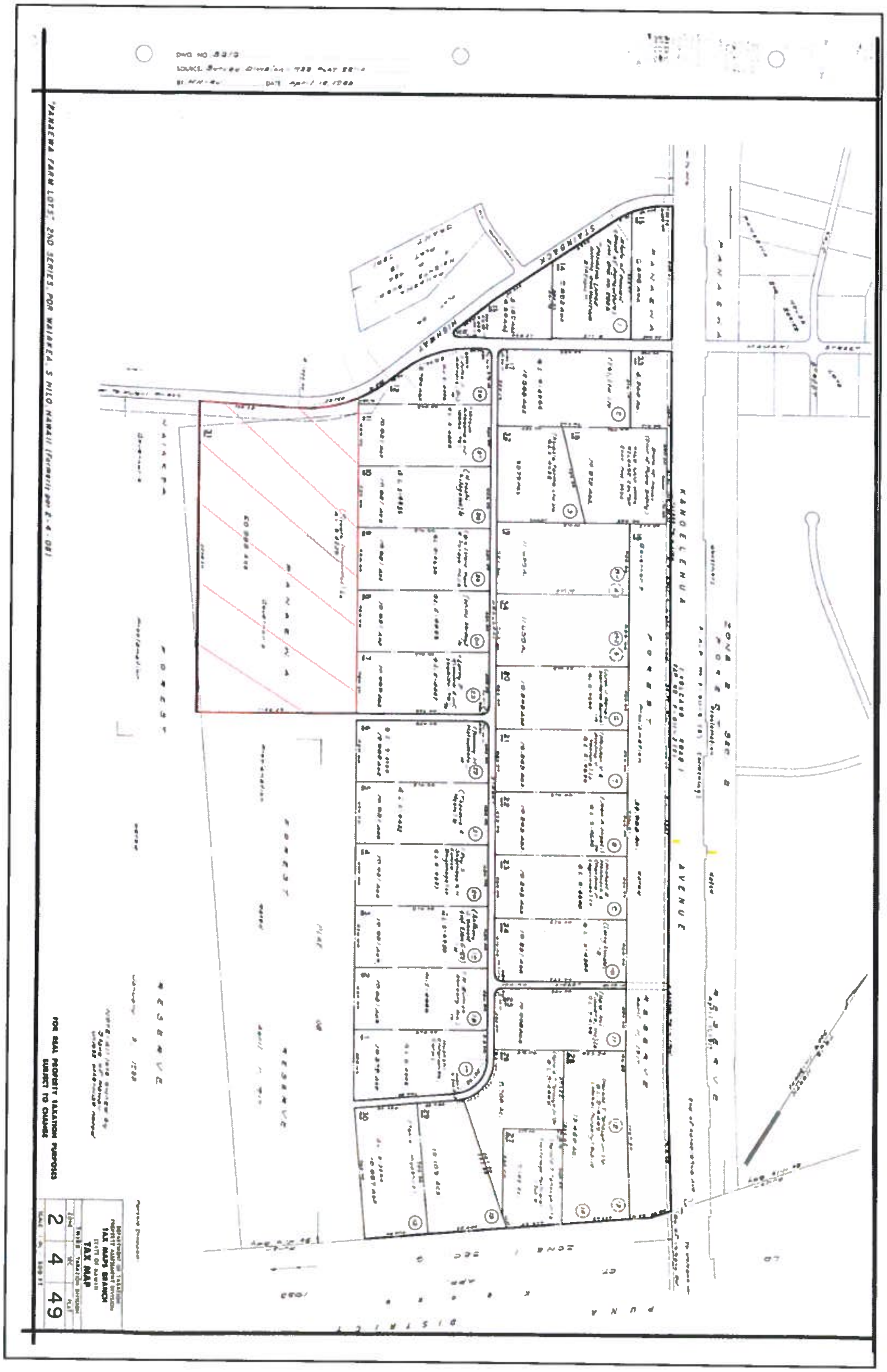
BRIAN KAU, P.E.
Administrator & Chief Engineer
Agricultural Resource Management Division

Attachment: Exhibit "A"

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

Exhibit "A"



B-27

State of Hawaii
Department of Agriculture
Plant Industry Division
Plant Quarantine Branch
Honolulu, Hawaii

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject: Request to: (1) Allow the Importation and Possession of Lab-Reared Strains of the Parasitoid Wasp, *Phymastichus coffea* (Hymenoptera: Eulophidae), an Insect on the List of Restricted Animals (Part A), by Permit, for Field Release to Control the Coffee Berry Borer, *Hypothenemus hampei*, by the U.S. Department of Agriculture - Agricultural Research Service (USDA ARS) and University of Hawaii at Manoa (UHM); and

(2) Establish Permit Conditions for the Importation and Field Release of Lab-Reared Strains of the Parasitoid Wasp, *Phymastichus coffea* (Hymenoptera: Eulophidae), an Insect on the List of Restricted Animals (Part A), to Control the Coffee Berry Borer, *Hypothenemus hampei,* by the USDA ARS and UHM.

I. Summary Description of the Request

PQB NOTES: *The Plant Quarantine Branch (PQB) submittal for requests for import or possession permits, as revised, distinguishes information provided by the applicants from procedural information and advisory comment and evaluation presented by PQB. With the exception of PQB notes, hereafter "PQB NOTES," the text shown below in section II from page 3 through page 6 of the submittal was taken directly from the applicants', Dr. Follett and Dr. Wright, application and subsequent written communications provided by the applicants. For instance, the statements on pages 5 and 6 regarding effects on the environment are the applicants' statements in response to standard PQB questions and are not PQB's statements. This approach for PQB submittals aims for greater applicant participation in presenting import requests in order to move these requests to the Board of Agriculture (Board) more quickly, while distinguishing applicant provided information from PQB information. The portion of the submittal prepared by PQB, including the environmental assessment, Advisory Subcommittee review, Advisory Committee review, and proposed permit conditions, are identified as sections III, IV, V, and VI of the submittal, which start at pages 6, 7, 12, and 22 respectively.*

II. Information Provided by the Applicant in Support of the Application

An application was submitted by the United States Department of Agriculture (USDA) Agricultural Research Service (ARS), Hilo, HI, and University of Hawaii at Manoa (UHM) Honolulu, HI, to the Hawaii Department Of Agriculture (HDOA) Plant Quarantine Branch (PQB), 1849 Auiki Street, Honolulu, Hawaii 96819, for a permit to introduce *Phymastichus coffea* LaSalle (Hymenoptera: Eulophidae) into the State of Hawaii under the provisions of Hawaii Revised Statutes, Chapter 141, Hawaii Revised Statutes (HRS) and Chapter 150A, HRS, Plant and Non-Domestic Animal Quarantine. *Phymastichus coffea* will be used to control the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae) (CBB), a serious invasive pest of coffee in Hawaii.

Phymastichus coffea was obtained from Cenicafé in Colombia under USDA Animal Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ), permit number P526P-18-00696 and brought into a fully certified quarantine insect containment facility managed by the USDA Forest Service at Hawaii Volcanoes National Park, Volcano, Hawaii, for host-specificity testing.

Purpose:

This is an application for a permit to import and field release the parasitoid *Phymastichus coffea* (Hymenoptera: Eulophidae) against the coffee berry borer (CBB), *Hypothenemus hampei* (Coleoptera: Curculionidae) in Hawaii coffee. The coffee berry borer is the most serious pest of coffee in most coffee producing countries. In Hawaii, CBB was first reported in 2010 in South Kona and soon spread throughout Hawaii island coffee farms and to the other islands. The coffee berry borer severely affects the yield and quality of coffee and it is an important constraint on production and development of the crop. The roasted value of Hawaii-grown coffee is estimated to be over $100 million annually. The current crop losses of coffee due to CBB infestation in Hawaii is estimated at $7.7 million. If left uncontrolled coffee berry borer can infest >90% of coffee berries. The primary means of controlling CBB in Hawaii is use of the microbial insecticide *Beauveria bassiana* and sanitation (removal of all coffee berries after harvest). The control of this pest with *Beauveria bassiana* is expensive and has limited success if the borer has reached the endosperm of the seeds. Biological control using parasitoids is a sustainable option to manage the coffee berry borer. *Phymastichus coffea* has proven to be an effective biological control agent of CBB in other coffee growing regions in the world, especially Central and South America. Furthermore, *P. coffea* is the only parasitoid tested thus far that has been shown to reduce yield loss from CBB damage. *P. coffea* has the potential to be an effective biological control agent against the coffee berry borer in Hawaii.

4. Abstract of Organism:

Phymastichus coffea is an idiobiont, gregarious endoparasitoid of adult coffee berry borer, commonly laying two eggs (a male and a female) per host. Both a male and female develop in a single host, the female in the abdomen and the male in the prothorax, although a single female parasitoid is sometimes found living solitarily in the abdomen of the host. This parasitoid develops through four major life stages—egg, larva (three instars lasting ~21 days), pupa (~9 days) and adult. The complete development (egg to adult) occurs over 30-43 days depending on temperature and condition of the CBB host mummies. For example, at 23°C (73.4°F) the life cycle of *P. coffea* is 43 days. The parasitoid emerges by cutting an opening in the host's integument. The average lifespan of the parasitoid is 1-2 days for males and 3-4 days for females. Upon emergence, female parasitoids can have up to 10 eggs in the ovarioles, but more eggs are formed throughout her short lifetime (synovigenic strategy). There is no preoviposition period and the adult female parasitoids can parasitize the coffee berry borer adults immediately after emergence. It has been shown that *H. hampei* is attracted to semiochemicals released from coffee fruits; semiochemicals released during *H. hampei* feeding on fruits have been shown to attract *P. coffea* and may play a significant role in mediating the host specificity of this parasitoid under field conditions.

5. Potential Effects on the Environment and Health:

Phymastichus coffea was chosen as the best candidate parasitoid in Hawaii because of its previously reported high host specificity and ability to significantly reduce and regulate *Hypothenemus hampei* (coffee berry borer) populations in the field. Using the centrifugal phylogenetic method, a widely accepted approach for non-target host screening, host range testing was conducted in quarantine in Hawaii to determine whether *P. coffea* might attack non-target species in addition to coffee berry borer, and thereby pose a risk to the environment (see Yousuf et al. 2020). *H. hampei* is a small bark beetle in the subfamily Scolytinae, so host range testing focused on other scolytine bark beetles, including several other exotic *Hypothenemus* spp. and native species in the genus *Xyleborus*, as well as a variety of other small Curculionidae and other coleopterans. Using no-choice tests, a total of 43 different species of Coleoptera were tested, including 23 scolytines (6 *Hypothenemus* species, 7 native *Xyleborus* species, and 10 others), and 4 additional Curculionidae. *P. coffea* was only able to parasitize the target host *H. hampei* (coffee berry borer) and 4 other adventive species of *Hypothenemus: H. obscurus* (tropical nut borer), *H. seriatus, H. birmanus and H. crudiae*. *Hypothenemus hampei* had the highest parasitism rate and shortest parasitoid development time of the five parasitized *Hypothenemus* spp. Parasitism and parasitoid emergence decreased with decreasing phylogenetic relatedness of the *Hypothenemus* spp. to *H. hampei*, and the most distantly related species tested, related authorization applies in those circumstances where the underlying permit activity for the importation initiates a "program or project" and where the use of state or county funds or state or county lands is involved. When those circumstances are present, as they appear to be when a new organism is used in a new program or project located at a facility located at UHM or UHH (state lands), an EA is required to determine whether the proposed project or program is likely to have a significant impact on the environment. However, certain activities may be eligible for an "exemption" under provisions established through the Environmental Advisory Council, provided that the project or program is determined to have little or no impact on the environment.

Analysis of Application re EA: Under the above-cited court decision, the EA requirement is triggered under certain circumstances, including when an applicant proposes an action on state or county lands that requires agency approval and is not specifically exempted under Chapter 343, HRS.

This appears to be the case here. The applicants' request in this instance involves importation and possession of *Phymastichus coffea* for field-release as biocontrol of *Hypothenemus hampei* (coffee berry borer) in the environment.

PQB NOTES: *Drs. Follett and Wright have completed the environmental review process and have obtained an EA with a Finding of No Significant Impact (FONSI). This process was completed on February 23, 2023 with their publication of the final EA in the Environmental Notice (Attachment 5).*

IV. Advisory Subcommittee Review

This request was submitted to the Advisory Subcommittee on Entomology for its review and recommendation. Advisory Subcommittee recommendations and comments are as follows:

1. **I recommend approval____/____disapproval to allow the importation of lab-reared strains of the parasitoid wasp, *Phymastichus coffea*, an insect on the List of Restricted Animals (Part A) for field release to control the coffee berry borer, *Hypothenemus hampei*, by the USDA ARS and the UHM.**

   Dr. Daniel Rubinoff: Recommends Approval.

   Comments: "The background work seems solid and the risk low in terms of non-target impacts."

   Dr. Jesse Eiben: Recommends Approval.

Dr. Howarth Comments: "On page 7 under "Analysis of Application re EA": Legally, it appears that Hawaii EA is **required** for this action! The agent is expected to invade and survive in the natural environment in the state – including on state lands. Also, much of the work will take place in UH labs and involve UH staff and students. Please reconsider the exemption!"

PQB NOTES: *The applicants originally did not plan to use State funding, property, lands, or employees for this project. As such, they were not subject to the State's environmental review requirements. The applicants have since decided to use State lands and equipment and have successfully completed the State's environmental review requirements. Dr. Howarth's responses and recommendations are partially based off of the applicants' original intent of not using State or county land, funding, and other resources.*

Dr. Howarth Comments: "The EA and project description do not provide enough information on the scope or precisely what will be done. It implies that the agents are expected to establish and provide adequate pest control, but it also claims that augmentative releases of high numbers of agents will be released. I recognize the need to be flexible, but if the latter strategy is planned, the methods for this should be appropriately described in the proposal. For example, where and by whom will the agents be mass-reared? What quality control methods will be used?"

> *Applicants' Response: "We will initially only release P. coffea reared at the USDA FS quarantine facility in Volcano. We hope to be able to one day import and release mass reared P. coffea from Cenicafe in Colombia. Cenicafe has never found a hyperparasitoid in P. coffea after 30 years of field collections and rearing. However, the possibility that parasitized CBB might carry coffee diseases should be evaluated.*

Dr. Howarth Comments: "Although the environmental risks may be low, they still affect the cost-benefit analysis. The other unknown is how effective the agent will be under Hawaii conditions. Weighing the evidence from both the information given in the proposal and the literature, this project is not worth the cost and risk. Another aspect not mentioned in the proposal is the prospect of the development of safer and more effective methods to control the pest coffee berry borer. For example, see Vega et al. 2017, which reported research conducted in Hawaii.

Vega FE, Simpkins A, Miranda J, Harnly JM, Infante F, Castillo A, Wakarchuk D, Cossé A. A Potential Repellent Against the Coffee Berry Borer (Coleoptera: Curculionidae: Scolytinae). J Insect Sci. 2017 Dec 23;17(6):122. doi: 10.1093/jisesa/iex095. PMCID: PMC5751034."

female and 5 male adult specimens pinned and 5 males and 5 females in 70% ethanol.

- And the edit to condition #17
The permittee(s) shall submit an annual report to the PQB by January 31st on results of the post release monitoring programs for the prior calendar year, and shall include the following: date, locations, number of restricted article(s) released, and number of releases;"

Applicants' Response: "We will submit pinned specimens and specimens in 70% alcohol of P. coffea to the Plant Pest Control Branch."

Dr. Francis Howarth: No Recommendation

Comments: "On page 8, "Proposed Permit Conditions": Condition #3: Not true as stated. The animals are to be released into the wild. Rephrase to clarify what is meant."

PQB NOTES: *In response to Dr. Howarth's comments, PQB has amended permit condition #3 and created permit condition #4.*

Dr. Howarth Comments: "On page 10, Condition #13: Contradicts Condition #10. Clarify."

PQB NOTES: *PQB does not see that there is a contradiction between permit conditions #13 and #10. Condition #10 is for information prior to shipment of the restricted article(s). Condition #13 are the requirements for what must accompany the restricted article(s) when entering Hawaii Although there may be slight differences in what is required in both permit conditions both conditions accurately detail the information needed for each shipment of P. coffea to Hawaii.*

Dr. Howarth's Comments: "On page 11, Condition #20. I recommend that the advisory committee review this document."

PQB NOTES: The applicants have submitted the biosecurity manual for the USDA FS Volcano quarantine facility as ATTACHMENT 8.

3. If lab-reared strains of the parasitoid wasp, *Phymastichus coffea*, an insect on the List of Restricted Animals (Part A) is accidently released, what is the probable impact on the environment?

___ minimal or no significant effects on the environment.
___ other (if "other", please explain).

previously looked at and put on the list a long time ago and believed there had already been strong consideration of importing this particular species in the past.

Committee member Hauff asked if that was just the Hawaii Department of Agriculture (HDOA) being proactive and anticipating the need for this import and going through the listing process in advance. Mr. Kishimoto believed that was the case. Mr. Hauff stated that was great work and should be done more often.

Committee member Hauff mentioned the applicants talked about needing to do additional mass rearing of *P. coffea* outside Hawaii and importing them for augmentative release. Would this be covered by the permit? Mr. Kishimoto answered that when the applicants were talking about mass import of *P. coffea*, they planned to do this in the future. He said this permit would just cover initial imports and releases.

Committee member Hauff then asked if there was a need to define a quantity of what's going to be imported so that it is clear that the Committee is not approving mass imports at this time.

Mr. Kishimoto said he thought that was something that the Committee could decide. They could ask the applicants how much *P. coffea* they intend to import, but he felt that the applicants' safeguarding practices and disinfection practices were satisfactory and the PQB is okay with them importing as much as they wanted, provided they apply those practices to everything that they import.

Committee member Hauff mentioned the application including an institution in Puerto Rico as a source for *P. coffea,* but the application only referenced Cenicafé in Colombia. He wanted to know if the insects were going to come from both facilities, and if so, why the applicants were using two facilities versus one. Mr. Kishimoto said he did not know and suggested asking the applicants, though it was his understanding they were only going to import *P. coffea* from Columbia. Mr. Hauff said he was just curious why the Puerto Rico Lab was listed. Chairperson Rogg said shipper one is Cenicafé and shipper two is the University of Puerto Rico and wanted verification from the petitioners if imported *P. coffea* will be going into the quarantine facility according to permit condition #7 for a minimum of two generations. Chairperson Rogg said there was a previous discussion with the idea of importing *P. coffea* straight from Centicafé and directly releasing into the field, but that would not be the case here. Mr. Kishimoto confirmed this was correct.

Mr. Darcy Oishi, Acting Manager, HDOA Plant Pest Control Branch, told the Committee that *P. coffea.* was put onto the List of Restricted Animals, Part A, over 20 years ago as

Committee member Eisen said if the entity applying for a permit is a State or County agency, then it's considered an agency action and that agency makes the determinations. If it is non-State or County agencies that are seeking the approval and proposing the project, then a State or County agency has to be considered the approving agency, and that would likely be the Hawaii Department of Agriculture (HDOA). But who is actually proposing the project determines what agency makes these judgment calls.

Chairperson Rogg said he felt this was a good time to talk about this because HDOA had the same question. Chairperson Rogg reminded the Committee that the EA issue was discussed in a recent petition that was brought before the Board of Agriculture (Board) noting the EA was an important topic of discussion. He thought this was a legitimate question for the Committee as well. Chairperson Rogg asked the Committee how they would address item #3 of the submittal, "Determine the Probable Impact to the Environment if Lab-Reared Strains of the Parasitoid Wasp are Accidentally Released". He noted that determining the necessity of the environmental review might need to be mentioned in the Committee's recommendation to the Board.

Committee member Eisen said that without an EA being completed, and without that analysis of the organism being done, it is very difficult to make the decision on whether or not the release of *P. coffea* into the environment will have a significant impact or not. He said this is why there is an EA review process that produces a vetted document to be used by the decision makers; but until it's completed, no one can make a knowledgeable decision whether *P. coffea*'s release will have a significant impact or not.

Committee member Gon agreed with Committee member Eisen saying unless the Committee did a global literature review of the biology of the species and previous releases, or of its utility and performance elsewhere, including any potential impacts that were done, it would not make much sense to make a recommendation on the potential impact should it be released since Hawaii can be a unique situation. He asked if there were similar issues in the past for other potential permits and releases?

Committee member Hauff stated in the past, when a Finding of No Significant Impact (FONSI) has not yet been issued, the Committee has gone ahead and made a recommendation to the Board, but HDOA's Attorney General requires the FONSI be issued before the Board makes a final decision. Committee member Hauff said he was not sure whether the EA is going to be prepared but there was a draft EA attached to the application that had not been published. He asked Mr. Kishimoto to confirm this.

coffea, it was the understanding of everyone involved that it did not involve state funding, etc. and funding for import would be from USDA Agriculture Research Service (ARS). He said USDA ARS submitted a substantial amount of data showing this importation would not have significant negative environmental impacts, but they were starting to hear people say they did not submit enough data. Dr. Wright told the Committee they looked very carefully at endemic species that are the closest in relation to the target species. He noted their work was not a trivial effort and reiterated he was prepared to submit an EA for the State process. He said the decision not to submit an EA was from USDA, who funded this, and ARS said they wanted to move ahead with the application to get it done, and the EA could be done later once UH became involved in the project. Dr. Wright understood it looked contradictory to be listed as an applicant and he brought it up before and no one seemed to have an issue about it at that time. He asked the Committee if they had any specific questions about the request and he would be happy to address them.

Chairperson Rogg explained the Committee cannot make a requirement whether or not an EA is needed as they are just an advisory committee making recommendations to the Board who ultimately make the decision. Chairperson Rogg said from his experience, some of the requests that have gone before the Board have caused issues for approval because of an incomplete EA. He said there have been delays in voting or deferrals in decision-making by the Board because the EA was not finalized. Chairperson Rogg reiterated he wanted to make sure that this request has the best chance of success if the Committee made the recommendation of approval of the request, saying the EA question would definitely come up as has been seen over the last year.

Dr. Wright thought the determination to go through the environmental review process was very opaque. He felt it was hard to figure how to make that determination but said that they were prepared to do an EA, noting he had almost completed his draft EA. Dr. Wright then asked the Committee about an issue he had about if there was an accidental release of this parasitoid? Was there a big concern because their intent is to make a purposeful release of this parasitoid? That kind of mutes the whole accidental release part. He asked the Committee if their objection is if there was an accidental release prior to them rearing *P. coffea* for two generations before they released it?

Chairperson Rogg replied that was correct. He explained the EA process is a procedural one. There were issues with previous requests that did not have an EA, using an earlier request for mosquito import as an example. He said there are going to be questions, reviews, and people looking into details. He said the Committee's have the stamp of Department of Agriculture or another State agency to move forward. This was really where this process got held up and why the draft EA was never formalized into an EA because they needed Department of Agriculture's support to move forward. Ms. Shriner said Dr. Follett would be better able to confirm that, but this was her understanding and at that time, the intent was to go through the full EA process.

Chairperson Rogg asked Mr. Kishimoto about a previous discussion where it was agreed that HDOA was not the agency to submit the draft EA. Mr. Kishimoto said to the best of his knowledge, UH as a collaborator and State agency, might be the agency that would submit the draft EA for Peter Follett. Committee member Eisen recalled a response was generated to Dr. Follett saying his draft EA has to come from a State or County agency either as a proposing agency or approving agency and it certainly seems like if UH becomes the proposing agency, and they make the determination of whether or not this request needs to go through the environmental review process, the issue can be resolved. He said if UH becomes the proposing agency, they can determine if Chap. 343, HRS applies and if UH did not want to be the proposing agency for the draft EA, another State or County agency would need to do that on behalf of Dr. Follett and USDA.

Dr. Wright stated he thought it was very unclear how this process works. He said the draft EA was prepared, but didn't know about these 13 points a State EA must address, but was fully prepared to address those points. Committee member Eisen said he could provide guidance in his role with the Environmental Review Program and could provide information outside the meeting on how to proceed.

Chairperson Rogg asked if there were any other comments or questions. Committee member Hauff asked if there was any way of moving this request to the Board so it can be voted on once either the EA FONSI was issued, or a determination was made that no State funds were used.

Chairperson Rogg said the Committee can recommend that the Board approve this request contingent upon the completion of the EA process. He remembered when a similar situation happened with a mosquito import request, the Board approved it once the EA has been completed and approved. The Committee is not making the approval, just making a recommendation to the Board. The Committee can say we recommend it because the applicants said they will prepare and submit the EA for approval.

Committee member Gon liked that course of action because it would certainly be possible to make a recommendation that Items #1 and #2 move forward as is with Item

Chairperson Rogg asked Dr. Wright to confirm that he understood that the port of Honolulu would be where *P. coffea* initially enters the State and would be inspected there before being allowed to be transported to USDA's quarantine facility in Volcano located on Hawaii Island. Dr. Wright agreed, cautioning that it was his colleague's (Dr. Follet) part of the project, but his understanding was that is acceptable and workable. Chairperson Rogg reminded Dr. Wright about the use of State resources triggering the need for environmental review. Dr. Wright responded that Dr. Follett would be picking up any shipments of *P. coffea*.

Chairperson Rogg asked Dr. Wright he had any questions for Committee. Dr. Wright was curious what people thought about the draft EA. But if there were no real, major concerns about that, he was fine. Committee member Hauff felt the information provided by the applicants was really helpful. He said they did a good job backing it up with the studies and the breadth of the non-target testing was great, including six native Scolitids. He also wanted to know how *P. coffea* was going to be used in the field by farmers and how it was used in the places where it has already been released. Would it require regular augmentative releases like seasonal releases or will it become really established so farmers can rely on either wild reservoirs of *P. coffea* for good control in coffee plantations?

Dr. Wright explained the initial thought was to propose this as an augmentative agent that the ARS would rear in portable quarantine facilities or mass production facilities. They shifted away from that and now expect *P. coffea* will become established. He noted there is feral and unmanaged coffee all over that provide reservoirs of coffee berry borer (CBB) that could facilitate establishment of *P. coffea*. Since it persists with very low densities of CBB in Kenya, where *P. coffea* is originally from, and it appears to suppress CBB efficiently. The point being that *P. coffea* persists with low densities of CBB and we have high densities in Hawaii. Dr. Wright said his expectation is that *P. coffea* will become established and become a typical classical biocontrol agent and you won't have to actually do anything to use it except restrict pesticides applications to conserve the insects into the environment once its established. He noted augmentative biocontrol releases come with a lot of issues like production costs and timing of releases.

Chairperson Rogg asked if there were any other questions. Committee member Gon said if not, then his motion stands. Chairperson Rogg asked if Committee member Gon would repeat his motion for the record. Committee member Gon said, "With regard to item number 4 on the agenda reviewed by the Committee, I move to #1, advise to allow the importation and possession of our lab reared strains of *Phymastichus coffea*; #2 establish permit conditions for the importation and field release of *P. coffea*; and #3 berry borer, *Hypothenemus hampei*, a purpose approved by the Board of Agriculture (Board). The restricted article(s), including progeny, shall not be sold, given away, or transferred except as approved by the Board.

2. The permittee(s), Dr. Peter Follett, U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS), 64 Nowelo St., Hilo, HI 96720 and Dr. Mark Wright, Department of Plant and Environmental Protection Sciences, UH-Manoa, 3050 Maile Way, Honolulu, HI 96822, shall be responsible and accountable for all restricted article(s) imported, including progeny, from the time of their arrival until their final disposition.

3. Upon import or while under observation for pest infestation or colony reproduction, the restricted article(s) shall be safeguarded and maintained at the following approved sites; the USDA approved Insect Containment Facility, USDA Forest Service (FS), Hawaii Volcanoes National Park Quarantine Facility, Kilauea Research Station, Building 34, Volcano, HI 96718 or the Hawai'i Department of Agriculture, Plant Pest Control Branch, 1428 South King Street, Honolulu, Hawaii 96814 sites inspected and approved by the Plant Quarantine Branch (PQB) prior to importation, by trained or certified personnel designated by the permittee(s), until their release.

4. Less than 24 hours prior to field release, the restricted article(s) may be taken out of quarantine and kept at another PQB-inspected and approved facility until their release.

5. Upon request by the PQB, the permittee(s) shall submit samples of the restricted article(s) prior to importation to the PQB.

6. The restricted article(s) shall be screened for other species, predators, parasites, parasitoids or hyperparasitoids for a minimum of two generations in the USDA approved Insect Containment Facilities at Hawaii Volcanoes National Park Quarantine Facility, Kilauea Research Station, Building 34, Volcano, HI 96718 or at the Hawai'i Department of Agriculture, Plant Pest Control Branch, 1428 South King Street, Honolulu, Hawaii 96814.A report shall be submitted to PQB detailing the discovery of any organisms besides the restricted article(s).

7. Upon receipt of the restricted article(s) at the approved site:

   a. All packing material shall be sterilized with a minimum 0.5% sodium hypochlorite solution or autoclaving or destroyed by autoclaving or incineration.

other similar PQB-approved document listing the scientific and common names of the restricted article(s), the quantity of the restricted article(s), the shipper, and the permittee(s) for the restricted article(s).

13. All parcels containing the restricted article(s) shall be subject to inspection by the PQB prior to entering the State and shall be imported through the port of Honolulu except as designated by the Board. Entry into Hawaii through another port is prohibited unless designated by the Board.

14. The approved site, restricted article(s), progeny, records, and any other document pertaining to the restricted article(s) and progeny under this permit, may be subject to post-entry inspections by the PQB. The permittee(s) shall make the site, restricted article(s), progeny, and records pertaining to the restricted article(s) available for inspection upon request by a PQB inspector.

15. It is the responsibility of the permittee(s) to comply with any applicable requirements of municipal, state, or federal law pertaining to the restricted article(s).

16. The permittee(s) shall submit to the PQB Chief a copy of all valid licenses, permits, certificates or their equivalent required for the restricted article(s) or for their import, possession, movement, or transfer. The permit issued by the PQB Chief may be cancelled upon revocation, suspension, or termination of any of the aforementioned documents.

17. The permittee(s) shall submit an annual report to the PQB by January 31st on results of the post release monitoring programs for the prior calendar year, and shall include the following:

    a. Number of restricted article(s) released and number of releases;

    b. Establishment and current field populations of the restricted article(s);

    c. Effects of the restricted article(s) on native plant and animal species;

    d. A summary of any significant changes to the permittee's operation, personnel, and/or procedures regarding the restricted article(s) and progeny; and

    e. Any significant events that occurred at the permittee's site regarding the restricted article(s) or progeny.

22. Any violation of the permit conditions may result in citation, permit cancellation, and enforcement of any or all of the penalties set forth in HRS §150A-14.

23. A cancelled permit is invalid and upon written notification from the PQB Chief, all restricted article(s) listed on the permit shall not be imported. In the event of permit cancellation, any restricted article(s) imported and in the permittee(s)' possession under permit may be moved, seized, treated, quarantined, destroyed, or sent out of State at the discretion of the PQB Chief. Any expense or loss in connection therewith shall be borne by the permittee(s).

24. This permit or conditions of this permit are subject to cancellation or amendment at any time due to changes in administrative rules restricting or disallowing import of the restricted article(s) or due to Board action disallowing a previously permitted use of the restricted article(s).

25. These permit conditions are subject to amendment by the PQB Chief in the following circumstances:

    a. To require disease screening, quarantine measures, and/or to place restrictions on the intrastate movement of the restricted article(s), as appropriate, based on scientifically validated risks associated with the restricted article(s), as determined by the PQB Chief, to prevent the introduction or spread of disease(s) and/or pests associated with the restricted article(s).

    b. To conform to more recent Board approved permit conditions for the restricted article(s), as necessary to address scientifically validated risks associated with the restricted article(s).

26. The permittee(s) shall agree in advance to defend and indemnify the State of Hawaii, its officers, agents and employees for any and all claims against the State of Hawaii, its officers, agents, employees, or Board of Agriculture members that may arise from or be attributable to any of the restricted article(s) that are introduced under this permit. This permit condition shall not apply to a permittee that is a federal or State of Hawaii entity or employee, provided that the State of federal employee is a permittee in the employee's official capacity.

STAFF RECOMMENDATION: Based on the favorable recommendations and comments of the Advisory Subcommittee on Entomology and the Advisory Committee's

(7-0) recommendation to approve this request, the Plant Quarantine Branch recommends approval of this request, with the proposed permit conditions.

Respectfully Submitted,

JONATHAN K. HO
Acting Manager, Plant Quarantine Branch

CONCURRED:

GREG TAKESHIMA
Acting Administrator, Plant Industry Division

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

Attachment 1

PQ-7 (01/04)

State of Hawaii
Department of Agriculture
PLANT QUARANTINE BRANCH
1849 Auiki Street, Honolulu, HI 96819-3100
Phone: (808) 832-0566, FAX: (808) 832-0584

PERMIT APPLICATION FOR RESTRICTED COMMODITIES INTO HAWAII

For Office Use Only

Fee: $______ Receipt No. ______

☐ Approve Permit No. ______ Date: ______
☐ Disapprove ☐ Other ______

Processed by: ______ Date: ______

Date: November 24, 2021

In accordance with the provision of Chapter ________, Hawaii Administrative Rules of the Division of Plant Industry, Department of Agriculture, a permit is requested for the following commodities:

Please type or print clearly.

Quantity	Commodity	Scientific Name
Multiple	Parasitic wasp	Phymastichus coffea LaSalle (Hymenoptera: Eulophidae)
		RECEIVED JAN 28 2022 PLANT QUARANTINE BRANCH
		NO PAYMENT Date: 1/28/22 Initial: TSY

Name and address of shipper: Multiple: Pablo Benavides, Cenicafe, Manizales, Colombia; Jose Carlo Verle Rodrigues, Univ. Puerto Rico, 1193 Guayacan St. S. Botanical Garden, San Juan, PR 00926; Earl Andress, USDA APHIS, 3545 Chipman Rd., Phoenix, AZ 85040

(Mainland or Foreign address)

Approximate date of arrival: 08/01/2022

Mode of Shipment: ☐ Mail ☐ Air Freight ☐ Boat

Type of Permit:
--- Import
☐ one time only ☑ multi-shipments
--- Intrastate shipment
☐ one time only ☑ multi-shipments
☐ Possession

Object of importation:
- ☐ Kept caged at all time
- ☐ Used for propagation
- ☐ Imported for exhibition
- ☑ Imported for liberation
- ☐ Other purposes - specify ______

Please type or print clearly.

Applicant's Name: Peter Follett

Company Name: USDA ARS
(if applicable)

Hawaii Mailing Address: 64 Nowelo St., Hilo, HI 96720

Telephone number: Off: 808-959-4303 Cell: 808-443-8031

Facsimile number: ______

Fee Amount Enclosed (cash, check or mail order) $______

(complete reverse side)

Attachment 2

PQ-7 (01/04)

State of Hawaii
Department of Agriculture
PLANT QUARANTINE BRANCH
1849 Auiki Street, Honolulu, HI 96819-3100
Phone: (808) 832-0566, FAX: (808) 832-0584

For Office Use Only

Fee: $__________ Receipt No. __________

☐ Approve Permit No. __________ Date: __________

☐ Disapprove ☐ Other __________

Processed by: __________ Date: __________

PERMIT APPLICATION FOR RESTRICTED COMMODITIES INTO HAWAII

Date: November 24, 2021

In accordance with the provision of Chapter __________, Hawaii Administrative Rules of the Division of Plant Industry, Department of Agriculture, a permit is requested for the following commodities:

Please type or print clearly.

Quantity	Commodity	Scientific Name
Multiple	Parasitic wasp	Phymastichus coffea LaSalle (Hymenoptera: Eulophidae)
		RECEIVED JAN 31 2022 PLANT QUARANTINE BRANCH
		NO PAYMENT Date: 1/31/22 Initial: TSY

Name and address of shipper: Multiple: Pablo Benavides, Cenicafe, Manizales, Colombia; Jose Carlo Verle Rodrigues, Univ. Puerto Rico, 1193 Guayacan St. S. Botanical Garden, San Juan, PR 00926; Earl Andress, USDA APHIS, 3545 Chipman Rd., Phoenix, AZ 85040

(Mainland or Foreign address)

Approximate date of arrival: 08/01/2022

Mode of Shipment: ☐ Mail ☐ Air Freight ☐ Boat

Type of Permit:
--- Import
☐ one time only ☑ multi-shipments
--- Intrastate shipment
☐ one time only ☑ multi-shipments
☐ Possession

Object of importation:
☐ Kept caged at all time
☐ Used for propagation
☐ Imported for exhibition
☑ Imported for liberation
☐ Other purposes - specify __________

Please type or print clearly.

Applicant's Name Mark G Wright

Company Name ~~USDA ARS~~ Univ. Hawaii (if applicable)

Hawaii Mailing Address ~~64 Nowelo St., Hilo, HI 96720~~
3050 Maile Way Rm 310 Honolulu 96822

Telephone number Off: 808-959-4303 Cell: 808-443-8031; 808-271-2037

Facsimile number __________

Fee Amount Enclosed (cash, check or mail order) $__________

(complete reverse side)

Attachment 3

Curriculum Vitae

Peter A. Follett, PhD
Research Entomologist (GS-15)
USDA-ARS, Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center
64 Nowelo St., Hilo, Hawaii 96720 USA
Ph.: (808) 959-4303, Fax: (808) 959-5470
e-mail: peter.follett@ars.usda.gov

Education:
Ph.D., 1993, North Carolina State University, Entomology
M.S., 1984, Oregon State University, Entomology
B.S. (Honors), 1980, University of Vermont, Plant and Soil Science

Research Positions:
1997- present, Research Entomologist (GS-15), USDA-ARS, U.S. Pacific Basin Agricultural Research Center, Hilo, Hawaii
1996-1997, Junior Researcher, Department of Entomology, Univ. of Hawaii at Manoa
1995-1996, Post-Doctoral Fellow, Department of Entomology, Univ. of Hawaii at Manoa
1994-1995, Post-Doctoral Fellow, Center for Conservation Research & Training, Univ. Hawaii at Manoa
1992-1993, Faculty Research Associate, Department of Entomology, Univ. of Maryland

Qualifications:
Dr. Follett has been an active researcher in applied entomology for 25 years and is internationally recognized as an expert in postharvest entomology and quarantine treatment development. He has authored or co-authored 230 scientific publications during his career, including 175 publications in peer-reviewed journals and 20 book chapters and 2 books, covering many important agricultural and quarantine pests in various crops. Dr. Follett currently serves as an associate editor for the Journal of Economic Entomology and Entomologia Experimentalis et Applicata and is a former editor of the Proceedings of the Hawaiian Entomological Society. He has served on expert missions for the International Atomic Energy Agency (IAEA) and USDA Foreign Agriculture Service in Thailand, Turkey, Bangladesh, Guatemala, Mexico, Colombia, Australia, and Argentina to advise on irradiation research and export programs. He was invited to prepare reviews on current trends in quarantine entomology and non-target effects of biological control for the Annual Review of Entomology. He is former president of the Hawaiian Entomological Society and the Pacific Branch of the Entomological Society of America.

Areas of Expertise:
Dr. Follett has extensive experience in postharvest biology, radiation science, entomology, integrated pest management, ecology and biological control and has worked with >30 species of invasive insect pests in a variety of temperate and tropical crops. The long-term goals of his research program are to develop and protect U.S. export markets for fresh tropical commodities with emphasis on expanding and diversifying agriculture and agricultural exports in Hawaii and other states by providing environmentally sound, economically viable systems, treatments, or processes that control quarantine pests, ensure product quality and food safety, and increase product value while safeguarding the agriculture of other states.

Hossain, F., **P. Follett**, S. Salmieri, K. D. Vu, M. Jamshidan, and M. Lacroix. 2017. Perspectives on essential oil-loaded nanodelivery packaging technology for controlling stored cereal and grain pests, pp. 487-509, In Green Pesticides Handbook: Essential Oils for Pest Control, L.M.L. Nollet and H.S. Rathore (eds.), CRC Press, Baco Raton, FL.

Nadel, H., **P. A. Follett,** C. Perry and R. Mack. 2018. Irradiation for quarantine control of the invasive fruit pest *Lobesia botrana* (Lepidoptera: Tortricidae). J. Econ. Entomol. 111 (1): 127-134.

Srimartpirom, M., I. Burikam, W. Limohpasmanee, T. Konggratarporn, T. Thannarin, A. Bunsiri, and **P. A. Follett**. 2018. Low dose irradiation with modified atmosphere packaging for mango against oriental fruit fly (Diptera: Tephritidae). J. Econ. Entomol. 111 (1): 135-140.

Nadel, H., **P. A. Follett,** C. Perry and R. Mack. 2018. Irradiation for quarantine control of the invasive fruit pest *Lobesia botrana* (Lepidoptera: Tortricidae). J. Econ. Entomol. 111 (1): 127-134.

Srimartpirom, M., I. Burikam, W. Limohpasmanee, T. Konggratarporn, T. Thannarin, A. Bunsiri, and **P. A. Follett**. 2018. Low dose irradiation with modified atmosphere packaging for mango against oriental fruit fly (Diptera: Tephritidae). J. Econ. Entomol. 111 (1): 135-140.

Follett, P. A. A. Swedman, and B. Mackey. 2018. Effect of low oxygen created by modified atmosphere packaging on radiation tolerance of *Drosophila suzukii* (Diptera: Drosophilidae) in sweet cherries. J. Econ. Entomol. 111 (1): 141-145.

Myers, R. Y., **P. A. Follett**, C. L. Mello, and K. A. Snook. 2018. Effects of irradiation on reproduction of *Rotylenchulus reniformis*. Nematology doi (online)

Nicholas, A., and **P. A. Follett**. 2018. Postharvest irradiation treatment for quarantine control of western flower thrips. J. Econ. Entomol. 111 (3): 1185-1189

Follett, P. A. 2018. Irradiation for postharvest quarantine control of coffee berry borer (Coleoptera: Curculionidae) and a generic dose for Curculionoidea. J. Econ. Entomol. 111 (4): 1633-1637.

Follett, P. A., N. Manoukis, and B. Mackey. 2018. Comparative cold tolerance in *Ceratitis capitata* and *Zeugodacus cucurbitae* (Diptera: Tephritidae). J. Econ. Entomol. 111 (6): 2632-2636.

Follett, P. A., L. Jamieson, L. Hamilton, and M. M. Wall. 2019. New associations and host status: infestability of kiwifruit by the fruit flies *Bactrocera dorsalis*, *Zeugodacus cucurbitae*, and *Ceratitis capitata* (Diptera: Tephritidae). Crop Protection 115: 113-121.

Avanesyan, A., K. Snook, **P. Follett**, and W. Lamp. 2019. Short-term physiological response of a native Hawaiian plant, *Hibiscus arnottianus*, to injury by the exotic leafhopper, *Sophonia orientalis* (Hemiptera: Cicadellidae). Environ. Entomol. (online)

Hossain, F., **P. A. Follett**, K. D. Vu, M. Harich, S. Salmieri, and M. Lacroix. 2019. Antifungal activity of combined treatments of active methylcellulosic based films containing encapsulated nanoemulsion of essential oils and γ-irradiation: in vitro and in situ evaluations. Cellulose 26 (2): 1335-1354.

Ayari, S., S. Shankar, **P. Follett,** F. Hossain, M. Lacroix. 2020. Potential synergistic antimicrobial efficiency of binary combinations of essential oils against *Bacillus cereus* and *Paenibacillus amylolyticus* – Part A. Microbial Pathogenesis 141: 104008.

Shankar, S., **P. Follett,** S. Ayari, F. Hossain, S. Salmieri, M. Lacroix. 2020.Microbial radiosensitization using combined treatments of essential oils and irradiation: Part B: comparison between gamma-ray and X-ray at different dose rates. Microbial Pathogenesis 143: 104118

Begum, T., P. A. Follett, F. Hossain, L. Christopher, S. Salmieri, and M. Lacroix. 2020. Microbial effectiveness of irradiation from gamma and X-ray sources at different dose rates against the foodborne illness pathogen *Escherichia coli*, *Salmonella* Typhimurium and *Listeria monocytogenes*. LWT – Food Science and Technology 132: 109841.

Hamilton, L. J., Y. Tagami, L. Kaluna, J. Jacob,S. Jarvi, and **P. A. Follett**. 2020. Demographics of the semi-slug *Parmarion martensi*, an intermediate host for *Angiostrongylus cantonensis* in Hawaii, during laboratory rearing. Parasitology 148 (2): 153-158.

Walse, S., D. Cha, B-Y. Lee, and **P. A. Follett**. 2020. Postharvest quarantine treatments for *Drosophila suzukii* in fresh fruits, pp.255-267, In F.R.M. Garcia (ed.), *Drosophila suzukii Management*. Springer International Publishing. https://doi.org/10.1007/978-3-030-62692-1_13

Brill, E., **P. A. Follett**, A. M. Kawabata. 2021. Feeding habits, movement, and reproduction in the predatory flat bark beetles *Cathartus quadricollis* (Coleoptera: Silvanidae) and *Leptophloeus* sp. (Leptophloeidae) in Hawaii coffee and macadamia nut. Intern. J. Trop. Insect Sci. 41(1): 285-294.

Follett P. A., F.E.H. Haynes, and B. C. Dominiak. 2021. Host suitability index for polyphagous tephritid fruit flies. J. Econ. Entomol. 104 (3): 1021-1034.

Yousuf, F., **P. A. Follett**, C.P.D.T. Gillett, D. Hornsberger, L. Camorro, M. T. Johnson, M. Giraldo-Jaramillo, P. Benavides-Machado, and M. G. Wright. 2021. Limited host range in the idiobiont parasitoid *Phymastichus coffea* (Hymenoptera: Eulophidae), a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii. J. Pest Sci. doi.org/10.1007/s10340-021-01353-8

Hossain, F., **P. A. Follett**, S. Shankar, T. Begum, S. Salmieri, and M. Lacroix. 2021. Radiosensitization of rice weevil *Sitophilus oryzae* using combined treatments of essential oil and ionizing radiation with gamma ray and x-ray at different doses. Radiation Physics and Chemistry DOI: 10.1016/j.radphyschem.2020.109286

Fezza, T. J., **P. A. Follett**, T. Shelly. 2021. The timing of pupal irradiation and the quality and sterility of oriental fruit flies (Diptera: Tephritidae) for use in the Sterile Insect Technique. Appl. Entomol. Zool. 56: 443-450.

Portilla, M., **P. A. Follett**, J. W. Armstrong, et al. 2021. Risk assessment of ozone fumigation under vacuum to control potential infestations of coffee berry borer and coffee leaf rust in green coffee beans imported into Hawaii. J. Econ. Entomol. doi.org/10.1093/jee/toab165

Begum, T., **P. Follett**, S. Shankar, J. Mahmud, S. Salmieri, and M. Lacroix. 2021. Mixture design methodology and predictive modelling for developing active formulations using essential oils and citrus

Attachment 4

CURRICULUM VITAE – MARK GERALD WRIGHT

Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, Hawaii 96822-2271. Email: markwrig@hawaii.edu

EDUCATION:

B.Sc. (1984 -1986): Major subjects: Zoology & Entomology
Institution: University of Stellenbosch, Stellenbosch 7600, South Africa.

B.Sc. (Honours) (1987): Major subject: Zoology (Ecology & environmental physiology). This one-year degree comprises graduate coursework, and an introduction to research.
Institution: University of Stellenbosch, Stellenbosch 7600, South Africa.

M.Sc. (1988-1990): Major subject: Entomology
Institution: University of Stellenbosch, South Africa.
Title of thesis: *The insect communities, herbivory, seed predation and pollination of* Protea magnifica *and* P. laurifolia.

Ph.D. (1991-1996): Subject: Zoology/Entomology
Institution: University of Natal, Pietermaritzburg, South Africa.
Title of dissertation: *Ecological correlates: endophagous insects and plants in Fynbos.*

Post-doctoral Fellow (1999-2001): Department of Entomology, Cornell University.

Other :
Certificate in Environmental Law: (1998): Potchefstroom University (Centre for Regional Development)
Certificate in Environmental Management Systems (ISO 14000): (1998): Potchefstroom University (Centre for Regional Development)
Certificate Programme in Project Management: (1996): University of Stellenbosch (Graduate School of Business).

LANGUAGES

First language:	English
Other languages:	Afrikaans

EMPLOYMENT HISTORY

August 2012 – present: Promotion to Professor/Extension Specialist (Entomology), Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa. Responsibilities: research and extension on ecology and management of invasive insects on tropical fruit and nut crops, including biological, cultural and chemical control measures. Instruction in insect ecology and biological control. Served as department chair (2013-2016 term). Graduate faculty (and program chair) in Entomology; Graduate faculty in Ecology, Evolution and Conservation Biology program.

- Member of Editorial Board, *Biological Control*, current.
- Member of Editorial Board, Entomological Society of America Plant-Insect Ecosystems Section representative, *Environmental Entomology*, 2013-2014 (Chair of editorial board 2014)
- Review manuscripts for journals including *African Entomology, Biodiversity and Conservation, Biological Control, Journal of Economic Entomology; Journal of Entomological Science, Crop Science, Environmental Entomology, Diversity and Distributions, Austral Ecology, Journal of Tropical Agriculture, Plant Disease, Entomologia Experimentalis et Applicata, Florida Entomologist, Pacific Science, Biological Invasions, Insects, Journal of Theoretical Biology,* and others.
- Grant proposal panel reviewer for the United States Civilian Research and Development Foundation for the Independent States of the Former Soviet Union (CRDF), Arlington, VA (2002-2008).
- Co-editor of a volume of *Acta Horticulturae.*
- Responsible for the initiation of conservation agriculture projects for ARC-Roodeplaat (1997-1998).

SCIENTIFIC PUBLICATIONS (in peer-reviewed journals/books/invited book reviews)
Book chapters, Reviewed conference proceedings, Book reviews:

1. Kaufman, L.V., **Wright, M.G.** 2022. Erythrina gall wasp successfully controlled by the introduction of a parasitoid wasp in Hawaii. In: contributions of classical biocontrol to the US food security, forestry and biodiversity. Eds van Driesche *et al.* (in review)
2. Cave, R., **Wright, M.G.**, Moore, A. 2022. Biological Control of the Cycad Aulacaspis Scale, *Aulacaspis yasumatsui.* In: contributions of classical biocontrol to the US food security, forestry and biodiversity. Eds van Driesche *et al.* (in review)
3. Mafra-Neto, A., **Wright, M.**, Fettig, C., Progar, R., Munson, S., Blackford, D., Moan, J., Graham, E., Foote, G., Borges, R., Silva, R., lake, R., Bernardi, C., Saroli, J., Clarke, S., Meeker, J., Nowak, J., Agnello, A., Martini, X., Rivera, M., Stelinski, L. 2022. Repellent semiochemical solutions to mitigate the impacts of global climate change on arthropod pests. In: *Advances in Arthropod Repellents*. Elsevier. pp. 279-322.
4. Day, M., Cock, M., Conant, P., Furlong, M., Paynter, Q., Ramadan, M., **Wright, M.G.** 2021. Biological control success and failures: Oceania region. In*: Biological Control: Global Impacts, Challenges and Future Directions of Pest Management*, Ed. P.G. Mason. CSIRO Publishing, Melbourne. pp. 342-376.
5. **Wright, M.G**. 2017. Assessing host use and population level impacts on non-target species by introduced natural enemies: can host range testing provide insight? *Proceedings of the 5th International Symposium on Biological Control of Arthropods*. Malaysia. P.G. Mason, D.R. Gillespie and C. Vincent (Eds.). CAB International. 50-51.
6. **Wright, M.G**. 2015. Proteas. In: *Insects of Cultivated Plants and Natural Pastures in Southern Africa*. Prinsloo, G.L. & Uys, V.M. (Eds). Entomological Society of Southern Africa, Pretoria: 680-695.
7. **Wright, M.G**. 2014. Biological control of invasive insect pests. In: *Integrated Pest Management – Current concepts and ecological perspective*. Ed. Abrol, D.P. Elsevier Academic Press. pp. 267-281.

biocontrol in Hawaii: case studies and trends. *Biological Control* (Submitted)

22. Honsberger, D.N., Huber, J.T. and **Wright, M.G**. 2022. A new *Mymaromma* sp. (Mymarommatoidea, Mymarommatidae) in Hawai'i and first host record for the superfamily. *Journal of Hymenoptera Research* 89: 73-87. https://doi.org/10.3897/jhr.89.77931
23. Honsberger, D.N., **Wright, M.G**. 2022. A new species of *Phymastichus* (Hymenoptera: Eulophidae: Tetrastichinae) parasitic on *Xyleborus* beetles (Coleopetera: Curculionidae: Scolytinae) in Hawaii. *Zootaxa* 5116: 107-122.
24. Elliot, C., Gillett, C.P.D.T., Parsons, E., **Wright, M.G**. and Rubinoff, D. 2021. Identifying key threats to a refugial population of an endangered Hawaiian moth. *Insect Conservation and Diversity* doi: 10.1111/icad.12553
25. Gugliuzzo, A., Biedermann, P.H.W., Carrillo, D., Castrillo, L.A., Egonyu, J.P., Gallego, D., Haddi, K., Hulcr, J., Jactel, H., Kajimura, H., Kamata, N., Meurisse, N., Li, Y., Oliver, J.B., Ranger, C.M., Rassati, D., Stelinski, L.L., Sutherland, R., Garzia, G.T., **Wright, M.G.**, and Biondi, A. 2021. Recent advances toward the sustainable management of invasive *Xylosandrus* ambrosia beetles. *Journal of Pest Science* https://doi.org/10.1007/s10340-021-01382-3
26. Le Roux, J.J., Crous, P.W., Kamutando, C.N., Richardson, D.M., Strasberg, D., Wingfield, M.J., **Wright, M.G**., and Valverde, A. 2021. A core of rhizosphere bacterial taxa associate with two of the world's most isolated plant congeners. *Plant and Soil* https://doi.org/10.1007/s11104-021-05049-x
27. Yousuf, F., Follett, P.A., Gillett, C.P.D.T., Honsberger, D., Chamorro, L., Johnson, T.M., Jaramillo, M.G., Machado, P.B. & **Wright, M.G.** 2021. Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii. *Journal of Pest Science* https://doi.org/10.1007/s10340-021-01353-8
28. Ali, A.N., & **Wright, M.G**. 2021. Response of *Trichogramma papilionis* to semiochemicals induced by host oviposition on plants. *Biological Control* 154: 104510.
29. Gutierrez-Coarite, R., Cho, A.H., Mollenido, J., Pulakkatu-Thodi, I., & **Wright, M.G**. 2021. Macadamia felted coccid impact on macadamia nut yield in the absence of a specialized natural enemy, and economic injury levels. *Crop Protection* 139: 105378.
30. Rugman-Jones, P.F., Au., M., Ebrahimi, V., Eskalen, A., Gillett, C.P.D.T., Honsberger, D., Husein, D., **Wright, M.G**., Yousuf, F., & Stouthamer, R. 2020. One becomes two: second species of the *Euwallacea fornicatus* complex (Coleoptera: Curculionidae: Scolytinae) species complex is established on two Hawaiian Islands. *PeerJ Life and Environment* 8:e9987 http://doi.org/10.7717/peerj.9987
31. Kaufman, L.V., Zarders, D.R., & **Wright, M.G.** 2020. Susceptibility of endemic *Myoporum* (Naio) species and populations to *Klambothrips myopri* (naio thrips) in Hawaii. *Pacific Science* 74: 309-318.
32. Ali, A.N., & **Wright, M.G.** 2020. Fitness effects of founder female number of *Trichogramma papilionis* reared on *Ephestia kuehniella. Proceedings of the Hawaiian Entomological Society* 52: 25-34.
33. Ali, A.N., & **Wright, M.G.** 2020. Behavioral response of *Trichogramma papilionis* to host eggs, host plants, and induced volatile plant cues. *Biological Control* 149: 104323.
34. Kaufman, L.V., Yalemar, J., & **Wright, M.G**. 2020. Classical biological control of the

48. Zarders, D.R. & **Wright, M.G.** 2016. Macadamia felted coccid, *Eriococcus ironsidei*: biology and life cycle in Hawaii. *Proceedings of the Hawaiian Entomological Society* 48: 51-55.
49. Manandhar, R. & **Wright, M.G**. 2016. Within-field spatial distribution of corn planthopper, *Peregrinus maidis* (Hemiptera: Delphacidae), and severity of hopperburn and Maize mosaic virus symptoms as influenced by sunn hemp intercropping. *Entomologia Experimentalis et Applicata* 161: 121-130. DOI: 10.1111/eea.12498.
50. Lu, B., Jin, Q., Wen, H., Bellis, G.A., **Wright, M.G**., Peng, Z., Wan, J., Guo, D. 2016. Biological, physiological and genetic response of *Tetrastichus brontispae* (Ferriere) (Hymenoptera: Eulophidae) following exposure to low temperature. *BioControl* 61: 649-659. DOI 10.1007/s10526-016-9757-9.
51. Manandhar, R. & **Wright, M.G**. 2016. Effects of interplanting flowering plants on the biological control of corn earworm (Lepidoptera: Noctuidae) and thrips (Thysanoptera: Thripidae) in sweet corn. *Journal of Economic Entomology* 109: 113-119.
52. Leblanc, L., San Jose, M., **Wright, M.G**. & Rubinoff, D. 2015. Declines in biodiversity and the emergence of pest species across land use gradients in Southeast Asia. *Landscape Ecology* 31:505-516. (DOI 10.1007/s10980-015-0276-3).
53. Greco, E.B. & **Wright, M.G**. 2015. Ecology, biology and management of the black twig borer (Coleoptera: Curculionidae: Scolytinae) with emphasis on coffee in Hawaii. *Journal of Integrated Pest Management* 6(1) 7; DOI: 10.1093/jipm/pmv007.
54. Manandhar, R., **Wright, M.G**. 2015. Enhancing biological control of corn earworm, *Helicoverpa zea* and thrips through habitat management and inundative release of *Trichogramma pretiosum* in corn cropping systems. *Biological Control* 89: 84-90.
55. Tavares, J.M., Villalobos, E.M. & **Wright, M.G**. 2015. Contribution of insect pollination to *Macadamia integrifolia* production in Hawaii. *Proceedings of the Hawaiian Entomological Society* 47: 35-49.
56. Benelli, G., Messing, R.H., **Wright, M.G.**, Giunti, G., Kavallieratos, N.G. & Canale, A. 2014. Cues triggering mating and host-seeking behavior in the aphid parasitoid *Aphidius colemani* (Hymenoptera: Braconidae; Aphidiinae): implications for biological control programs. *Journal of Economic Entomology* 107: 2005-2022.
57. Vorsino, A.E., Wieczorek, A.M., **Wright, M.G.**, Messing, R.H. 2014. Genetic analysis of an introduced biological control agent reveals temporal and geographic change, with little evidence of a host mediated shift. *Biological Control* 77: 41-50.
58. Leblanc L., Rubinoff, D. **Wright M.G**. 2013. Conservation implications of changes in endemic Hawaiian Drosophilidae diversity across land use gradients. *PLoS ONE* 8(5): e62464. doi:10.1371/journal.pone.0062464.
59. Benelli, G., Giunti, G., Messing, R.H. & **Wright, M.G**. 2013. Visual and olfactory female-borne cues evoke male courtship in the aphid parasitoid *Aphidius colemani* Viereck (Hymenoptera: Braconidae). *Journal of Insect Behavior* 26: 695-707.
60. Greco, E.G. & **Wright, M.G**. 2013. Dispersion and sequential sampling plan for *Xylosandrus compactus* (Coleoptera: Curculionidae) infesting Hawaii coffee plantations. *Environmental Entomology* 42: 277-282.

macadamia nut in Hawaii: nut maturity and cultivar effects. *Environmental Entomology*. 38: 1168-1173.

75. Hooks, C.R.R., Fukuda, S., Perez, E.A., Manandhar, R., Wang, K.H., **Wright, M.G.** & Almeida, R.P.P. 2009. Aphid transmission of Banana bunchy top virus to bananas after treatment with a bananacide. *Journal of Economic Entomology* 102: 493-499.
76. Kaufman, L.V. & **Wright, M.G**. 2009. Life history, seasonal phenology and parasitism of the Hawaiian endemic moth *Udea stellata* (Lepidoptera: Crambidae). *Annals of the Entomological Society of America* 102: 104-111.
77. Kaufman, L.V. & **Wright, M.G**. 2009. The impact of exotic parasitoids on populations of a native Hawaiian moth assessed using life table studies. *Oecologia* 159: 295-304.
78. Manandhar, R., Hooks, C.R.R., **Wright, M.G.** 2009. Influence of cover crop and intercrop systems on *Bemisia argentifolli* (Hemiptera: Aleyrodidae) infestation and associated Squash Silverleaf Disorder in zucchini. *Environmental Entomology* 38: 442-229.
79. Hooks, C.R.R., **Wright, M.G.**, Kabasawa, D., Manandahr, R. & Almeida, R.P.P. 2008. Effect of Banana Bunchy Top Virus infection on morphology and growth characteristics of banana. *Annals of Applied Biology* 153: 1-9.
80. Leonhardt, K.W., Littleton, T.E., & **Wright, M.G**. 2008. Evaluation of *Leucopsermum* hybrids for warm-temperature tolerance. *Acta Horticulturae* (ISHS) 805: 81-92.
81. Le Roux, J.J., Wieczorek, A.M, **Wright, M.G.** & Tran, C.T. 2007. Super-genotype: global monoclonality defies the odds of nature. *PloS ONE* 2(7): e590. doi: 10.1371/journal.pone.0000590.
82. Robson, J.D., **Wright, M.G.**, and Almeida, R.P.P. 2007. Effect of imidacloprid foliar treatment and banana leaf age on *Pentalonia nigronervosa* (Hemiptera, Aphididae) survival. *New Zealand Journal of Crop and Horticultural Science* 35: 415-422.
83. **Wright, M.G.**, Follett, P.A. & Golden, M. 2007. Long-term patterns and feeding sites of southern green stink bug (Hemiptera: Pentatomidae) in Hawaii macadamia orchards, and sampling for management decisions. *Bulletin of Entomological Research* 97: 569-575.
84. Robson, J.D., **Wright, M.G.** & Almeida, R.P.P. 2007. Biology of *Pentalonia nigronervosa* Coq. (Hemiptera, Aphididae) on banana using different rearing methods. *Environmental Entomology*. 36: 46-52.
85. Englund, R.A., **Wright, M.G**. & Polhemus, D.A. 2007. Aquatic insect taxa as indicators of aquatic species richness, habitat disturbance, and invasive species impacts in Hawaiian streams. *Bishop Museum Bulletins in Cultural and Environmental Studies.* 3: 205-230.
86. Robson, J.D., **Wright, M.G**. & Almeida, R.P.P. 2006. Within-plant spatial distribution and binomial sampling of *Pentalonia nigronervosa* Coquerel (Hemiptera: Aphididae) on banana in Hawai'i. *Journal of Economic Entomology*. 99: 2185-2190.
87. Messing, R.H. & **Wright, M.G**. 2006. Biological control of invasive species: solution or pollution? *Frontiers in Ecology and Environment* 4: 132-140.
88. Golden, M., Follett, P.A. & **Wright, M.G**. 2006. Assessing *Nezara viridula* (Hemiptera: Pentatomidae) feeding damage in macadamia nuts using a biological stain. *Journal of Economic Entomology* 99: 822-827.
89. **Wright, M.G.**, Hoffmann, M.P., Kuhar, T.P., Gardner, J. & Pitcher, S.A. 2005. Evaluating risks of biological control introductions: a probabilistic risk-assessment approach. *Biological Control* 35: 338-347.

104. **Wright, M.G.** & Samways, M.J. 2000. Biogeography and species richness of endophagous insects associated with Proteaceae in South Africa. *African Journal of Ecology* 38: 16-22.
105. Khan, S., **Wright, M.G.** & Davison, S. 2000. Polyhedrin gene sequence of a South African isolate of *Helicoverpa armigera* single-enveloped nuclear polyhedrovirus. *South African Journal of Science* 96: 584-588.
106. Khan, S., Davison, S. & **Wright, M.G.** 2000. Identification of an entomopathogenic bacterium that infected a colony of *Pieris brassicae* (Linnaeus) (Lepidoptera: Pieridae) in South Africa. *African Entomology* 8:141-143.
107. **Wright, M.G.** & Samways, M.J. 1999. Plant characteristics determine insect borer assemblages on *Protea* species in the Cape fynbos, and importance for conservation management. *Biodiversity and Conservation* 8:1089-1100.
108. Visser, D., **Wright, M.G.**, van den Berg, A. & Giliomee, J.H. 1999. Species richness of arachnids associated with *Protea nitida* (Proteaceae) in the Cape Fynbos. *African Journal of Ecology* 37: 334-343.
109. **Wright, M.G.** & Samways, M.J. 1998. Insect species richness tracking plant species richness in a diverse flora: gall insects in the Cape Floristic Region, South Africa. *Oecologia* 115: 427-433.
110. Price, P.W., Fernandes, G., Lara, A.C., Brawn, J., Gerling, D., Barrios, H., **Wright, M.**, Ribeiro, S.P. & Rothcliff, N. 1998. Global patterns in local numbers of insect galling species. *Journal of Biogeography*. 25: 581-591.
111. Coetzee, J.H., **Wright, M.G.** & Giliomee, J.H. 1997. Antiherbivore mechanisms of five commercially important Cape Proteaceae. *Journal of Applied Entomology*. 121: 367-372.
112. **Wright, M.G.** & Samways, M.J. 1996. Gall-insect species richness in African Fynbos and Karoo vegetation: The importance of plant species richness. *Biodiversity Letters* 3: 151-155.
113. Visser, D., **Wright, M.G.** & Giliomee, J.H. 1996. The influence of the Argentine ant (*Linpethema humile*) on flower visitors of *Protea nitida* in the Jonkershoek Valley. *African Entomology* 4: 285-287.
114. **Wright, M.G.** 1995. Integrated pest management - concepts and potential for the control of borers on Proteas. *Acta Horticulturae* 387: 153-157.
115. **Wright, M.G.** & Saunderson, M.D. 1995. Protea plant protection: from the African context to the international arena. *Acta Horticulturae* 387: 129-139.
116. Mustart, P.J., Cowling, R.M. & **Wright, M.G.** 1995. Seed clustering in infructescences of serotinous Proteaceae: An anti predation mechanism. *African Journal of Ecology* 33: 224-229.
117. **Wright, M.G.** 1994. Unpredictable seed-set: A defence mechanism against seed eating insects in *Protea* species (Proteaceae). *Oecologia* 99: 397-400.
118. **Wright, M.G.** 1994. Seed set in *P. laurifolia* following insect vs. insect and bird pollination - a quality difference? *South African Journal of Science*. 90: 199.
119. **Wright, M.G.** & Coetzee, J.H. 1992. An improved technique for disinsectation of *Protea* cut flowers. *Journal of the South African Society of Horticultural Science* 2: 92-93.
120. **Wright, M.G.** & Giliomee, J.H. 1992. Insect herbivory and putative defence mechanisms of *Protea magnifica* and *P. laurifolia* (Proteaceae). *African Journal of Ecology* 30: 157-168.

7. Wright, M.G. 2004. White peach scale on papaya. *Proceedings, 40th Annual Hawaii Papaya Industry Association Conference.*
8. Wright, M.G., Diez, J.M. & Follett, P.A. 2004. Dispersal and effectiveness of mass-released green stinkbug egg parasitoids. *Proceedings, 44th Hawai'i Macadamia Nut Association Conference.*
9. Wright, M.G. & Vorsino, A.E. 2005. Macadamia Felted Coccid – Preliminary Data on Insecticidal Control and Distribution in Trees. *Hawai'i Macadamia Nut Association 45th Annual Conference Proceedings* pp. 26-29.
10. Golden, M., Follett, P. & Wright, M.G. 2005. Forecasting Stink Bug Injury in Macadamia Nuts. *Hawai'i Macadamia Nut Association 45th Annual Conference Proceedings* pp. 35-40.
11. Nelson, S., Easton-Smith, V. and Wright, M.G. 2005. Banana moth as a pest of coffee. CTAHR CES IP-21 pp. 1-4.
12. Nelson, S. and Wright, M.G. 2005. Banana Moth—A potentially fatal pest of Pritchardia and other palms. CTAHR CES IP-24 pp. 1-4
13. Wright, M.G. 2006. Multiple-pest management decisions for macadamia nut pests. *Hawai'i Macadamia Nut Association 47th Annual Conference Proceedings* pp. 35-39.
14. Hooks, C.R[2]., and Wright, M.G. 2008. Use of living and dying mulches as barriers to protect zucchini from insect-caused viruses and phytotoxemias. CTAHR CES PD-36. pp. 1-8.
15. Wright, M.G. and Conant, P. 2009. Pest status and management of macadamia felted coccid (Hemiptera: Eriococcidae) in Hawaii. *Southern African Macadamia Growers Association Yearbook* 17: 72-75.
16. Kawabata, A., Follett, P., Wright, M., Brill, E., Curtiss, R.T. 2016. An introduction to the square-necked grain beetle as a predator of coffee berry borer in Hawaii. CTAHR-CES IP-40. pp. 1-4.
17. Gutierrez, R., Pulakkatu-Thodi, I., Zarders, D., Mollenedo, J., Yalemar, J., Wright, M.G., & Cho, A. 2017. Macadamia felted coccid, *Eriococcus ironsidei* (Hemiptera: Eriococcidae) description, monitoring and control. CTAHR CES IP-43. pp. 1-5.
18. Gutierrez-Coarite, R., Kawabata, A., Cho, A., Mollinedo, J., Wright, M.G. 2020. Macadamia nut orchard modification strategies for reducing macadamia felted coccid (*Eriococcus ironsidei*) populations in Hawaii. CTAHR CES IP-48. pp.1-8.
19. Wright, M.G. 2020. Avocado lace bug in Hawaii. CTAHR CES IP-50. pp. 1-2.

PUBLISHED ABSTRACTS: CONFERENCE PRESENTATIONS

1. Coetzee, J.H., Wright, M.G. & Willems, N.S.F.1987. Phytophagous insects of five proteaceous species. Proceedings, Sixth Entomological Congress of the Entomological Society of Southern Africa: 96.
2. Coetzee, J.H. & Wright, M.G.1990. Harvest and post harvest control of insects in protea cut flowers. Proc. Int. Hort. Congress, Italy Sept 1990. Article No 3247.
3. Khan, S., Davison, S. & Wright, M.G. 1997. Genetic and protein characterisation of a baculovirus isolated from *Helicoverpa armigera* (American bollworm), with reference to potential as a biological control agent. Insects in African economy and environment. Proc. Joint Congress of the Entomological Society of Southern Africa and the African Association of Insect Scientists, Stellenbosch. 116-117.

18. Hoffmann, M.P., Wright, M.G., Chenus, S.A. & Gardner, J. 2000. Inoculative releases of *Trichogramma ostriniae* for European corn borer control. Proceedings, XXI International Congress of Entomology, Iguassu, Brazil. 391.
19. Valdivia-Buitriago, L. & Wright, M.G. 2003. Retrospective probabilistic non-target risk assessments for insect biological control agents. Paper presented (by MGW) at XIII International Entomophagous Insects Workshop, Tucson, AZ, July 27-31. Abstract published in *Journal of Insect Science*, 3:33, p. 25.
20. Villalobos, E.M., Wright, M.G., Johnson, M.W. & Vorsino, A. 2003. Ecological parameters that affect he behavioral response and efficiency of *Ganaspidium utilis* as a bio-control agent of *Liriomyza trifolli*. Paper presented (by EMV) at XIII International Entomophagous Insects Workshop, Tucson, AZ, July 27-31. Abstract published in *Journal of Insect Science*, 3:33, p. 27.
21. Van Elsen, K., Messing, R.H. & Wright, M.G. 2003. Parasitism of aphids by *Endaphis maculans* (Diptera: Cecidomyiidae) in Hawai'i. Paper presented at XIII International Entomophagous Insects Workshop, poster session, Tucson, AZ, July 27-31. Abstract published in *Journal of Insect Science*, 3:33, pp. 25-26.
22. Perez, E., Hooks, C., Wang, K., Wright, M.G., Almeida, R. & Manadhar, R. 2008. The virulence of Banana bunchy top virus in banana plants after injection with a bananacide. *Phytopathology* 98: s124.
23. Kaufman, L.V. & Wright, M.G. 2009. The role of *Anagyrus loecki* (Hymenoptera: Encyrtidae) in suppressing *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in commercial papaya farms in Hawaii. Proceedings of ISBCA 3 – P. G. Mason, D. R. Gillespie and C. Vincent Eds. (2008). p.569.
24. Kaufman, L.V., Wright, M.G., Yalemar, J. & Messing, R.H. 2013. Biological control of the Erythrina gall wasp: protecting a native keystone forest species in Hawaii. Eds: P.G. Mason, D.R. Gillespie & C. Vincent. *Proceedings of the 4th International Symposium on Biological Control of Arthropods,* Pucón, Chile. pp. 72-74.

***Prior to employment at University of Hawai'i*:**

- Hoffmann, M., Wright, M. & Kuhar., T. 2001. Inoculative releases of *Trichogramma ostriniae* for suppression of European corn borer in sweet corn. In: Proceedings, New York State Vegetable Conference. Feb. 14-16, Syracuse, NY. pp. 81-84.
- Wright, M.G. & Hoffmann, M.P. 2001. Selection of vegetables for intercropping as a pest management strategy. In: Merwin, I. & Rangarajan, A. (Eds) Summary reports for New York Research in organic agriculture funded by the Towards Sustainability Foundation. Cornell University. pp. 87-96.
- Wright, M.G. 1992. Monitoring, synthesizing and unconventional control measures: enhancing thrips control. In: Wright, M.G. (Ed.) *Proceedings: Thrips workshop*, VOPI, Agricultural Research Council. pp. 45-47.
- Coetzee, J.H. & Wright, M.G.1991. Post harvest treatment and disinsectation of *Protea* cut flowers. *Conference Proceedings: International Protea Assoc.*, Sixth Biennial Conference, Perth, Western Australia, Sept 1991. pp 63-66.

AWARDS

- S.P. Green Bursary for zoology (1986).
- CSIR Bursary for graduate study (1987).
- International Protea Association Scholarship (1994).
- College of Tropical Agriculture and Human Resources Ka Pouhana (Mentor) Award (2004).
- Hawaii Tropical Fruit Growers Association Award for Service (2015).
- Nominated for Dean's for award for Excellence in Teaching, College of Tropical Agriculture and Human Resources, 2020.
- Invited speaker at international conferences (Protea conference in Zimbabwe, Ecological Agriculture Conference in Zambia, Diversity and ecosystem function, Cape Town; Benefits and Risks of biological control, Denver, CO; International Conference on Biological Control of Arthropods, Davos, Switzerland, Pucon, Chile, Malaysia).

NEW TECHNOLOGY GENERATED:

- Developed a technique for environmental coding of pesticides (world-first for this), and farmer-friendly means of transferring this technology;
- Initiated various aspects of integrated pest management for use on high-value, high quality vegetable crops for export, and tested these under commercial conditions;
- Developed a commercial-scale fumigation system for disinsectation of cut flowers.
- Developed a means of selecting vegetable crops to intercrop as a pest-avoidance strategy, aimed at resource-poor farmers.
- Developed indigenous insect pathogens as biological control agents to the point where commercial trials were conducted in tomato and ornamental crops.
- Inoculative releases of *Trichogramma ostriniae* for biological control of European corn borer.

Last update of CV 28 March 2022.

Attachment 5

Final Environmental Assessment

Field Release of *Phymastichus coffea* (Hymenoptera: Eulophidae) for the Biological Control of Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera: Scolytinae) in Hawaii

Peter A. Follett
USDA-ARS
U.S. Pacific Basin Agricultural Research Center
64 Nowelo St.
Hilo, Hawaii 96720

Mark G. Wright
Department of Plant and Environmental Protection Sciences
University of Hawaii at Manoa
3050 Maile Way,
Honolulu, HI 96822

Agency Contact
Mark G. Wright
Ph: 808-271-2037, Fax: 808-956-2428
email: markwrig@hawaii.edu

February 2023

Addressing 13 Administrative Criteria for Significance from the Guide to the implementation and Practice of the Hawaii Environmental Policy Act 2012 edition:

Each criterion as listed in the above guide is addressed below:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource

   The release of *Phymastichus coffea* for the biological control of coffee berry borer will not result in any destruction or other negative impacts on natural or cultural resources in Hawaii. The draft EA details the results of work conducted to determine whether this prospective biological control agent will pose any environmental threats in Hawaii, showing that no negative impacts are expected. No native beetles in the subfamily Scolytinae were parasitized by *P. coffea* under no-choice testing conditions, providing high-confidence evidence that non-target impacts on native species are highly unlikely. This is addressed extensively in the attached DEA.

2. Curtails the range of beneficial uses of the environment

   The release of *P. coffea* for biological control of coffee berry borer will not curtail beneficial uses of the environment in any way. On the contrary, it will increase the viability of coffee farming in Hawaii, thus sustaining the range of beneficial uses of the environment.

3. Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in [Chapter] 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders

   There is no conflict with the State's long-term environmental policies or goals.

4. Substantially affects the economic or social welfare of the community or State

   No negative impacts on the social welfare of communities is anticipated. The biological control of coffee berry borer will likely increase the economic and social welfare of communities. These benefits will primarily be realized through financial savings resulting from effective invasive pest management using options other than pesticide applications.

5. Substantially affects public health

   No negative impacts on public health are expected or likely. The biological control agent is a small non-stinging Hymenoptera species, restricted to using coffee berry borer, and possibly some closely related invasive insect species, as hosts. The biological control agent poses no potential risk to human health.

13. Requires substantial energy consumption

This project does not require substantial energy consumption.

From: **Mark Wright** markwrig@hawaii.edu
Subject: Re: JADAM
Date: December 16, 2022 at 4:09 PM
To: Dana Melina Keawe danakeawe@gmail.com

Dear Ms. Keawe
Thank you for your comment. We are strongly supportive of a range of options for CBB management, including potential JADAM solutions.
We see biological control as a safe and sustainable tool to include in the integrated CBB management options available to Hawaii growers.

Aloha, Mark

Mark G Wright Ph.D.
Professor and Extension Entomologist
Entomology Section
Department of Plant and Environmental Protection Sciences
University of Hawaii at Manoa

Lab website: http://wrightlabuh.weebly.com

> On Dec 15, 2022, at 5:49 PM, Dana Melina Keawe <danakeawe@gmail.com> wrote:
>
> JADAM is the best way to combat CBB. You can subscribe to their Utube channel to see their research project which proved JADAM works to combat CBB. And also get the recipe solution.
> Introducing a wasp to Hawai'i is NOT a good idea.
> Dana Keawe

From: **HC Bittenbender** hcbitt@hawaii.edu
Subject: Proposed release of Phymastichus coffea for control of the Coffee Beery Borer
Date: December 22, 2022 at 3:17 PM
To: Mark G. Wright markwrig@hawaii.edu
Cc: Ania Wieczorek ania@hawaii.edu, Sharon Hurd sharon.k.hurd@hawaii.gov

Aloha Mark Wright,

I am submitting my comments in strong support of the proposed release of the parasitic wasp Phymastichus coffea to control the Coffee Berry Borer (*Hypothenemus hampei*) aka CBB.

As a retired CTAHR extension specialist responsible for coffee (1986- 2018) and macadamia (1986-1995) I am familiar with the serious crop loss of green coffee beans caused by CBB.

In addition I am familiar crop losses caused by related Hypothenemus spp. The Black Twig Borer (*H. seriatus*) began attacking anthuriums in the 1960s and was later found attacking coffee trees in Kona, this was reported by the late CTAHR entomologist Arnold Hara. Until now our only control for Black Twig borer on coffee has been pruning the damaged branches and destroying the prunings to kill the adult borer, larvae and eggs. In the 1986 I referred damaged macadamia nuts to the late CTAHR entomologist Jack Beardsley, who identified the insect in the nuts as *H. obscurus* initially named the macadamia shot hole borer later the Tropical nut borer. To date our only control measure has been harvesting the nuts from the ground within 3 weeks of dropping and drying immediately; this is much earlier than the previous six week harvest interval prior to the arrival Tropical Nut Borer.

Draft Environmental Assessment: Field Release of *Phymastichus coffea* (Hymenoptera: Eulophidae) for the Biological Control of Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera: Scolytinae) in Hawaii section 3.8 Table 1. 'Previous reports of parasitism of Scolytinae species by *Phymastichus coffea* in no- choice laboratory assays' states that P. coffea also parasitizes the Tropical Nut Borer and Black Twig Borer.

Releasing *P. coffea* provides Hawaii farmers an opportunity to biologically control three Hypothenemus species for which the current recommended control practices add substantial labor and materials costs to our farmers.

Seldom does the opportunity arise to control, if only partially, three pests at minimal costs to farmers. This is a great contribution to Hawaii agriculture.

If I should direct my letter of support to another agency or individual please let and I will do so.

H.C. "Skip" Bittenbender, Ph.D.
Emeritus Extension Specialist for Cacao, Coffee and Kava

Tropical Plant and Soil Sciences
CTAHR-College of Tropical Agriculture and Human Resources

End of comments received on draft EA

1. Summary

The coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari), (Coleoptera: Curculionidae: Scolytinae) is the most destructive insect pest of coffee globally. Though endemic to Central Africa, CBB is now found in almost every coffee-producing country in the world. In 2010, it first invaded the island of Hawai'i where high quality coffee is the second largest cash crop, valued at more than $55 million during the 2020-21 season. Coffee berry borer has since invaded coffee on the islands of Oahu, Maui and Kaui. Coffee crop loss due to CBB is estimated at $7.7 million. CBB has had the effect of making coffee farming more intensive and less profitable: damage causes significant losses in yield and alters the flavor profile of salvageable coffee beans. If left unmanaged, CBB can damage >90% of the crop.

Figure 1: CBB gallery inside bean, with visible eggs and larvae

The primary means of control in Hawaii is using the microbial insecticide *Beauveria bassiana* and sanitation (removal of all coffee berries after harvest). Biological control of CBB using parasitoids has been conducted in many countries around the world, especially in Latin America (Mexico south to Brazil) and has potential for Hawaii. One of the most promising agents is a parasitoid wasp, *Phymastichus coffea* LaSalle (Hymenoptera: Eulophidae). *Phymastichus coffea* is a primary, gregarious, idiobiont endoparasitoid of CBB adult females. After being parasitized by *P. coffea*, females stop oviposition and usually die after 4-12 days. Therefore, *P. coffea* was chosen as a potential biological control agent and was brought from Colombia into a quarantine containment facility in Volcano, Hawaii for host range testing to determine whether the parasitoid might attack non-target species and thereby pose a risk to the environment. Using no-choice tests, 43 different species of Coleoptera were tested, including 23 scolytines (6 *Hypothenemus* species, 7 native *Xyleborus* species, and 10 others), and 4 additional Curculionidae. *P. coffea* was only able to parasitize the target host *H. hampei* and 4 other adventive species of *Hypothenemus: H. obscurus, H. seriatus, H. birmanus and H. crudiae*. *Hypothenemus hampei* had the highest parasitism rate and shortest parasitoid development time of the five parasitized *Hypothenemus* spp. Parasitism and parasitoid

regions in the world (Escobar-Ramirez et al., 2019). Furthermore, *P. coffea* is the only parasitoid tested thus far that has been shown to reduce yield loss from CBB damage (Infante et al., 2013). *Phymastichus coffea* has the potential to be an effective biological control agent against the coffee berry borer in Hawaii.

Figure 2: Adult CBB as found inside a green berry

1.3 Reasons for choice of entomophagous biological control agent

The parasitoids, *Cepahlonomia stephanoderis* Betrem, *C. hyalinipennis* Ashmead, *Prorops nasuta* Waterston (Hymenoptera:Bethylidae), *Heterospilus coffeicola* Schneideknecht (Hymenoptera:Braconidae), and *Phymastichus coffea* LaSalle (Hymenoptera:Eulophidae), all of African-origin, have been introduced in many coffee producing countries, particularly in Central and South America (Klein-Koch et al. 1988; Barrera et al. 1990; Baker 1999; Jaramillo et al. 2005; Portilla and Grodowitz 2018), but none have been released in Hawaii.

Phymastichus coffea was chosen as the best candidate parasitoid in Hawaii because of its previously reported high host specificity and ability to significantly reduce and regulate *H. hampei* populations in the field (Gutierrez et al. 1998; López-Vaamonde and Moore 1998; Castillo et al. 2004a,b; Rodríguez et al. 2017). In field cage studies in Mexico and Costa Rico, *P. coffea* proved to be the most promising biological control agent against *H. hampei* with parasitism rates as high as 95% (Espinoza et al. 2009; Infante et al. 2013).

H. hampei flights and optimize timing of *Beauveria bassiana* applications for control (Aristizabal et al. 2016). After *H. hampei* bores into the coffee berries it is protected and difficult to control with biopesticides or conventional insecticides. To achieve maximum *P. coffea* parasitism in the field, releases should be made at times when *H. hampei* adults are active (e.g. when trap catches are high, or female *H. hampei* are actively boring into fruits) and the coffee crop is at a susceptible stage. Optimal timing of releases may differ for different elevations due to *H. hampei* population dynamics (Hamilton et al. 2019). Studies suggest *P. coffea* may be susceptible to *B. bassiana,* however (Barrera 2005; Castillo et al. 2009; Ruiz et al. 2011), so releases should be timed to avoid *B. bassiana* applications or used in alternation with *B. bassiana* against *H. hampei.* If *P. coffea* is highly effective, then dependence on *B. beauveria* applications could be reduced dramatically.

1.6 Location of planned first release

First releases will be made in the South Kona district of the Big Island of Hawaii in the main coffee growing region as it is close to the USDA ARS laboratory and University of Hawaii experiment station which will facilitate monitoring. Other sites may also be selected depending on the number of parasitoids available.

According to the simulation model output, *P. coffea* is predicted to provide feasible control of coffee berry borers in areas where flowering periods are frequent throughout the year (Rodríguez et al. 2017). In Hawaii, Maui and Oahu due to relatively constant temperatures with abundant rainfall, coffee flowering and harvesting seasons may be irregular. However, Kona is different with more pronounced seasonal conditions. So, depending on the flowering season, releases of *P. coffea* will be made approximately 70 and 170 days after flowering periods (when coffee berries have >20% dry matter content), or at times when CBB adults are active (e.g. trap catches are high) and the crop is at a susceptibility stage.

P. coffea may be sensitive to *Beauveria bassiana*, the fungal biopesticide used against the coffee berry borer and to other insecticides (Castillo et al.2009; Barrera 2005; Gómez et al. 2011). Therefore, it is important to make sure that the parasitoids are not released just before or just after or concurrently with pesticides to prevent any negative effects on survivorship and establishment.

1.7 Methods to be used after agent importation

Newly emerged female *P. coffea* will be collected into plastic containers covered with muslin impregnated with a 50% honey-water solution. The containers will be placed in a cool box and transported to the field. The parasitoids will be released in the center of the coffee field. A ratio of 1 parasitoid per 10 hosts (determined from random field sampling for infested coffee berries) or less would be ideal (Espinoza et al. 2009). Once the parasitoids are released, they will disperse naturally to search for new coffee berry borer hosts to parasitize.

1.8 Methods to be used for disposing of any host material, pathogens, parasities, parasitoids, and hyperparasitoids accompanying an import

Because of its short life span (2-4 days), *P. coffea* will be shipped from Cenicafé as parasitized adult CBB into quarantine containment and reared through a generation to ensure that no hyperparasitoids. A sample of parasitized CBB will be tested for plant pathogens, e.g.

Although the vast majority of *Hypothenemus* species live innocuously in twigs, some have become important pests, most notably the coffee berry borer *Hypothenemus hampei* (Ferrari), which lives inside the coffee berry and consumes the seeds, and the tropical nut borer *Hypothenemus obscurus* (F.), which attacks a range of seeds and fruits.

The frons of *H. hampei* may have a broad, indistinct frontal groove, or no groove at all. There are usually four marginal asperities. The setae on the pronotum are mixed, with some slightly flattened. The shape of the pronotum, viewed from above, is slightly more narrowly rounded (i.e., more triangular) than the similar *Hypothenemus* species. The elytral declivity of H. hampei is much more broadly rounded than in the similar species, without a distinct transition from the elytral disc. When viewed laterally, the declivity takes up more than half of the length of the elytra, whereas in the similar species, the elytral disc takes up more than half of the length. As with most *Hypothenemus*, the interstrial bristles are prominent and in almost perfectly uniseriate rows. The shape of the interstrial bristles, however, is distinctive, and differentiates the coffee berry borer from most other *Hypothenemus* species. The bristles are long, narrow, and slightly flattened. The tip of each bristle is square, and not much wider than the rest of its length. The bristles on the elytral disc are not much shorter than those on the declivity. Males are smaller with reduced eyes. The interstrial bristles are relatively long, and often not in distinct rows.

Phylogenetically, *H. hampei* is in a clade distantly related to native Hawaiian Scolytinae species, which are all within the Tribe Xyleborini (Johnson et al. 2018). There are other *Hypothenemus* species in Hawaii, all adventive. While there are anecdotal reports of *H. hampei* feeding on plants other than coffee (e.g. *Leucaena leucocephala*), there is no indication that they could complete their life cycle in those hosts. No native Scolytinae are known to utilize those plants.

2.2 Economic impact and benefits of the target pest: *Hypothenemus hampei*

The coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari), (Coleoptera: Curculionidae: Scolytinae) is the most destructive insect pest of coffee globally, inflicting economical loses of over US$500 million annually. Though endemic to Central Africa, CBB is now found in almost every coffee-producing country in the world. In 2010, it first invaded the island of Hawai'i where high quality coffee is the third largest cash crop, valued at more than $43 million during the 2017-18 season. Coffee berry borer has since invaded coffee on the islands of Oahu and Maui and most recently Kauai. Coffee crop loss due to CBB is estimated at $7.7 million. CBB has had the effect of making coffee farming more intensive and less profitable: damage causes significant losses in yield and alters the flavor profile of salvageable coffee beans. If left unmanaged, CBB can damage >90% of the crop.

CBB has been found on several incidental non-crop host plants in Hawaii such as haole koa (*Leucaena leucocephala*), black wattle (*Acacia decurrens*), and red fruit passionflower or love-in-a-mist (*Passiflora foetida*). However, to date researchers have found only a very low incidence of CBB in any of these other plants, and no signs of CBB reproduction in any of them. Wild (uncultivated) coffee plants are a significant reservoir for CBB populations (Messing 2012).

2.6 Regulatory or pest status of the target pest in the state, provincial or federal law

Hypothenemus hampei is established on all the Hawaiian Islands growing coffee and considered a significant pest that is actively being controlled.

2.7 Knowledge of status of other biological control agents (indigenous or introduced) that attack the pest

No biocontrol agents were previously released in Hawaii against *H. hampei*. Two exotic predatory beetles, *Cathartus quadricollis* and *Leptophloeus* sp., are commonly found in overripe and dried coffee berries naturally predating on the immature stages of *H. hampei* in Hawaii (Follett et al. 2016; Brill et al. 2020). Our host testing in quarantine showed that *P. coffea* will not parasitize these beetles, and that the beetles did not predate on the parasitoids. Also, these predators attack eggs, larvae and pupae of *H. hampei* in overripe and dried berries (left after harvesting), whereas *P. coffea* attacks adult female *H. hampei* primarlily in developing green berries at an earlier stage of crop maturity.

Beauveria bassiana, formulated as BotaniGard®, is sprayed frequently for *H. hampei* control. Repeated applications reduce coffee berry borer damage, but are costly, and efficacy varies depending on local conditions (Greco et al. 2018).

2.8 Life stage of the pest that is vulnerable to the biological control agent

Phymastichus coffea is a primary, gregarious, idiobiont endoparasitoid of adult *H. hampei* females. The beetles are parasitized by *P. coffea* while actively boring into coffee fruits with the abdomen exposed, which can be a prolonged process depending on the ripeness of the fruits. This is unique behavior among Scolytinae, which typically bore into wood.

3. Biological Control Agent Information

3.1 Taxonomy: scientific name (order, family, genus, species, scientific authority

Phymastichus coffea LaSalle (Hymenoptera: Eulophidae). It has no common name. *Phymastichus coffea* was collected in Togo in 1987 and described by LaSalle in 1990. The parasitoid wasp belongs to the family Eulophidae, one of the largest in the Hymenoptera, with nearly 4000 described species. The sub family Tetrastichinae to which the parasitoid belongs has 42 genera and is most widespread of all parasitic groups. Tetrastichinae has an extraordinarily wide host range attacking over 100 families of insects in 10 different orders, as well as mites, spider eggs, and even nematodes (LaSalle 1994). *Phymastichus* can be distinguished from other Tetrastichinae by the presence of distinctively swollen parastigma and lack the presence of a sensory plaque on the ventral edge of the male scape (LaSalle 1990). There are only two known species in this genus, (i) *Phymastichus coffea* and (ii) *P. xylebori*. Both species have potential value in biological control programs against scolytines. *Phymastichus coffea* attacks mainly adult *H. hampei* (CBB) whereas, *P. xylebori* attacks adults of the highly polyphagous island pinhole borer, *Xyleborus perforans* (Wollaston). A third species, *Phymastichus* sp. nova (D. Honsberger pers. comm.) is currently being described from Hawaii. The latter does not parasitize *H. hampei.*

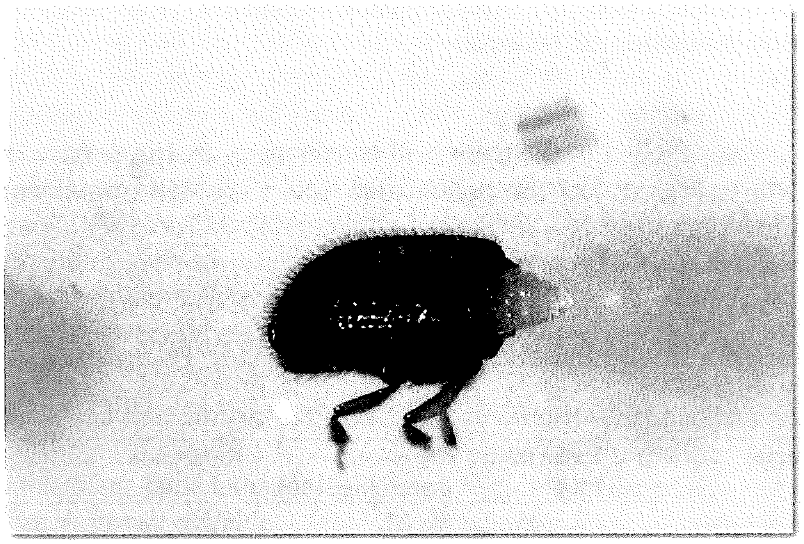


Figure 5: Parasitized CBB with Phymastichus pupa in abdomen.

The average lifespan of the parasitoid is 1-2 days for males and 3-4 days for females (Espinoza et al., 2009). Longevity can be prolonged with 50% honey-water solution as food and if the temperature is decreased (F. Yousuf unpublished). On emergence, female parasitoids can have up to 10 eggs in the ovarioles, but more eggs are formed throughout her lifetime (synovigenic strategy) (Lopez-Vaamonde and Moore, 1998). There is no preoviposition period and the adult female parasitoids can parasitize the coffee berry borer adults immediately after emergence (Infante et al., 1994). It has been shown that *H. hampei* is attracted to semiochemicals released from coffee fruits (Mendesil et al. 2009); semiochemicals released during *H. hampei* feeding on fruits have been shown to attract *P. coffea* (Cruz-Lopez et al. 2016), and may play also a significant role in mediating the host specificity of their parasitoids under field conditions.

3.7 Biology and reproductive potential (including dispersal capability and damage inflicted on the target pest.)

Gravid *P. coffea* females start to search for their hosts immediately after emerging from the adult female host and parasitism occurs within the first hours after emergence (Infante et al. 1994). *Phymastichus coffea* has an extremely short life span as an adult; the longevity of males ranges from 8-48 h and females from 16-72 h (Vergara et al. 2001; Portilla and Grodowitz 2018). *Phymastichus coffea* commonly lays two eggs (a male and a female) (López-Vaamonde and Moore 1998) in an *H. hampei* adult female at the time she is initiating fruit perforation, which causes paralysis and prevents further damage to the coffee berry. Both male and female develop in a single host, the female in the abdomen and the male in the prothorax (Espinoza et al. 2009). The parasitized *H. hampei* usually dies within 4-12 days after parasitism (Infante et al. 1994). The life cycle (egg to adult) of *P. coffea* varies from 30-47 days depending on the environmental conditions (temperature and humidity). Females are ~1 mm long, whereas males are half that size (LaSalle 1990). *P. coffea* can parasitize multiple hosts during its short lifespan. High levels of parasitism have been recorded in previous studies under cage and field conditions.

~800,000 *P. coffea* (Feb-Jun 2021) in 40 ha of coffee to examine parasitism rates and the potential for inundative releases of mass reared parasitoids for *H. hampei* control (P. Benevides, pers. comm.).

3.10 Pathogens, parasites, parasitoids and hyperparasitoids (order, family, genus, species, scientific authority) of the agent and how they will be eliminated from the imported culture of the agent.

Imported *P. coffea* will be reared for a generation in quarantine before release to inspect for hyperparasitoids or other insect contaminants. A sample of *P. coffea*-parasitized CBB will be tested for the presence of plant pathogens, e.g. coffee leaf rust, by USDA ARS scientists.

3.11 Procedures stating how the biological control agent will be handled in containment (e.g. scaling up for release)

Phymastichus coffea will be obtained from an established stock maintained at the National Coffee Research Center-Cenicafé, Manizales (Caldas) Colombia, which was started from *P. coffea* collected in Kenya and shipped to Colombia in 1996 and has been maintained in colony in large numbers since that time (Orozco and Aristizábal 1996). *Phymastichus coffea* has been mass reared by Cenicafé on wild-caught CBB for field releases on multiple occasions and the colony receives frequent infusions of field collected material. For nontarget testing, *Phymastichus coffea* was shipped from Cenicafé in its larval stage in parasitized *H. hampei* hosts under USDA APHIS PPQ, permit no. P526P-18-00696 to a certified quarantine insect containment facility managed by the USDA Forest Service at Hawaii Volcanoes National Park, Volcano, Hawaii. Parasitized *H. hampei* were incubated in controlled climate chambers at 25° ± 1°C, 75 ± 10% relative humidity, and 8:16 h light:dark photocycle at the quarantine containment facility. In the future, we hope that USDA APHIS and HDOA will allow the shipment of *P. coffea* from Cenicafé to Hawaii for release directly in the field without containment. Cenicafé is developing a new rearing system on diet rather than infested coffee beans to improve quality control and reduce the risk of contaminants.

3.12 Closely related genera, sibling species, cryptic species and ecologically similar species of the biological control agent in Hawaii, when they occur

The eulophid genus *Phymastichus* contains two described species: *P. coffea* and *P. xylebori*. The candidate biological control agent *Phymastichus coffea* is not known to occur in Hawaii. *Phymastichus xylebori* is adventive in Hawaii and has been found on the Big Island parasitizing *Xyleborus perforans*; *P. xylebori* has not been found in coffee parasitizing *H. hampei* in Hawaii.

4. Host Specificity Testing

4.1 Selection of nontarget test arthropods

The selection of non-target hosts in Hawaii was based on phylogenetic relatedness to the target host (Johnson et al. 2018), sympatry of target- and non-target species, and size. Coleoptera species commonly occurring in the coffee landscape and species in culture at USDA-ARS in Hilo, included as a positive control to confirm parasitoid viability. The host:parasitoid ratio of the *H. hampei* controls was adjusted to match the nontarget species in the test, whether it was 5:1 or otherwise. The generalized behavioral response of the parasitoids towards target and non-target hosts was also determined for a subset of parasitoids by visual observation and video recording of parasitoid behavior, e.g. any contact with the host by landing on the host or antennation, and/or walking on the host. Host acceptance was noted when the parasitoid adopted a characteristic oviposition position on top the elytra of the host (Lopez-Vaamonde and Moore 1998).

After *P. coffea* exposure, *H. hampei* and all other non-target species were incubated at 25 ± 1°C, 75 ± 10% RH and 24:0 (L:D) photoperiod for 72h. After 72h, parasitoids and filter paper linings were removed and the beetles were provided with a small cube (2 x 2 x 2 cm) of general beetle diet (F. Yousuf, unpublished). The beetles were again incubated at the same environmental conditions but now at 0:24 (L:D). After 10 days all the remaining diet and frass was removed (without disturbing the parasitized beetles) to avoid fungal contamination. Parasitized beetles typically became paralyzed and eventually died within 4-12 days after parasitoid oviposition. Beetles were held for a total of ~5-6 weeks for parasitoid emergence. Beginning after 25 days incubation, *H. hampei* mummies were inspected daily for adult wasp emergence. Parasitism was assessed based on observation of emergence of parasitoid progeny (F1 adult wasps) from the parasitized beetles, by inspection for exit holes on cadavers, or by dissection. Beetles with no exit holes were dissected (by separating the thorax from the abdomen) under a stereomicroscope using fine forceps and entomological pins at 20-100X magnification for evidence of parasitism, i.e., presence of *P. coffea* immature life stages (eggs, larvae or pupae), or unemerged adults. The number of unemerged life stages was recorded for each dissected beetle. After 5-6 weeks of incubation, dead beetle specimens sometimes became very dry and searching for the presence of eggs and early instar larvae was difficult. In such cases, beetles were dissected and examined under a compound microscope at 200X to seek unemerged *P. coffea*. The sex of emerged adult *P. coffea* offspring was determined by examination using a stereomicroscope. In most cases, two parasitoids (one male and one female) emerged per beetle host. To confirm this the sum of the emerged male and female parasitoids in each replicate was divided by two and compared to the number of parasitized hosts with exit holes. The sex of unemerged parasitoids was not determined. For data on parasitism, life stages, sex ratio, and development time, averages were calculated for each replicate (per Petri dish) for each species and used in statistical analysis. Grand means of all the replicates for each of the five *Hypothenemus* species are presented in figures and tables.

Statistical analysis

Parasitism rate was calculated by dividing the number of parasitized hosts by the total number of hosts exposed to the parasitoids in each replicate. Parasitism included both emerged and unemerged wasps. Emergence rate was calculated by dividing the number of beetles with exit holes by the total number of parasitized hosts (emerged plus unemerged wasps). The sex ratio of the parasitoid progeny was calculated by dividing the number of emerged female parasitoids (F) by the total number of emerged male (M) and female (F) parasitoids [F/ (F+M) x 100]. The Shapiro–Wilk test (Shapiro and Wilk 1965; Razali and Wah 2011), numerical approaches (skewness and kurtosis indices), and the normal Q-Q plot-based graphical method were used to check the distribution of the data and showed that the data were not normally distributed. Generalized linear models (GLM) were therefore used to analyze the data, with shortest in *H. hampei* (32.2 ± 0.5 days, mean ± SE), longest in *H. crudiae* (41.0 ± 0.0 days) and intermediate in the other three *Hypothenemus* spp. (Table 2), which generally agrees with the phylogenetic pattern observed for parasitism and emergence (Figure 1). The percentage of female versus male *P. coffea* emerging from parasitized *H. hampei* was 50.8% ± 0.4 (mean ± SE), which was significantly different (χ^2 = 27.3, df = 4, p = 0.0001) from *H. seriatus* and *H. birmanus* (Table 2). *Hypothenemus eruditus* was not parasitized by *P. coffea* and hence was not included in any statistical analyses.

Table 2. Development time and sex ratio of *Phymastichus coffea* in no-choice in vitro non-target host selection screening of *Hypothenemus* species, including *H. hampei* as a control species.

Species	**Insect status**	**Total beetles exposed**	**Development time (days ± SE)**	**Sex ratio (mean % females ± SE)**
Hypothenemus hampei (control)	Exotic/Pest	170	32.2 ± 0.5	50.8 ± 0.4
Hypothenemus obscurus	Exotic/Pest	80	35.0 ± 0.9	54.8 ± 1.6*
Hypothenemus seriatus	Exotic	60	38.0 ± 1.0	51.1 ± 1.1
Hypothenemus birmanus	Exotic	40	37.0 ± 1.0	57.7 ± 3.8*
Hypothenemus crudiae	Exotic	30	41.0 ± 0.0*	50.0
Hypothenemus eruditus	Exotic	80	-	-

* significantly different from *Hypothenemus hampei* (control), $p < 0.05$.

Parasitized *H. hampei* had the lowest percentage of unemerged parasitoids compared to the other four *Hypothenemus* species (Figure 7), indicating that *H hampei* is a superior host for *P. coffea* development. For each parasitized host beetle with unemerged parasitoids, invariably two parasitoids were present, and the parasitoids were of the same life stage (larva, pupa, or adult). The frequency of the different life stages for parasitized hosts with unemerged parasitoids differed among *Hypothenemus* species (Figure 7). Parasitized *H. hampei* had a significantly lower percentage of larval (χ^2 = 15.10, df= 3, p= 0.001) and higher percentage of adult parasitoids that were unemerged (χ^2 = 18.36, df= 3, p= 0.0001) compared to the other *Hypothenemus* species. The higher percentage of unemerged parasitoids developing to the adult stage again indicates that *H. hampei* is a superior developmental host than the other *Hypothenemus* spp. The percentage of unemerged pupae found in parasitized *H. hampei* was not significantly different from *H. obscurus*, *H. seriatus* and *H. birmanus*, but *H. crudiae* had a significantly higher percentage of pupae than *H. hampei* (χ^2 = 95.40, df= 4, p= 0.0001) (Figure 7). No eggs were found in any of the parasitized *Hypothenemus* hosts.

Table 3. Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* exposed to various Scolytinae (Hawaii native and non-native) species.

Family	Species	Insect status	Total beetles exposed	Parasitism (%) (Mean ± SE)	Parasitoid emergence (%) (Mean ± SE)
Curculionidae:	*Xylosandrus compactus*	Exotic/Pest	80	0	0
Scolytinae	*Xylosandrus crassiusculus*	Exotic	80	0	0
	Xyleborinus saxeseni	Exotic	80	0	0
	Xyleborinus andrewesi	Exotic	60	0	0
	Xyleborus ferrugineus	Exotic	60	0	0
	Euwallacea fornicatus	Exotic	60	0	0
	Euwallacea interjectus	Exotic	60	0	0
	Hypochryphalus sp.	Exotic	60	0	0
	Chryphalus sp.	Exotic	80	0	0
	Ptilopodius pacificus	Exotic	80	0	0
	Xyleborus molokaiensis	Native	30	0	0
	Xyleborus mauiensis	Native	15	0	0
	Xyleborus simillimus	Native	18	0	0
	Xyleborus hawaiiensis	Native	9	0	0
	Xyleborus lanaiensis	Native	19	0	0
	Xyleborus obliquus	Native	3	0	0
	Xyleborus kauaiensis	Native	35	0	0

Table 4. Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of Phymastichus coffea on beneficial Coleoptera species.

Family	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Chrysomelidae: Cassidinae	*Uroplata girardi*	Exotic	60	0	0
Coccinellidae	*Scymnodes lividigaster*	Exotic	40	0	0
Coccinellidae	*Rhyzobius forestieri*	Exotic	60	0	0
Coccinellidae	*Halmus chalybeus*	Exotic	40	0	0
Laemophloeidae	*Leptophloeus* sp.	Unknown	60	0	0
Silvanidae	*Cathartus quadricollis*	Exotic	80	0	0

coffea is highly effective, then dependence on *B. beauveria* applications could be reduced dramatically.

5.3 Direct impact of the biological control agent on target and non-target species.

Phymastichus coffea is expected to help suppress *H. hampei* populations in coffee and may also provide a level of suppression of *H. obscurus* in macadamia nut farms which are relatively close to coffee growing areas or interspersed with coffee farms in some cases. Using a no-choice laboratory bioassay, we demonstrated that *P. coffea* was only able to parasitize the target host *H. hampei* and four other adventive species of *Hypothenemus*: *H. obscurus, H. seriatus, H. birmanus* and *H. crudiae* (Figure 6; Yousuf et al. 2021). *Hypothenemus hampei* had the highest parasitism rate and shortest parasitoid development time of the five parasitized *Hypothenemus* spp. Parasitism and parasitoid emergence decreased with decreasing phylogenetic relatedness of the *Hypothenemus* spp. to *H. hampei*, and the most distantly related species included in the trials, *H. eruditus*, was not parasitized. No species in any of the other genera tested were parasitized. These results suggest that the risk of harmful non-target impacts is minimal because there are no native species of *Hypothenemus* in Hawaii, and *P. coffea* could be safely introduced for classical biological control of *H. hampei* in Hawaii. Furthermore, as *P. coffea* is attracted to semiochemicals released from coffee fruit damaged by *H. hampei*, it is likely that under field conditions they will not be attracted to non-target species on different host plants lacking those cues.

5.4 Indirect impacts

Potentially, *P. coffea* might interfere with two resident predators, *Cathartus quadricollis* and *Leptophloeus* sp., that naturally occur in coffee and attack CBB, or vice versa. However, these predators are mainly found in overripe and dried coffee berries naturally predating on the immature stages of *H. hampei* in Hawaii (Follett et al. 2016; Brill et al. 2020). Our host testing in quarantine showed that *P. coffea* will not parasitize these beetles, and that the beetles did not predate on the parasitoids. Also, these predators attack eggs, larvae and pupae of *H. hampei* in overripe and dried berries (left after harvesting), whereas *P. coffea* attacks adult female *H. hampei* primarlily in developing green berries at an earlier stage of crop maturity. The biopesticide *Beauveria bassiana* also has the potential to interfere with *P. coffea* parasitism of CBB and survival. Indeed, studies suggest *P. coffea* may be susceptible to *B. bassiana* (Barrera 2005; Castillo et al. 2009; Ruiz et al. 2011). Therefore, releases of *P. coffea* should be timed to avoid *B. bassiana* applications or used in alternation with *B. bassiana* against *H. hampei*. If *P. coffea* is highly effective, then dependence on *B. bassiana* applications could be reduced dramatically.

5.5 Possible direct or indirect impact on threatened or endangered species in Hawaii

Only five species from the genus *Hypothenemus* were parasitized by *P. coffea*, including the two pest species *H. hampei* (coffee berry borer) and *H. obscurus* (tropical nut borer, a macadamia nut pest), and three other exotic species *H. seriatus*, *H. birmanus*, and *H. crudiae* (Figure 1). Thus, *P. coffea* appears to be host specific at the genus level, on beetles relatively closely related to *H. hampei*, and, as there are no native Hawaiian species of *Hypothenemus*, should pose no harm to endemic species if released in Hawaii coffee for classical biological from residual fruits on coffee trees and from fallen fruits that lie beneath plants and sustain *H. hampei* reservoirs. The abundance of adult *H. hampei* available as hosts to *P. coffea* will decline during the months between harvest and the fruit set, a period of 4-5 months depending on location. We will investigate the potential for *P. coffea* to enter diapause during this period, allowing them to survive within *H. hampei* in desiccating fruit on trees or on the ground. Possible diapause will be detected by collecting desiccated fruits form the ground and overripe fruit remaining on trees, andholding them to determine if parasitoids emerge over a prolonged period. Laboratory trials will be conducted to assess whether diapause can be induced in *P. coffea* under controlled conditions.

The above studies will measure dispersal of *P. coffea*, as well as inter-seasonal survival of the wasps, thus whether wide-spread establishment occurred. We will simultaneously commence measuring the intergenerational impact of *P. coffea* on *H. hampei* populations. Cohorts of *H. hampei* will be monitored commencing when newly developed coffee fruit become susceptible in the field. Using life table analyses, the contribution of *P. coffea* to *H. hampei* generational mortality will be quantified and compared with other mortality factors that may be acting on the beetle population. These analyses will provide an accurate assessment of the impact of the biological control agent on the target pest densities over time since introduction of the natural enemy.

6.3 Impact on selected non-target species for which potential impacts are identified

Preliminary data will be collected on semiochemical attraction of *Phymastichus coffea* to different *Hypothenemus* and other Scolytinae spp. *in vitro*., to investigate the potential for developing methods to screen parasitoids for non-target effects based on responses to semiochemical diversity. We will compare *P. coffea* responses to chemical signals from Scolyitinae species of varying host-specificity and compare this with two other *Phymastichus* species in Hawaii, *Phymastichus xylebori* LaSalle and *Phymastichus* sp. nova. *P. xylebori* parasitizes *Xyleborus perforans*, while *Phymastichus* sp. nova has been recorded from at least five host beetles (D. Honsberger pers. comm.). These comparisons will provide insights into the cues used by *Phymastichus* to locate hosts, and potentially the extent to which host specificity is mediated by parasitoid-host chemical interactions.

Various scolytines in the vicinity of release sites will be sampled periodically to determine whether any non-target parasitism occurs. While no non-target host use is predicted in Hawaii, this will serve as a test of the quarantine host-range testing predictions. This information will contribute to our overall understanding of and ability to prediction zero impact on nontarget species.

7. Pre-release compliance

7.1 Reference specimens

Phymastichus coffea specimens in vials with alcohol have been deposited at multiple locations including Cenicafé, USDA ARS in Hilo, Hawaii, and the University of Hawaii at Manoa. Hundreds of specimens are available for DNA extraction. All specimens were reared at Cenicafé

9. References

Aristizábal, L., Bustillo, A., and Arthurs, S. (2016). Integrated pest management of coffee berry borer: strategies from Latin America that could be useful for coffee farmers in Hawaii. *Insects*, *7*(1), 6.

Baker PS (1999) The coffee berry borer in Colombia:Final report of the DFID-Cenicafé-CABI Bioscience IPM for coffee project (CNTR 93/1536A). DFID-CENICAFÉ.

Barrera JF, Baker PS, Valenzuela JE, Schwarz A (1990) Introducción de dos especies de parasitoides africanos a México para el control biológico de la broca del café, *Hypothenemus hampei* (Ferrari)(Coleoptera:Scolytidae). Folia Entomológica Mexicana 79:245–247.

Barrera, J.F. (2005). Investigación sobre la broca del café en México: Logros, retos y perspectivas. In: Barrera, J.F. (Ed.), Situación actual y perspectivas de la investigación y manejo de la broca del café en Costa Rica, Cuba, Guatemala y México, Symposium. El colegio de la Frontera Sur, México, pp. 1–13.

Brill E, Follett PA, Kawabata AM (2020) Feeding habits, movement, and reproduction of the predatory flat bark beetles *Cathartus quadricollis* (Coleoptera:Silvanidae) and *Leptophloeus* sp. (Coleoptera:Laemophloeidae) in Hawaii coffee and macadamia nut. Int J Trop Insect Sci 1-10.

Bustillo AE, Cárdenas R, Villalba D, Benavides P, Orozco J, Posada F, Manejo Integrado de la Broca Del Café, *Hypothenemus hampei* (Ferrari) en Colombia, 1st ed. Cenicafé: Chinchiná, Colombia, 1998; p 134.

Castillo, A., Infante, F., López, G., Trujillo, J., Kirkendall, L.R., and Vega, F.E. (2004a). Laboratory parasitism by *Phymastichus coffea* (Hymenoptera: Eulophidae) upon non-target bark beetles associated with coffee plantations. *Florida Entomologist*, 87, 274–277.

Castillo, A., Infante, F., Vera-Graziano, J., and Trujillo, J. (2004b). Host-discrimination by *Phymastichus coffea*, a parasitoid of the coffee berry borer. *BioControl*, 49, 655–663.

Castillo, A., Gómez, J., Infante, F., and Vega, F.E., (2009). Susceptibilidad del parasitoide *Phymastichus coffea* LaSalle (Hymenoptera: eulophidae) a *Beauveria bassiana* en condiciones de laboratorio. Neotrop. Entomol. 38, 665–670.

Cognato, A., and D. Rubinoff (2008). New exotic ambrosia beetles found in Hawaii (Curculionidae: Scolytinae: Xyleborini). Coleopterists Bulletin 62: 421-424.

Cruz-Lopez, I., Diaz-Diaz, B., Rojas, J.C. (2016) Coffee volatiles induced after mechanical injury and beetle herbivory attract the coffee berry borer and two its parasitoids. *Arthropod-Plant Interactions* 10, 151-159.

CTAHR (College of Tropical Agriculture and human resources) (2019). https://www.ctahr.hawaii.edu/site/CBBManage.aspx Retrieved on Oct 25, 2019.

Hamilton LJ, Hollingsworth RG, Sabado-Halpern M, Manoukis NC, Follett PA, Johnson MA. (2019) Coffee berry borer (*Hypothenemus hampei*) (Coleoptera:Curculionidae) development across a elevational gradient on Hawai'i Island: Applying laboratory degree-day predictions to natural field populations. PLOS ONE https://doi.org/10.1371/journal.pone.0218321

Infante, F., Castillo, A., Pérez, J., and Vega, F.E. (2013). Field-cage evaluation of the parasitoid *Phymastichus coffea* as a natural enemy of the coffee berry borer, *Hypothenemus hampei. Biological control*, *67*(3), 446–450.

Infante, F., Murphy, S.T., Barrera, J.F., Gómez, J., de la Rosa, W., Damon, A. (1994). Cría de *Phymastichus coffea*, parasitoide de la broca del café y algunas notas sobre su historia de vida. Southwest. Entomol. 19, 313–315.

Jaramillo, J., Bustillo, A.E., Montoya, E. C., and Borgemeister, C. (2005). Biological control of the coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae) by *Phymastichus coffea* (Hymenoptera: Eulophidae) in Colombia. *Bulletin of entomological research*, *95*, 467–472.

Jaramillo J, Borgemeister C, Baker P (2006) Coffee berry borer *Hypothenemus hampei* (Coleoptera:Curculionidae): searching for sustainable control strategies. B Entomol Res 96:223-233.

Johnson, A.J., McKenna, D.D., Jordal, B.H., Cognato, A.I., Smith, S.M., Lemmon, A.R., Lemmon, E.M., Hulcr, J. 2018. Phylogenetics clarifies repeated evolutionary origins of inbreeding and fungus farming in bark beetles (Curculionidae, Scolytinae). *Molecular Phylogenetics, and Evolution* 127, 229-238.

Klein-Koch C, Espinoza O, Tandazo A, Cisneros P, Delgado D (1988) Factores naturales de regulación y control biológico de la broca del café (*Hypothenemus hampei* Ferr.) Sanidad Vegetal 3:5-30

LaSalle, J. (1990). New genus and species of *Tetrastichinae* (Hymcnopicra: Eulophidae) parasitic on the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae). *Bulletin of entomological research*, 80, 7–10.

LaSalle, J. (1994). North American genera of Tetrastichinae (Hymenoptera: Eulophidae). *Journal of Natural History*, 28, 109–236.

Le Pelley, R.H. (1968). Las plagas del cafeto. Editorial Labor S.A. Barcelona. 693 pp.

Louda SM, Pemberton RW, Johnson MT, Follett PA (2003) Nontarget effects—the Achilles' heel of biological control? Retrospective analyses to reduce the risk of biocontrol introductions. Ann Rev Entomol 48:365-396

López-Vaamonde, C., and Moore, D. (1998). Developing methods for testing host specificity of *Phymastichus coffea* LaSalle (Hym.: Tetrastichinae), a potential biological control agent of

Swezey OH (1954) Forest Entomology in Hawaii. An annotated checklist of the insect faunas of the various components of the Hawaiian forests. Bernice P, Bishop Museum, Honolulu, Hawaii.

Ticheler, J.H.G. (1963). Estudio analítico de la epidemiología del escolítido de los granos de café, Stephanoderes hampei Ferr. en Costa de Marfil. (Traducción G. Quiceno). Revista Cenicafé, 14, 223–294.

Van Driesche RG, Murray TJ (2004) Overview of testing schemes and designs used to estimate host ranges, pp. 56-67, In: Van Driesche R.G and Reardon R (eds.), *Assessing host ranges for parasitoids and predators used for classical biological control: a guide to best practice.* United States Department of Agriculture Forest Health Technology Enterprise Team, Morgantown, West Virginia, USA FHTET-2004-03.
https://www.fs.fed.us/foresthealth/technology/pdfs/HostRangeBook.pdf

Vega, F.E., Infante, F., and Johnson, A.J. (2015). The genus *Hypothenemus*, with emphasis on *H. hampei*, the coffee berry borer. In *Bark Beetles* (pp. 427–494). Academic Press.

Vergara JD, Orozco J, Bustillo A, Chavez, B (2001) Dispersion de *Phymasticus coffea* en un lote de café infestado de *Hypothenemus hampei.* Rev Cenicafé 52:104–110

Waterhouse, D.F. and Norris, K.R. (1989). Biological control: Pacific prospects. Supplement 1. Australian Centre for International Agricultural Research, Canberra. pp. 56–75.

Withers TM, Mansfield S (2005) Choice or no-choice tests? Effects of experimental design on the expression of host range, pp. 620-633 *In* (Hoddle, MS, editor) Proceedings 2nd International Symposium of Biological Control of Arthropods, 12-16 September 2005, Davos, Switzerland. USDA, Forest Health Technology Enterprise Team, Morgantown, West Virginia, USA.

Yousuf, F., Follett, P.A., Gillett, C.P.D.T., Honsberger, D., Chamorro, L., Johnson, T.M., Jaramillo, M.G., Machado, P.B. & Wright, M.G. 2021. Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii. *Journal of Pest Science* https://doi.org/10.1007/s10340-021-01353-8 (Appendix A)

Journal of Pest Science
https://doi.org/10.1007/s10340-021-01353-8

ORIGINAL PAPER

Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii

Fazila Yousuf[1,2] · Peter A. Follett[1] · Conrad P. D. T. Gillett[2] · David Honsberger[2] · Lourdes Chamorro[3] · M. Tracy Johnson[4] · Marisol Giraldo-Jaramillo[5] · Pablo Benavides-Machado[5] · Mark G. Wright[2]

Received: 2 August 2020 / Revised: 7 February 2021 / Accepted: 15 February 2021

Abstract
Phymastichus coffea LaSalle (Hymenoptera:Eulophidae) is an adult endoparasitoid of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera:Curculionidae:Scolytinae), which has been introduced in many coffee producing countries as a biological control agent. To determine the effectiveness of *P. coffea* against *H. hampei* and environmental safety for release in Hawaii, we investigated the host selection and parasitism response of adult females to 43 different species of Coleoptera, including 23 Scolytinae (six *Hypothenemus* species and 17 others), and four additional Curculionidae. Non-target testing included Hawaiian endemic, exotic and beneficial coleopteran species. Using a no-choice laboratory bioassay, we demonstrated that *P. coffea* was only able to parasitize the target host *H. hampei* and four other adventive species of *Hypothenemus*: *H. obscurus, H. seriatus, H. birmanus* and *H. crudiae. Hypothenemus hampei* had the highest parasitism rate and shortest parasitoid development time of the five parasitized *Hypothenemus* spp. Parasitism and parasitoid emergence decreased with decreasing phylogenetic relatedness of the *Hypothenemus* spp. to *H. hampei*, and the most distantly related species, *H. eruditus*, was not parasitized. These results suggest that the risk of harmful non-target impacts is low because there are no native species of *Hypothenemus* in Hawaii, and *P. coffea* could be safely introduced for classical biological control of *H. hampei* in Hawaii.

Keywords Coffee berry borer · Host specificity testing · Non-target · Biocontrol · Endoparasitoid · Scolytinae

Communicated by Antonio Biondi.

✉ Peter A. Follett
peter.follett@usda.gov

1 U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS), Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, 64 Nowelo Street, Hilo, HI 96720, USA

2 Entomology Section, Department of Plant and Environmental Protection Sciences, University of Hawaii At Manoa, 3050 Maile Way, Honolulu, HI 96822, USA

3 Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, MRC-168, P.O. Box 37012, Washington, DC 20013-7012, USA

4 U.S. Forest Service, Institute of Pacific Islands Forestry, and Hawaii Volcanoes National Park Quarantine Facility, Volcano, HI, USA

5 Centro Nacional de Investigaciones de Café - Cenicafe, Manizales, Colombia

Key message

- *Phymastichus coffea* is an idiobiont adult parasitoid of the coffee pest *Hypothenemus hampei*.
- In host range testing, *P. coffea* parasitized only five *Hypothenemus* spp.
- The parasitism rate was highest and parasitoid development time was shortest in *H. hampei.*
- No Hawaiian native species was parasitized by the parasitoid.
- *Phymasticus coffea* can be introduced safely for biocontrol of coffee berry borer in Hawaii.

introduced biological control agents are likely to occur on species closely related to the target pest species (Van Driesche and Murray 2004), but not always (Messing 2001), and thus, phylogenetically closely and distantly related species should be included in non-target screening efforts. This is an important element of biological control, particularly in Hawaii, where classical biological control may have had significant negative impacts on native species in the past (e.g., Howarth 1991; Henneman and Memmott 2001). While some studies have suggested that this is true (see references in Messing and Wright 2006), a number of carefully crafted field studies of population level impacts on non-target species have suggested that introduced parasitoids have had minimal, or sometimes moderate, impacts on endemic species (Johnson et al. 2005; Kaufman and Wright 2009). Where higher impacts have been detected, they are typically from accidentally introduced parasitoid species, and host insects in disturbed habitats are most susceptible to these impacts (Kaufman and Wright 2011). However, the potential for non-target impacts must be carefully considered, and outcomes of exposures of unintended hosts to prospective biological control agents can provide insights into host range patterns and determinants.

In this paper, we present new insights into the host specificity of *P. coffea*, a prospective biological control agent of *H. hampei* in Hawaii, by testing it against 43 different species of Coleoptera. Non-target testing included Hawaiian endemic, exotic and beneficial coleopteran species. There are currently no records of native Hawaiian *Hypothenemus* spp. except for an old record (1913) of *H. ruficeps* (Swezey 1954), which has never been collected or reported since and is possibly a synonym with the adventive species *H. eruditus* or *H. crudiae* (C. Gillett, unpublished). There are, however, many native species in another scolytine genus, *Xyleborus* (Samuelson 1981; Gillett et al. 2019), which may potentially be impacted by release of an exotic parasitoid against a scolytine pest such as *H. hampei*. We test the hypothesis that *P. coffea* is host specific and will not attack native Hawaiian Scolytinae species.

Materials and methods

Parasitoid, Phymastichus coffea

Phymastichus coffea used in this study were obtained from an established stock maintained at the National Coffee Research Center-Cenicafé, Manizales (Caldas) Colombia, which was started from *P. coffea* collected in Kenya and shipped to Colombia in 1996 and has been maintained in colony in large numbers since that time (Orozco-Hoyas and Aristizábal 1996). *Phymastichus coffea* has been mass reared by Cenicafé for field releases on multiple occasions and the colony receives frequent infusions of field-collected material. *Phymastichus coffea* was shipped from Cenicafé in its larval stage in parasitized *H. hampei* hosts under USDA APHIS PPQ, permit no. P526P-18-00,696 to a certified quarantine insect containment facility managed by the USDA Forest Service at Hawaii Volcanoes National Park, Volcano, Hawaii. Parasitized *H. hampei* were incubated in controlled climate chambers at 25° ± 1 °C, 75 ± 10% relative humidity and 8:16 h light:dark photocycle at the quarantine containment facility.

Emerged male and female parasitoid adults were collected using a manual aspirator into a clean glass container. Parasitoids were held for mating and oocyte maturation and provided with 50% (w/v) honey (raw organic) solution for ~ 2 h before being used in the experiments (López-Vaamonde and Moore 1998). Infante et al. (1994) reported that *P. coffea* does not go through a preoviposition period and exhibits facultative arrhenotokous-type parthenogenesis, where the female parasitizes its host before or after copulation, producing haploid males (Portilla and Grodowitz 2018). Feldhege (1992) reported a preoviposition period of between 5 min and 4 h. The adult parasitoids are very short-lived: males (~ 8–48 h) and females (~ 16–72 h) (Vergara et al. 2001; Rojas et al. 2006; Espinoza et al. 2009; Portilla and Grodowitz 2018). The ability to parasitize hosts decreases with age, so it was important to use freshly emerged parasitoids (< 12 h old) in all experiments.

Coffee berry borer, Hypothenemus hampei

Field-collected *H. hampei* were used in all no-choice host specificity experiments. *Hypothenemus hampei*-infested coffee berries were collected from coffee trees (*Coffea arabica*) at OK Coffee Farm in Hilo, Hawaii (19.727583, − 155.111186, elevation 156 m). These collections were transported in cold boxes to the USDA-ARS laboratory and placed in a custom-made extraction unit lined with tissue paper (Tech wipes 1709/7052, Horizon) to absorb condensation and prevent mold growth. Adult *H. hampei* were collected directly from the infested coffee berries by dissecting the berries or from the extraction unit using an aspirator. All the collected *H. hampei* were provided with artificial diet (modified from Brun et al. 1993) until use in the experiments.

Collection of non-target coleopteran species

The selection of non-target hosts was based on phylogenetic relatedness to the target host, sympatry of target and non-target species, and size. Species commonly occurring in the coffee landscape and species in culture at USDA-ARS in Hilo, Hawaii, were also tested. There are 21 native and 38 non-native scolytine species in Hawaii (Samuelson 1981;

Table 3 Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on beneficial Coleoptera species

Family	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Chrysomelidae:Cassidinae	*Uroplata girardi*	Exotic	60	0	0
Coccinellidae	*Scymnodes lividigaster*	Exotic	40	0	0
Coccinellidae	*Rhyzobius forestieri*	Exotic	60	0	0
Coccinellidae	*Halmus chalybeus*	Exotic	40	0	0
Laemophloeidae	*Leptophloeus* sp.	Unknown	60	0	0
Silvanidae	*Cathartus quadricollis*	Exotic	80	0	0

Table 4 Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on Hawaiian native and introduced coleopteran species from families and subfamilies other than Curculionidae:Scolytinae

Family	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Anthribidae	*Araecerus simulatus* or *A. levipennis*	Unknown	6	0	0
Anthribidae	*Araecerus* sp. near *varians*	Unknown	15	0	0
Brentidae:Brentinae	*Cylas formicarius*	Exotic/Pest	80	0	0
Chrysomelidae:Bruchinae	*Acanthoscelides macrophthalmus*	Unknown	10	0	0
Curculionidae:Cossoninae	*Phloeophagosoma tenuis*	Unknown	8	0	0
Curculionidae:Cossoninae	*Nesotocus giffardi*	Native	12	0	0
Curculionidae:Curculioninae	*Sigastus* sp.	Exotic/Pest	6	0	0
Curculionidae:Platypodinae	*Crossotarsus externedentatus*	Exotic	60	0	0
Dryophthoridae:Dryophthorinae	*Sitophilus oryzae*	Exotic/Pest	60	0	0
Dryophthoridae:Dryophthorinae	*Sitophilus linearis*	Exotic	40	0	0
Nitidulidae:Carpophilinae	*Carpophilus dimidiatus*	Exotic	10	0	0
Nitidulidae:Carpophilinae	*Carpophilus zeaphilus*	Exotic	60	0	0
Tenebrionidae	*Tribolium castaneum*	Exotic/Pest	21	0	0
Tenebrionidae	*Hypophloeus maehleri*	Exotic	60	0	0

No-choice tests

In this study, we used no-choice tests because these would reflect physiological host range and the potential for parasitism in the field more accurately than choice tests (Van Driesche and Murray 2004). Choice tests that include the target host may mask the acceptability of lower ranked hosts, thereby producing false negative results (Withers and Mansfield 2005). Twenty individuals of each test species were placed in a sterilized glass Petri dish (80 mm in diameter) lined with filter paper and immediately afterward four *P. coffea* females (< 12 h old) that had not been exposed to adult hosts prior to the experiments were introduced. Therefore, when ample hosts were available, each replicate consisted of 20 hosts and four parasitoids for a 5:1 host–parasitoid ratio. However, due to difficulties in finding certain species live in adequate numbers, e.g., native scolytine bark beetles, and difficulties synchronizing parasitoid emergence with field collection or emergence from wood of live beetles, the host–parasitoid ratio and numbers of replicates were adjusted as needed. For example, if only 10 non-target beetles were available for screening, then two replicates each with 5 beetles and 1 parasitoid (maintaining the 5:1 host–parasitoid ratio) were performed. In all non-target host screening tests, *H. hampei* was included as a positive control to confirm parasitoid viability. The host–parasitoid ratio of the *H. hampei* controls was adjusted to match the non-target species in the test, whether it was 5:1 or otherwise. The generalized response of the parasitoids toward target and non-target hosts was also determined for a subset of parasitoids by visual observation and video recording of parasitoid behavior, e.g., any contact with the host by landing on the host or antennation, and/or walking on the host. Host acceptance was noted when the parasitoid adopted a characteristic oviposition position on top the elytra of the host (Lopez-Vaamonde and Moore 1998).

After *P. coffea* exposure, *H. hampei* and all other non-target species were incubated at 25 ± 1 °C, 75 ± 10% RH and 24:0 (L–D) photoperiod for 72 h. After 72 h, parasitoids and filter paper linings were removed and the beetles were species. *Hypothenemus hampei* had the highest percentage emergence of *P. coffea* at 70.4%, whereas *H. crudiae* had the lowest at 16.7% (Fig. 1). In *H. crudiae*, out of five parasitized hosts only one had emergence. Although *P. coffea* only parasitized *Hypothenemus* spp., it did inspect three other non-target scolytine hosts, *Hypothenemus eruditus*, *Xyleborus kauaiensis* and *Xyleborus ferrugineus,* but left hosts without initiating oviposition (i.e., no parasitism found). The phylogenetic relationship of five *Hypothenemus* species included in our tests, extracted from Johnson et al. (2018), is also shown in Fig. 1; *H. crudiae* is not included in the phylogeny because it was not included in Johnson et al (2018). Both parasitism and emergence in our tests decreased across *Hypothenemus* species with decreasing phylogenetic relatedness to *H. hampei*. *Hypothenemus eruditus*, the most distantly related species from *H. hampei* according to Johnson et al. (2018), was not parasitized (Fig. 1).

Parasitoid development time among the three different *Hypothenemus* spp. did not differ significantly compared with *H. hampei* ($\chi^2=0.17$, df=4, $p=0.997$), but did differ with *H. crudiae* (Table 1). The mean development time of *P. coffea* from oviposition to adult emergence was shortest in *H. hampei* (32.2 ± 0.5 days, mean ± SE), longest in *H. crudiae* (41.0 ± 0.0 days) and intermediate in the other three *Hypothenemus* spp. (Table 1), which generally agrees with the phylogenetic pattern observed for parasitism and emergence (Fig. 1). The percentage of female versus male *P. coffea* emerging from parasitized *H. hampei* was 50.8% ± 0.4 (mean ± SE), which was significantly different ($\chi^2=27.3$, df = 4, $p=0.0001$) from *H. seriatus* and *H. birmanus* (Table 1). *Hypothenemus eruditus* was not parasitized by *P. coffea* and hence was not included in any statistical analyses.

Parasitized *H. hampei* had the lowest percentage of unemerged parasitoids compared to the other four *Hypothenemus* species (Fig. 1), indicating that *H hampei* is a superior host for *P. coffea* development. For each parasitized host beetle with unemerged parasitoids, invariably two parasitoids were present, and the parasitoids were of the same life stage (larva, pupa or adult). The frequency of the different life stages for parasitized hosts with unemerged parasitoids differed among *Hypothenemus* species (Fig. 2). Parasitized *H. hampei* had a significantly lower percentage of larval ($\chi^2=15.10$, df = 3, $p=0.001$), and higher percentage of adult parasitoids that were unemerged ($\chi^2=18.36$, df = 3, $p=0.0001$) compared to the other *Hypothenemus* species. The higher percentage of unemerged parasitoids developing to the adult stage again indicates that *H. hampei* is a superior developmental host than the other *Hypothenemus* spp. The percentage of unemerged pupae found in parasitized *H. hampei* was not significantly different from *H. obscurus*, *H. seriatus* and *H. birmanus*, but *H. crudiae* had a significantly higher percentage of pupae than *H. hampei*

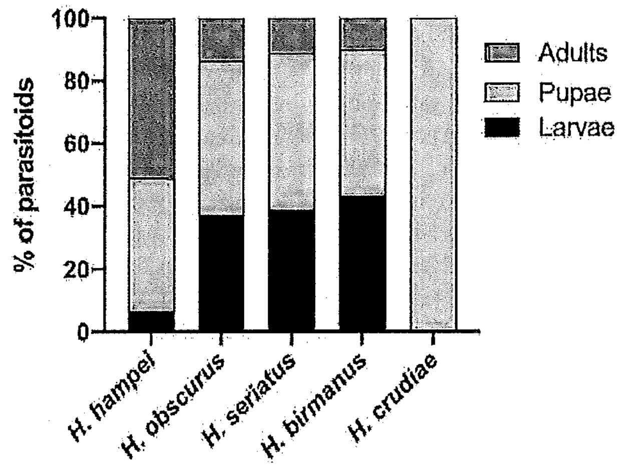


Fig. 2 Fate of unemerged *Phymastichus coffea* parasitoids from parasitized *Hypothenemus* spp. in no-choice in vitro non-target host selection screening. Parasitized *Hypothenemus* beetles with unemerged parasitoids were dissected to identify life stages (larva, pupa, adult)

($\chi^2=95.40$, df=4, $p=0.0001$) (Fig. 2). No eggs were found in any of the parasitized *Hypothenemus* hosts.

Discussion

Phymastichus coffea is a potential biological control agent of *H. hampei* and was brought from Columbia into a quarantine containment facility in Hawaii for host range testing to determine whether the parasitoid might attack non-target species and therefore pose a risk to Hawaiian endemic species. Using no-choice tests, 43 different species of Coleoptera were exposed to *P. coffea* in vitro, including 23 scolytines (six natives, 17 non-native species including *H. hampei*), six beneficial species and 12 other species including one native weevil (*N. giffardi).* Only five species from the genus *Hypothenemus* were parasitized by *P. coffea,* including the two pest species *H. hampei* (coffee berry borer) and *H. obscurus* (tropical nut borer, a macadamia nut pest), and three other exotic species *H. seriatus*, *H. birmanus* and *H. crudiae* (Fig. 1). Thus, *P. coffea* appears to be host specific at the genus level and should pose no harm to endemic species if released in Hawaii coffee for classical biological control of *H. hampei*. Nevertheless, no level of host specificity testing can ensure zero risk to non-target organisms when introducing a natural enemy in a new habitat (Louda et al. 2003).

We observed that once the host and parasitoids were exposed in the Petri dish arena that *P. coffea* inspected *H. hampei* and other *Hypothenemus* spp. hosts by antennation before proceeding to oviposition or rejection. *Phymastichus coffea* did not show any oviposition response to other non-target hosts. This could be dependent on several factors facilitate detoxification of caffeine, permitting it to exploit *Coffea arabica* seeds as their host (Ceja-Navarro et al. 2015), and potentially other physiological adaptations to its unique host, possibly providing adaptive challenges to parasitoids, and mediating host specificity of *P. coffea*. Messing (2001) questioned the practicality of applying centrifugal phylogeny approaches to selecting species to examine in non-target studies of potential biological control agents, particularly parasitoids. Our results support the predictions of the latter approach, with more distantly related *Hypothenemus* species less susceptible to *P. coffea* attack and more distantly related genera (e.g., *Xyleborus* spp.) not attacked at all. However, Messing (2001) emphasized the fact that interactions between the host insect and its host plant may override host phylogenetic patterns, by providing the stimuli for parasitoids to attack hosts, a consideration which may play a role in this study system. If this is the case, it is possible that *P. coffea* will produce even higher levels of parasitism than recorded in the artificial environment we used in our study, when attacking wild *H. hampei* boring into coffee fruits, producing the full range of cues stimulating parasitism, and lower field parasitism of the non-target *Hypothenemus* spp. included here.

Among all the parasitized *Hypothenemus* species, *H. hampei* had the highest rate of parasitoid emergence. The total developmental time (from egg to adult) of *P. coffea* was shortest in *H. hampei* (32 days); parasitism of *H. crudiae* resulted in the longest developmental time (41 days). Another study reported a similar development time of the *P. coffea* in *H. hampei*, 38–42 days at 23 °C and 66% RH (Rafael et al. 2000). Castillo et al. (2004) reported a *P. coffea* development time of 42.6 days for *H. hampei* and 40 days for *H. crudiae* at 26 ± 2 °C and 70–80% RH. Total developmental time is directly related to the temperature. For example, the total development period of *Diglyphus isaea* (Hymenoptera:Eulophidae) decreased with increasing temperature between 15 and 35 °C and no development was found at 10 and 40 °C (Haghani et al. 2007). Temperature is a critical abiotic factor influencing the physiology and dynamics of insects. Therefore, in this study we selected a temperature for our no-choice assays which reflects the ambient field temperature the insects are expected to experience. In addition to temperature, age of the parasitoids and host play an important role in the subsequent development of parasitoid offspring (Pizzol et al. 2012). Hence, we used uniformly aged parasitoids and hosts throughout our experiments to minimize any impact on host parasitism and parasitoid development.

Phymastichus coffea commonly lays two eggs (a male and a female) per host (López-Vaamonde and Moore 1998). Both male and female develop in a single host, the female in the abdomen and the male in the prothorax (Espinoza et al. 2009). In this study, slightly fewer male parasitoids emerged as compared to females from parasitized hosts. The proportion of females emerging from *H. hampei* was 50.8% which is consistent with the results obtained by López-Vaamonde and Moore (1998) and Rafael et al. (2000). Likewise, sex ratios of *P. coffea* emerging from *H. obscurus* 54.8%, *H. seriatus* 51.1% and *H. crudiae* 50.0% were consistent with the sex ratio results reported by (López-Vaamonde and Moore 1998; Castillo et al. 2004) of 1.25:1, 1:1 and 1:1 (female–male), respectively, for these species. In our study, the proportion of females emerging from parasitized *H. birmanus* 57.7%, was the highest among all other *Hypothenemus* species tested. The slightly fewer males produced per host in our study could be due to either to some parasitoid's preference to lay one egg per host (Feldhege 1992) or the lower survivorship of male eggs or larvae. Preference to lay female eggs over male can be dependent on several factors such as host quality, host age, immune response, genetic factors, photoperiod and relative humidity, host density or host-related volatile composition (King 1987).

All the above tests were conducted in a quarantine laboratory with no field studies. We conducted no-choice tests because they may provide more accurate and conservative information on host preferences and physiological host range than choice tests because of lower levels of interference due to unexpected responses to multiple host cues (Van Driesche and Murray 2004). Sands (1997) showed that laboratory studies often overestimate the host range of the parasitoid and realized ranges under field conditions may be substantially less than predicted from no-choice tests, but they are necessary to give a worst-case prediction of the number of hosts at risk of being attacked in the field (Avilla et al. 2016). *Phymastichus coffea* attacked other non-target *Hypothenemus* species in our no-choice trials, but this does not necessarily mean that those species will be attacked in the field. For example, an idiobiont braconid wasp, *Bracon hebetor* is reported to parasitize a wide variety of moths within and outside in Phycitinae (Lepidoptera:Noctuidae) in the laboratory, but in the field it is restricted to only larvae of *Plodia interpunctella* (Lepidoptera:Noctuidae) (Antolin et al. 1995). This is because in the field, parasitoids use a spectrum of long- and short-range cues (chemical, visual, vibrational and tactile signals) to locate hosts (Strand and Pech 1995). Chemical cues (infochemicals) can play an important role in host location. A study conducted by Rojas et al. (2006) showed that *P. coffea* can distinguish between *H. hampei*-infested and uninfested coffee berries, and were highly attracted to the dust/frass originating from *H. hampei* infested berries, but showed no response to the dust/frass originated from the closely related non-target host, *H. crudiae*. This behavior depending on plant and host cues suggests that it is very unlikely that *P. coffea* will have any

Avila GA, Withers TM, Holwell GI (2016) Retrospective risk assessment reveals likelihood of potential non-target attack and parasitism by Cotesia urabae (Hymenoptera:Braconidae): a comparison between laboratory and field-cage testing results. Biol Cont 103:108–118. https://doi.org/10.1016/j.biocontrol.2016.08.008

Baker PS (1999) The coffee berry borer in Colombia:Final report of the DFID-Cenicafé-CABI Bioscience IPM for coffee project (CNTR 93/1536A). DFID-CENICAFÉ.

Barrera JF Investigación sobre la broca del café en México:logros, retos y perspectivas (2005) In: Simposio sobre Situación Actual y Perspectivas de la Investigación y Manejo de la Broca del Café en Costa Rica, Cuba, Guatemala y México. Sociedad Mexicana de Entomología y El Colegio de la Frontera Sur. Tapachula, Chiapas, México, pp 1–13

Barrera JF, Baker PS, Valenzuela JE, Schwarz A (1990) Introducción de dos especies de parasitoides africanos a México para el control biológico de la broca del café, *Hypothenemus hampei* (Ferrari)(Coleoptera:Scolytidae). Folia Entomológica Mexicana 79:245–247

Brill E, Follett PA, Kawabata AM (2020) Feeding habits, movement, and reproduction of the predatory flat bark beetles *Cathartus quadricollis* (Coleoptera:Silvanidae) and *Leptophloeus* sp. (Coleoptera:Laemophloeidae) in Hawaii coffee and macadamia nut. Int J Trop Insect Sci 2020:1–10. https://doi.org/10.1007/s42690-020-00205-9

Brun L-O, Gaudichon V, Wigley P (1993) An artificial diet for continuous rearing of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera:Scolytidae). Int J Trop Insect Sci 14:585–587. https://doi.org/10.1017/S1742758400017963

Burbano E, Wright M, Bright DE, Vega FE (2011) New record for the coffee berry borer, *Hypothenemus hampei*, in Hawaii. J Insect Sci 11:1–3. https://doi.org/10.1673/031.011.11701

Bustillo AE, Cárdenas R, Villalba D, Benavides P, Orozco J, Posada F, Manejo Integrado de la Broca Del Café, Hypothenemus hampei (Ferrari) en Colombia, 1st ed. Cenicafé: Chinchiná, Colombia, 1998; p 134

Castillo A, Gómez J, Infante F, Vega FE (2009) Susceptibilidad del parasitoide *Phymastichus coffea* LaSalle (Hymenoptera:Eulophidae) a *Beauveria bassiana* en condiciones de laboratorio. Neotrop Entomol 38:665–670. https://doi.org/10.1590/S1519-566X2009000500017

Castillo A, Infante F, López G, Trujillo J, Kirkendall LR, Vega FE (2004) Laboratory parasitism by *Phymastichus coffea* (Hymenoptera:Eulophidae) upon non-target bark beetles associated with coffee plantations. Fla Entomol 87:274–277. https://doi.org/10.1653/0015-4040(2004)087[0274:LPBPCH]2.0

Ceja-Navarro JA, Vega FE, Karaoz U, Hao Z, Jenkins S, Lim HC, Kosina P, Infante F, Northen TR, Brodie EL (2015) Gut microbiota mediate caffeine detoxification in the primary pest of coffee. Nat Commun 6:7618. https://doi.org/10.1038/ncomms8618

Chiu-Alvarado P, Rojas JC (2008) Host location behaviour by two Cephalonomia spp (Hymenoptera:Bethylidae) wasps associated with the coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae:Scolytinae). Int J Trop Insect Sci 28(4):179–184. https://doi.org/10.1017/S1742758408199660

Cognato AI, Rubinoff D (2008) New exotic ambrosia beetles found in Hawaii (Curculionidae:Scolytinae:Xyleborina). Coleopts Bull 62:421–424. https://doi.org/10.1649/1084.1

Damon A (2000) A review of the biology and control of the coffee berry borer, *Hypothenemus hampei* (Coleoptera:Scolytidae). Bull Entomol Res 90:453–465. https://doi.org/10.1017/S0007485300000584

Decazy B (1990) Descripción, biología, ecología y control de la broca del fruto del cafeto, *Hypothenemus hampei* (Ferr.). Paper presented at the 50 años de Cenicafé 1938–1988, Conferencias Conmemorativas, Chinchiná, Colombia.

Desneux N, Barta RJ, Hoelmer KA, Hopper KR, Heimpel GE (2009) Multifaceted determinants of host specificity in an aphid parasitoid. Oecologia 160:387–398. https://doi.org/10.1007/s00442-009-1289-x

Escobar-Ramírez S, Grass I, Armbrecht I, Tscharntke T (2019) Biological control of the coffee berry borer:main natural enemies, control success, and landscape influence. Biol Cont 136:103992. https://doi.org/10.1016/j.biocontrol.2019.05.011

Espinoza JC, Infante F, Castillo A, Pérez J, Nieto G, Pinson EP, Vega FE (2009) The biology of *Phymastichus coffea* LaSalle (Hymenoptera:Eulophidae) under field conditions. Biol Cont 49:227–233. https://doi.org/10.1016/j.biocontrol.2009.01.021

Feldhege M (1992) Rearing techniques and aspects of biology of *Phymastichus coffea* (Hymenoptera:Eulophidae), a recently described endoparasitoid of the coffee berry borer, *Hypothenemus hampei* (Coleoptera:Scolytidae) Café. Cacao 36:45–54

Follett PA, Duan J (1999) Nontarget effects of biological control. Kluwer Academic Publishers, Boston, p 316. https://doi.org/10.1007/978-1-4615-4577-4

Follett PA et al (2016) Predation by flat bark beetles (Coleoptera: Silvanidae and Laemophloeidae) on coffee berry borer (Coleoptera:Curculionidae) in Hawaii coffee. Biol Cont 101:152–158. https://doi.org/10.1016/j.biocontrol.2016.07.002

Fox CW, Mousseau TA (1995) Determinants of clutch size and seed preference in a seed beetle, *Stator beali* (Coleoptera:Bruchidae). Environ Entomol 24:1557–1561. https://doi.org/10.1093/ee/24.6.1557

Gillett CPDT, Honsberger D, Elliott C, Rubinoff D (2020a) Two endemic species of Hawaiian bark beetles newly recorded from the island of Moloka'i (Coleoptera:Curculionidae:Scolytinae). Trans Am Entomol Soc 146:251–257. https://doi.org/10.3157/061.146.0108

Gillett CPDT, Yousuf F, Rubinoff D (2020b) First host plant record for the endemic Hawaiian ambrosia beetle *Xyleborus pleiades* Samuelson, 1981 (Coleoptera:Curculionidae:Scolytinae). P Hawaii Entomol Soc 52:5–7. http://hdl.handle.net/10125/67801

Gillett CP, Elliott C, Rubinoff D (2019) Records of seven species of native and exotic bark beetles new to Pu'u Wa'awa'a Dry Forest Unit, Hawai 'i Islànd (Coleoptera:Curculionidae, Scolytinae). Fragmenta Entomologica 51:233–240. https://doi.org/10.4081/fe.2019.381

Gutierrez AP, Villacorta A, Cure JR, Ellis CK (1998) Tritrophic analysis of the coffee (*Coffea arabica*)-coffee berry borer [*Hypothenemus hampei* (Ferrari)]-parasitoid system. Anais da Sociedade Entomologica do Brasil 27:357–385. https://doi.org/10.1590/S0301-80591998000300005

Haghani M, Fathipour Y, Talebi AA, Baniameri V (2007) Temperature-dependent development of *Diglyphus isaea* (Hymenoptera:Eulophidae) on *Liriomyza sativae* (Diptera:Agromyzidae) on cucumber. J Pest Sci 80:71–77. https://doi.org/10.1007/s10340-006-0154-5

Hamilton LJ, Hollingsworth RG, Sabado-Halpern M, Manoukis NC, Follett PA, Johnson MA (2019) Coffee berry borer (*Hypothenemus hampei*) (Coleoptera:Curculionidae) development across a elevational gradient on Hawai'i Island: applying laboratory degree-day predictions to natural field populations. PLoS ONE. https://doi.org/10.1371/journal.pone.0218321

Hawkins BA, Shaw MR, Askew RR (1992) Relations among assemblage size, host specialization and climate variability in North American parasitoid communities. Am Nat 139:58–79. https://doi.org/10.1086/285313

Henneman ML, Memmott J (2001) Infiltration of a Hawaiian community by introduced biological control agents. Science 293(5533):1314–1316. https://doi.org/10.1126/science.1060788

Hawaii coffee marketings final season estimates (2018) https://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Fruits_and_Nuts/201807FinalCoffee.pdf. Accessed 14 August 2020

Van Driesche RG, Murray TJ (2004) Overview of testing schemes and designs used to estimate host ranges, pp. 56–67, In: Van Driesche RG, Reardon R (eds), Assessing host ranges for parasitoids and predators used for classical biological control: a guide to best practice. United States Department of Agriculture Forest Health Technology Enterprise Team, Morgantown, West Virginia, USA FHTET-2004–03. https://www.fs.fed.us/foresthealth/technology/pdfs/HostRangeBook.pdf

Vega FE, Infante F, Johnson AJ (2015) The genus Hypothenemus, with emphasis on *H. hampei*, the coffee berry borer. In: Vega FE, Hfstetter R (eds) Bark beetles. Academic Press, Elsevier, pp 427–494. https://doi.org/10.1016/b978-0-12-417156-5.00011-3

Vergara JD, Orozco J, Bustillo A, Chavez B (2001) Dispersion de *Phymasticus coffea* en un lote de café infestado de *Hypothenemus hampei*. Rev Cenicafe 52:104–110

Withers TM, Mansfield S (2005) Choice or no-choice tests? Effects of experimental design on the expression of host range, pp. 620-633 In: Hoddle MS (ed), Proceedings 2nd international symposium of biological control of arthropods, 12–16 September 2005, Davos, Switzerland. USDA, Forest health technology enterprise team, Morgantown, West Virginia, USA

Yang Z-Q, Wang X-Y, Gould JR, Wu H (2008) Host specificity of *Spathius agrili* Yang (Hymenoptera:Braconidae), an important parasitoid of the emerald ash borer. Biol Cont 47:216–221. https://doi.org/10.1016/j.biocontrol.2008.08.001

Cultural Impact Assessment for Proposed Statewide Release of *Phymastichus Coffea* to Control Coffee Berry Borer

Principal Investigators
Suzanne Shriner
Joan Obra
Krista Johnson

Synergistic Hawaii Agriculture Council
190 Keawe St, Suite 25
Hilo, Hawaii, 96720
info@shachawaii.org
808-365-9041

Introduction

At the request of the University of Hawai'i and the United States Department of Agriculture Agricultural Research Service, the Synergistic Hawai'i Agriculture Council (SHAC) conducted a Cultural Impact Assessment (CIA) for the proposed statewide release of *Phymastichus coffea*. Used as a biocontrol in coffee, *P. coffea* is a tiny wasp that targets and parasitizes the coffee berry borer beetle (CBB) *Hypothenemus hampei* (Coleoptera: Curculionidae).

This CIA and its interviews were designed to identify any utilization of coffee for cultural practices or community concerns about environmental impacts from the release of *P. coffea*. It is a companion document to an Environmental Assessment drafted by USDA and was prepared in adherence with the Office of Environmental Quality Control (OEQC) *Guidelines for Assessing Cultural Impact*, adopted by the Environmental Council, State of Hawai'i, on November 19, 1997 and pursuant to Chapter 343 of the Hawaii Revised Statutes as well as the 2019 revisions to HAR Chapter 11-200.1.

Proposed Action

Biological control (biocontrol) is a component of an integrated pest management strategy. It is defined as the reduction of pest populations by natural enemies and typically involves an active human role (Flint, 1998). Classical biocontrol is the selection and introduction of a natural enemy of an invasive plant or insect pest, and then "reuniting" of this natural enemy with the invasive pest to provide long-term, cost-effective, and sustainable pest management. Both State and Federal agencies have been cooperating on biocontrol activities to minimize the threat of invasive pests in Hawaii's natural environment. Selection of a biocontrol for potential release undergoes a multi-step regulatory process to ensure native plants, insects, or traditional and customary practices are not impacted by the introduction.

Coffea arabica and *Phymastichus coffea*

Coffee (*Coffea arabica*) is an introduced plant to Hawai'i , and familiar to most people. Thought to be native to Ethiopia, the intensive cultivation of coffee in Northern Africa (and beyond) began as early as the 16th century. Thriving in subtropical climate zones, there is now a "coffee belt" between the Tropics of Cancer and Capricorn, where some 70 countries grow and export the bean. Early traders noticed Hawai'i 's place on the belt, and began to import seeds in the 19th century.

Coffea favors a tropical climate with a distinct wet and dry season. Despite this preference, the well-draining cinder soils of Hawai'i can support the plant even in extremely wet locations.

greatly to the post-contact agricultural history of the State. There are almost 1,500 coffee farmers in the state. The majority of commercial growers are smallhold, operating less than five acres of land, and are considered socially-disadvantaged by the USDA (NASS, 2017).

Figure 2: Commercial coffee field in Pahala, Ka'u District, Island of Hawai'i

CBB is the most devastating invasive insect pest in coffee plantations and is estimated to cause more than $500 million in damage around the world (Vega 2020). The *Hypothenemus* is a genus of over 200 described oriental bark beetles within the Curculionidea family (Johnson et al., 2020). CBB was first reported in coffee plantations during an 1897 survey of the West African nation of Liberia (Hopkins, 1915). The pest is notably distinguished from all 850 other insect species that can feed on parts of the coffee plant in that it is the only one able to feed and complete its life cycle in the coffee bean itself. The female beetle bores a small hole into the developing fruit and lays up to 100 eggs in the bean (Jaramillo, 1997). Larvae subsequently feed on the bean, and create cavities, greatly reducing quality and impacting market value. Because the lifecycle occurs largely within the protection of the bean, once the insect penetrates the bean, she and her progeny are relatively protected from insecticides or other conventional control measures. The insect rapidly propagates in Hawai'i , with a mean life cycle of approximately 51 days, totaling more than 7 generations per year (Hamilton 1999).

applications of chemical insecticides. In the years following, detection, multiple programs, and resources were directed at the problem of CBB in Hawai'i , including pest subsidies, grower education programs and a relaxation of the Hawai'i Department of Agriculture quality standards (Johnson et al., 2020). Despite these efforts, CBB remains an intractable issue for growers due to high labor costs and the unsuitability of control through chemical pesticides. Thus, management strategies that limit human labor, such as biocontrol, are identified by farmers as a major need.

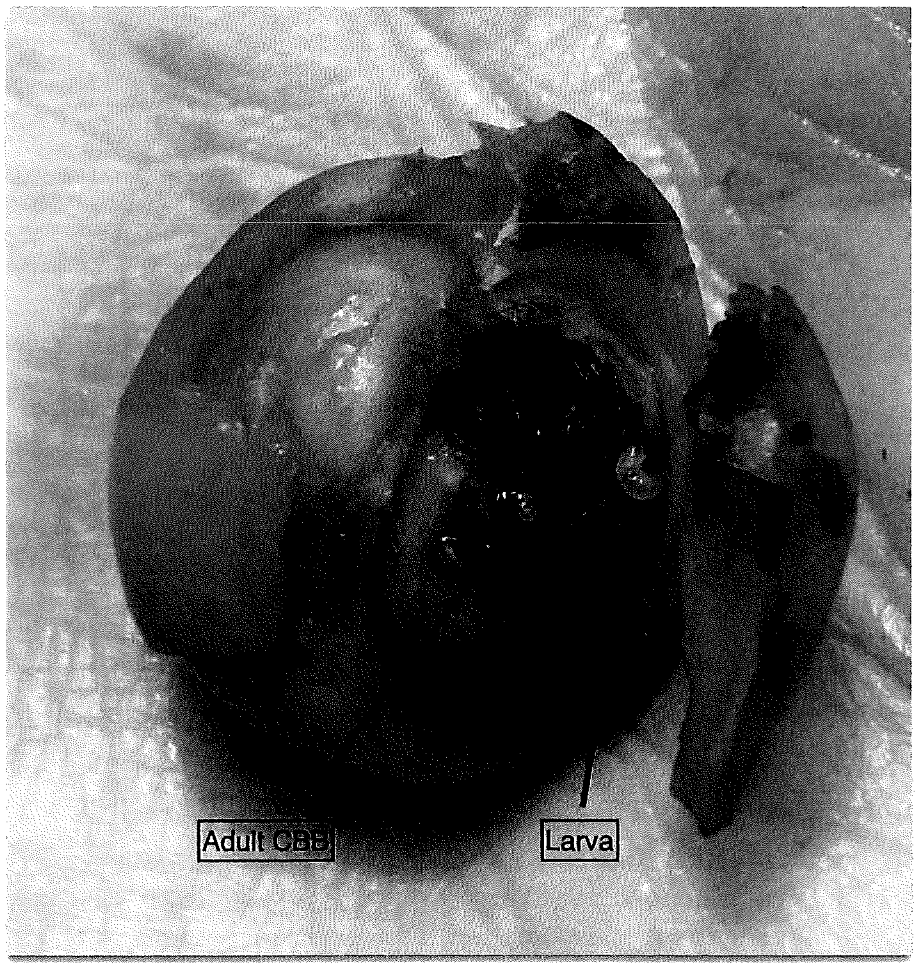


Figure 4: Live beetle and damage inside the bean. Adult CBB is approximately 1.8 mm long

There are three natural enemies to CBB that are indigenous to Africa. One of these, *Phymastichus coffea* is an endoparasitoid that attacks CBB adults and is found widespread in African coffee regions. Females, under 1mm in length, oviposit in the abdomen of the CBB adults, laying a single male and a single female egg, which hatch and feed on the internal tissues of the host. Host CBB that are parasitized by *P. coffea* die within 15 days (Espinoza, 2009). This species of parasitoid is considered ideal for use as a CBB biocontrol agent because

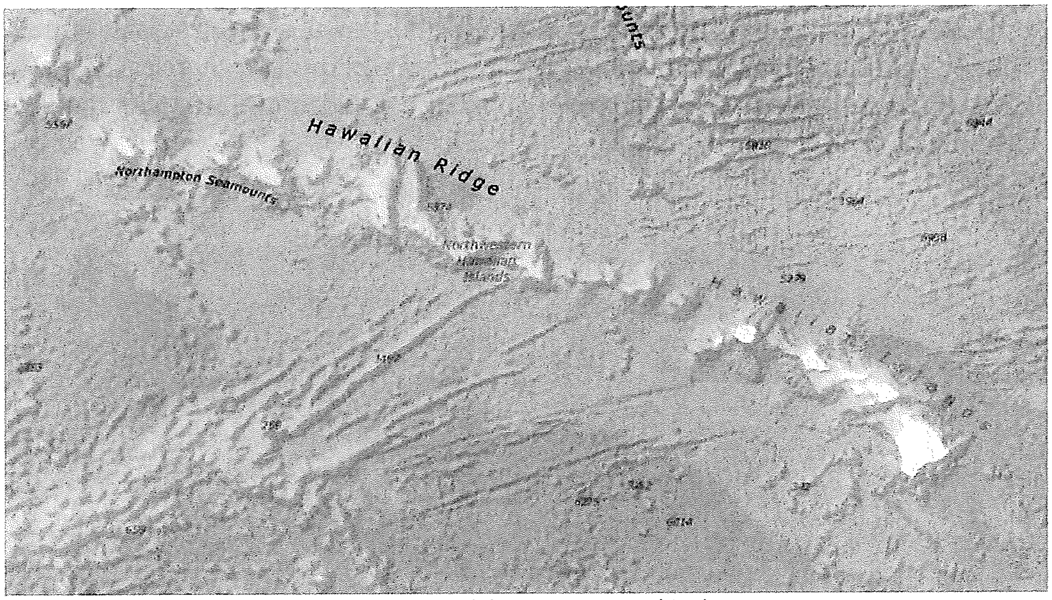


Figure 5: Map of the Hawaiian Archipelago
NOAA

PLANTS AND ANIMALS

The position of these islands on the planet created space in which flora and fauna developed unimpeded and unchallenged. Various birds, trees, plants, and creatures of the sea and land made their way by air or water here to thrive on the shores and slopes of this volcanic chain, creating an abundance of life (Olson, 2004). This life would eventually come to support the Polynesians who made their way across the Pacific to the many island groupings in one of the most rapid settlement excursions known to humans.

Plants existing pre-settlement:

Koa, pūkiawe, māmaki, ʻaʻaliʻi, olonā, ʻukiʻuki, kauila, ʻōlapa, ʻākala, maile, māmane, ʻōhelo, ʻūlei, hāpuʻu, ʻilima, alaheʻe, alani, ʻōhiʻa lehua, mokihana and wiliwili (Dunford, et. al. 2013).

SETTLEMENT & PRE-EUROPEAN CONTACT

There is dispute as to the actual dates of arrival of the Polynesians who settled the Hawaiian islands. Current archaeological carbon dating points to 1000 CE as the approximate date of first settlement in the islands although ranges from 800-1200 CE are possible (Kirch, 2011 and Cordy 2000). Two possible sources for the voyagers who made their way to Hawaiʻi are the Marquesas (Nuʻuhiwa) c. 900 CE and Tahiti (Kahiki) c. 1200 CE (Dunford et. al. 2013).

Polynesian settlers sailed with many plants and animals on their waʻa (canoes). The history of settlement is also the history of agriculture, and of species introduction. During the pre-contact era up to about 1450 CE, when migration seems to have slowed perhaps due to the Little Ice Age (Dunford, et al. 2013), several species were introduced.

Species introduced by Polynesians:

puaʻa (pig), moa (chicken), ʻīlio (dog), ʻiole (rat)

kō (sugar cane), 'ohe (bamboo), niu (coconut palm), kalo (taro),
kī (ti), pia (Polynesian arrowroot,), uhi (yam)
Pi'a (Five-Leafed yam), mai'a (banana), 'ōlena (turmeric)
'awapuhi (wild ginger), 'awa (kava), 'ulu (breadfruit)
wauke (paper mulberry), pa'ihi (nasturtium), auhuhu (Fish Poison plant), kukui (candlenut tree), hau (hibiscus), milo (Portiatree)
kamani (Alexandrian laurel), 'ōhi'a 'ai (mountain apple)
ʻuala (sweet potato), kou (Cordia wood), noni (Indian mulberry)
ipu (Bottle gourd) (Dunford, et. al. 2013 and St. John et. al 1980).

The introduction of these new species provided great sustenance for the kanaka maoli (Hawaiians) (Dunford et. al. 2013). These species, however, also began to encroach upon the endemic pre-settlement species. Puaʻa dug up rooted vegetables and "the main source of destruction of the native forests was the introduction of the Polynesian rat, *Rattus exulans*" (Athens et. al, 2002). Prehistoric avian species also suffered from the rat but also from human settlement as initially forests where the birds resided were burned and cleared for agricultural development by the settlers.

fields and planted on each side, either with a row of sugar cane or the sweet root of these island (ti)...so that even these stony uncultivated banks are by this means made useful to the proprietors, as well as ornamental to the fields they intersect. The product of these plantations, besides the above mentioned, are the cloth plant, taro, and sweet potatoes...The whole field is generally covered with a thick layer of hay, made from the long coarse grass or the tops of sugar cane, which continually preserves a certain degree of moisture in the soil that would otherwise be parched by the scorching heat of the solar rays...Their fields in general are productive of good crops that far exceed in point of perfection the produce of any civilized country within the tropics."

The kua'iwi system is still evident today, and forms the backbone of land in use for agriculture and coffee in South Kona.

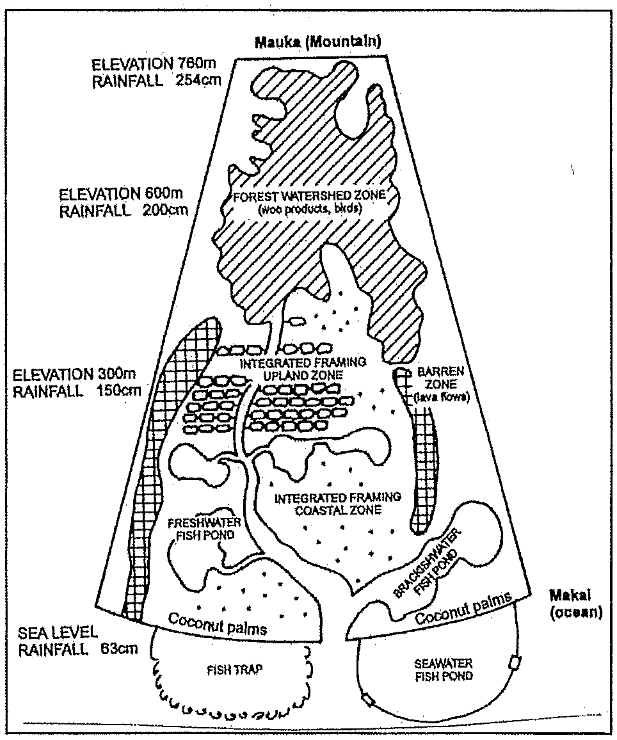


Figure 8: Example of individual ahuapu'a configuration (Davidson-Hunt, 2021)
Adapted from Costa-Pierce (1987)

Within each ahupua'a area, crops were cultivated for specific microclimate zones. Uka provided trees and plants used for canoe-building, weaponry, tools, cloth (kapa), cordage, lei and feathers for ali'i clothing collected from the native birds in these upland forests. The kula plains grew most of the food plants including mai'a (at the fringes of uka), kalo, 'ulu, 'uala and uhi. Kukui for oil, ipu for gourds, kī for capes and pili grass for thatched roofing were also grown in the kula areas. Finally, kai was where Hawaiians resourced fish (i'a), salt (pa'akai),

EUROPEAN CONTACT & THE HISTORIC PERIOD

"With the general demise of native Hawaiian society, the majority of Hawaiian integrated farming systems fell into disuse and disrepair" (Costa-Pierce, 1987).

The arrival of Captain James Cook to the islands in 1778 CE heralded immense change for the Hawaiian people who had lived for approximately a millenia without contact except from other occasional Polynesian voyagers (Kirch, 1998).

The next most significant person in the initial contact years was Captain George Vancouver who had served as an officer to Cook. Returning in 1791 leading the second British expedition, he made several trips to the islands bringing cattle (pipi), goats, geese, sheep and oranges (Speakman & Hackler 1989 and Hawai'i Dept. Of Agriculture). Eventually, mangoes, papaya, plumeria, coffee and lychee would also be introduced in the early nineteenth century (Dunford et. al, 2013).

After Cook's arrival to Hawai'i, the islands become a stopping point and eventual base for Western political and economical expansion into the Pacific and Asia. Landscape and cultural changes sailed in with the explorers, New England whaling industry and the missionaries who arrived in its wake. Over time, the raising of the new crops and animals they introduced to Hawai'i would contribute to the undermining of the traditional farming practices (Lâm, 1989). Development of imported agricultural in the Hawaiian islands increased rapidly during the early nineteenth century. The increase in the foreign population and creation of whaler ports on several of the islands produced a new supply and demand chain that would forever alter the islands.

'Iliahi (sandalwood) became a major commodity in 1810 heralding the increased economic investment by foreigners. Eventually when the sandalwood trade waned, the damage to the traditional subsistence economy had been done. The whaling industry as well now had a foothold in the islands and the ali'i had incurred massive debt to the foreign investors. By 1826, the first gunboat incidence occurred when the U.S. Navy moored in Honolulu harbor attempting to forcefully collect on these ali'i debts.

The whaling industry impacted traditional Hawaiian lifestyles in many areas. The cash economy began to supplant the previous subsistence economy. Hawaiians began to relocate to the now town and city centers for work, with many men signing on to the whaling ships. Agriculutre turned to growing crops to be sold to the peoples inhabiting these areas and to provision all the trade and merchant vessels at port. Disruption of the agriculutral farming systems that had served Hawai'i for a millenia seriously impacted the traditional socio-cultural basis for the kanaka maoli. It would pave the way for the end of land tenureship and the evolution of private property rights especially to be held by foreign entities (Kent, 1993).

were only part of the process of the change in society. For a long period of time, Hawai'i enjoyed the separation from the outside world and along with that, freedom from newly transmitted diseases. That changed with the arrival of Cook in 1778 and led to a steep decrease in Hawaiian population over the next century (Bushnell,1993).

Sailors on the voyaging ships introduced several venereal diseases, followed by tuberculosis in 1786. By 1804, Hawai'i saw its first large epidemic of what was most likely typhoid fever. Leprosy made its way to the islands by 1823 (Kamakau, 1992). There were continual outbreaks from 1826-57 derived from insect-borne disease, venereal disease and epidemics from inbound ships. An American warship brought in measles to Hilo in 1848 killing off 1/3 of the population. Several outbreaks of colds and flus occurred and by 1853 smallpox had arrived.

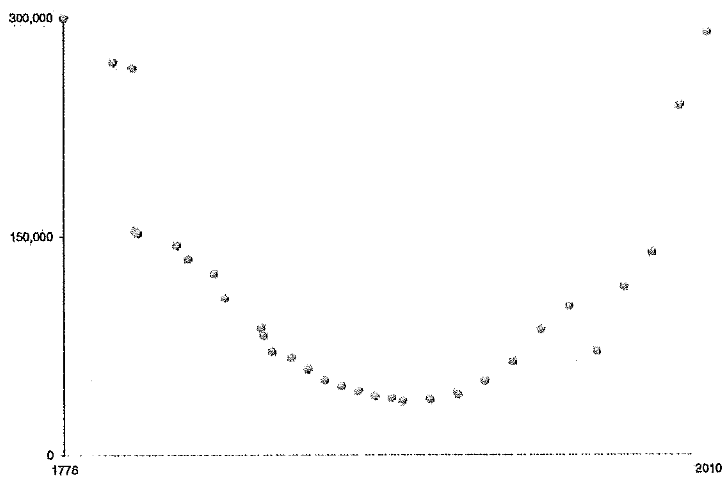


Figure 9: Map showing population decrease (Office of Hawaiian Affairs, 2017)

Decimation of the native Hawaiian population in the nineteenth century along with changes in the laws governing land ownership, created a space into which foreign investment and eventual political policy would lay the foundations for the modern era in Hawai'i.

AGRICULTURE IN THE POST-CONTACT ERA

The rise of foreign influences and trading ports saw a divergence in the agricultural production of each island.

O'ahu, Maui and Kauai followed similar paths during the period from the late 1790's through the 1850's. Whaling ports were the main drivers for change on these three islands and Honolulu, Lahaina and Kōloa Harbors became major resupply points for ships.

advent of the twentieth century, pineapple became a staple crop and eventually canneries were started on the island (Bartholomew et al., 2002).

Modern agriculture now includes a thriving coffee industry, cattle, pineapple, onions, papayas, tropical flowers, raw sugar, and the GMO biotech seed industry (mauicounty.gov).

LĀNA'I

Lāna'i has a uniquely different history of agricultural development than the other islands. The population had been decimated by wars within the Hawaiian kingdom's expansion under Kamehameha I and remained sparsely populated with subsistence farmers and fishermen. It wasn't until Walter Gibson arrived in the 1860's and acquired private land that agriculture shifted to more modern crops. Gibson brought ranching to the island which was followed by sugar from 1899-1921. The first pineapples were grown during the latter period of that time, and in 1921, James Dole acquired the island under private ownership. Soon Lāna'i became known as the pineapple island (lanaichc.org). Pineapple was phased out of production by 1992, due to high labor and land costs. Today, with 91% of the island in private ownership, the focus is increasingly on tourism and resort development instead of major agricultural crops (Land Use Baseline).

MOLOKA'I

Aquaculture and ranching were mainstays of the transitional agricultural landscape on Moloka'i. When the Hawaiian Homes Act of 1920 was estabished, many homesteads were created on the north shore in Ho'olehua. Initially, land was leased out for pineapple production but moved into diversified crops as did the other islands, just at a later rate of change (hdoa.hawaii.gov).

Moloka'i's strong winds and lack of water prevented the larger crop systems from maintaining economic sustainability. Pineapple companies left in the 1970's, as did a large portion of the population dependent on their income. Today, Moloka'i is predominantly Hawaiian by population and the residents do not cater highly to tourism. In the homestead area, foodcrops such as banana, papaya, taro, sweet potatoes and onions are grown (molokai.org). There is a large commercial coffee farm in the Kualapu'u village area.

The GMO biotech seed companies comprise more than 50% of the crop production on the island and as with other islands, has become a controversial land use issue (molokai.org). The only true port on the island is Kaunakakai on the south shore.

HAWAI'I

Hawai'i island has a rich history in agricultural development, both pre- and post-contact. A variety of ethnographic materials exist for West Hawai'i, primarily because it was the ancestral seat of a powerful line of hereditary chiefs, including Kamehameha. The early European visitors virtually impossible for many Kānaka Maoli as housing prices have risen well beyond what is affordable to many residents in a service-based economy. Even the neighbor islands of Hawaiʻi, Maui, Molokaʻi, Lānaʻi and Kauai have seen housing prices rise close to equal of those on Oʻahu. This has led to an exodus of Hawaiians to the mainland United States in search of better jobs and housing opportunities.

On the upside, there is a nascent effort in smaller communities to restructure the economy. The focus is on industries that serve and benefit the community especially in the areas of economic, social and mental welfare. Agriculture is one of the industries that could help alleviate the reliance on tourism. Coffee, avocados, kalo, bananas, papayas, mangoes and pineapples are just a few of these crops that are produced locally. Perhaps with strong support to these farming endeavors, Hawaiʻi can reclaim its inherent agricultural proficiency in order to support a healthier economic base for its social and cultural communities.

Community Interviews

To gain deeper understanding of the project area, a variety of stakeholders was interviewed for their knowledge of cultural practices within the coffee-growing Hawaiian islands: Oahu, Maui, Molokai, and Hawaiʻi Island. In keeping with the *Guidelines for Assessing Cultural Impacts* from the State's Department of Health - Office of Environmental Quality Control, interviews concerned not just coffee on these islands, but larger areas and cultural practices that could be affected by the release of *Phymastichus coffea.*

SHAC staff contacted eight community members for these interviews via telephone and email. Two declined, while six others agreed to be interviewed in May 2021. Each person contacted fits into one or more of the following categories: 1) Native Hawaiian cultural practitioner, 2) coffee farmer in Hawaiʻi, or 3) conservationist managing lands planted with Hawaiian coffee. To solicit additional feedback from members of the public who fit these criteria, a public notice was published on June 1 in Ka Wai Ola, the Office of Hawaiian Affairs newspaper and on their website at https://kawaiola.news/hoolahalehulehu/public-notice-june-2021/. No responses were received.

- The wasp cannot sting humans or animals.

Subsequent questions focused on four areas: 1) each individual's background and cultural practices, as well as experiences with pests and plant diseases that impact their cultural practices; 2) their knowledge about coffee production and Hawaiian agriculture; 3) their views about proper methods of pest control; and 4) any additional comments and concerns. SHAC staff prepared draft summaries of participants' interviews for them to review and add revisions. Below are the approved summaries of each interview:

Shalan Crysdale, The Nature Conservancy

Since 2009, Crysdale has been working on Hawai'i Island for The Nature Conservancy (TNC). He began his tenure with TNC as the field coordinator for the Ka'u Preserve, was promoted to natural resource manager, and is now the Hawai'i Island forest program director. As such, he is directly responsible for three units of TNC-owned lands: Ka'u Preserve, Kona Hema in South Kona, and Kamehame in Ka'u District.

Of these three, Kona Hema has a few patches of naturalized planted coffee. Situated on old terraces, these thick patches of coffee may date to the turn of the 20th century, Crysdale says. In addition, Kona Hema has an experimental, high-elevation strand of macadamia nuts planted by longtime agribusiness developer Sally Rice, who currently co-owns consultancies Agricon Hawaii and Agro Resources Hawaii.

Another TNC-owned unit, Pelekunu on North Molokai, is the site of a long-gone village that once grew coffee. Some coffee trees still exist there, Crysdale says.

Like others interviewed for this CIA, Crysdale doesn't know of any traditional Hawaiian cultural practices utilizing the coffee plant, fruit or seeds. Instead, coffee was a cash crop that many Japanese families depended on at the turn of the 20th century. Crysdale recalls hearing stories about agricultural workers who declined to renew their contracts as sugarcane workers, choosing instead to grow coffee on the Kona side of Hawai'i Island. For decades, those farms have provided harvesting jobs for new arrivals to the island. Coffee picking, Crysdale says, "is an entry point to Hawai'i living."

One hundred years ago, the farmers had limited themselves to the best areas for growing coffee. But as the popularity of Kòna coffee grew, Crysdale increasingly saw native forests and more marginal lands converted to coffee farms. With the addition of more farms came an increased reliance on herbicide.

"In the long run, that's a negative," he says. We don't want to see that show up in our water table."

Originally from Hilo and now living on Oahu, Shibata is a longtime educator of Native Hawaiian cultural practices and history. She is co-owner of the Ka Mahina Project, which promotes a healthier life through traditions that honor Hina, the Hawaiian moon goddess. Shibata also is lead cultural trainer for the Native Hawaiian Hospitality Association. Previously, she spent 14 years as education manager at the Bishop Museum in Honolulu. Shibata's own cultural practices include *lomilomi* and traditional *ho'oponopono.*

She also has conducted farmer education, based on her own family's experience with small-scale agriculture. Her husband had a two-acre farm that grew crops such as taro, *'ulu,* sugarcane and bananas -- just enough to feed family and friends. (They are looking for another plot of land to resume farming.) Over the years, she has seen growth in the number of Hawai'i's small and large farms. She hopes to see the establishment of more small ones.

Shibata's family doesn't grow coffee, but she has participated in coffee harvesting and processing at the Hawai'i Agricultural Research Center. She has noticed a difference in flavor between coffee produced on Hawai'i Island, versus coffee grown on the other Hawaiian islands. It's a variance she attributes to Hawai'i Island's younger volcanic soils.

Kona coffee has contributed much to the history of Hawai'i, especially since it's known globally, Shibata says. As coffee is not a traditional Hawaiian plant, she doesn't know of Native Hawaiian cultural practices that incorporate it. "It's not like they rejected it," she says of the Polynesian pioneers to Hawai'i. "I just don't think it's something they had."

Shibata has seen invasive pests affect both agriculture and plants important to Native Hawaiian culture. *'Uala* and taro are targeted by sweet potato weevil and apple snails, respectively. On her husband's farm, they noticed longneck turtles, poisonous dark frogs, and Japanese eels -- all non-native species, Shibata says. *Wiliwili* trees have been harmed by the Erythrina Gall Wasp. And the leaves of the *hala* tree, used by lauhala weavers, suffer from hala scale.

"Any time a native plant is affected negatively, it will have multiple effects on our culture," Shibata says. Since shipping introduces invasive species, she hopes more local agriculture would reduce imports. Shibata also would like to see more inspectors looking for invasive pests: "Protecting agriculture and ecosystems, it's really important. And it's really hard, because there's very little money."

When it comes to controlling pests, Shibata prefers physical and biological controls. She has participated in removing invasive miconia trees. And she's in favor of parasitoids -- as long as they are researched as extensively as the one that saved the *wiliwili* trees from the Erythrina Gall Wasp. "I'm not into chemicals because they go into our water systems," she says.

Kimokeo Kapahulehua, Kimokeo Foundation

To protect both farms and natural ecosystems, Kapahulehua prefers biocontrol methods over chemical sprays as long as they are tested properly. Such a process would involve scientists studying flora and fauna, in addition to entomologists, he says. With regards to *P. coffea*, the parasitoid wasp that would kill CBB, Kapahulehua questions what percentage of native insect species in Hawai'i were tested against it. His concern is adequate testing to ensure the protection of Hawai'i's endangered insects -- such as moths, as well as of Hawai'i's native plants and fruits.

Bryce Nakamura, Kona coffee farmer

Nakamura, 67, is a third-generation Kona coffee farmer. He is descended from Japanese immigrant laborers for Hawai'i's sugar industry. His great-grandfather established the family farm on 30 acres of Bishop Estate (now Kamehameha Schools) land overlooking Kealakekua Bay. The family's first crop was tobacco, followed by coffee.

Coffee's importance to his family is economic. Before tourism grew, agriculture was the main industry in Hawai'i. And back then, anyone who leased Bishop land was required to improve it with agriculture, Nakamura says. In subsequent decades, the Kona coffee brand helped build more farms.

Watching his father work so hard on the farm convinced Nakamura to become a pharmacist. He spent 29 years working at Kona Community Hospital before retiring. "I went to school to run away from coffee," he says. But now that Nakamura's father has died and his mother is in her 90s, the responsibility for tending the fields rests on him.

Granted, the acreage isn't as much as it used to be. Nakamura's father sold off most of the farm in the early 2000s, leaving 5.5 acres of Bishop Estate land under the family's control. Two acres are planted with interspersed macadamia nut trees and coffee trees. A separate 1-acre plot is planted with only coffee.

When asked if he knew of Native Hawaiian cultural practices that involve coffee, Nakamura couldn't think of any. His family's own Japanese cultural practices consisted of pounding mochi with a rock his great-grandfather found in Waipio Valley and crafted into a mochi pounding bowl, as well as going to Obon dances. None of these activities have been affected by pests, but his farm certainly has been.

Nakamura knows firsthand what it's like to battle coffee berry borer (CBB). It's recommended that farmers spray *Beauveria bassiana*, the fungus that dessicates the beetles upon contact, every three weeks in his area. But the CBB population is high in nearby wild coffee stands and poorly-tended neighboring farms -- which means Nakamura must spray every two weeks to control the beetles on his own farm. He sees a difference between the CBB populations in his two fields: On the one acre planted only with coffee, the CBB infestation stays under 5%. But in

Impact Assessment.) Even though coffee was much cheaper when Leslie was a child compared to now, there was still money to be made, he says.

Like the other interviewees, Leslie doesn't recall any Native Hawaiian cultural traditions around coffee. Interestingly, peak *'opelu* fishing season coincides with peak ripeness of the coffee harvest in Kona -- a parallel that has remained true over the decades despite variations in harvest season from year to year, he says.

Leslie is familiar with coffee berry borer (CBB) and its damaging impact on Hawai'i's coffee industry. He believes in quickly protecting agriculture and ecosystems from invasive species. "If you know it's gonna be a pest, get rid of it as soon as possible," he says.

To Leslie, past introductions of non-native species offer cautionary tales. Roi, a type of grouper that was brought from French Polynesia to Hawai'i in the 1950s, has since spread to coral reefs throughout the State. In addition to eating native fish, roi can harbor the toxin that causes ciguatera fish poisoning. Leslie says a number of his friends have fallen ill with ciguatera -- sometimes from roi, and sometimes from other species. Like Kimokeo Kapahulehua (see interview above), Leslie points out that the yellow-skinned snapper called *ta'ape* eats the eggs of native fish. It was introduced to Hawai'i by the Division of Fish and Game in the 1950s and 1960s. *To'au*, an invasive blacktail snapper, hurts coral reefs. And gorilla ogo, a seaweed that was introduced to Hawai'i with the aim of producing agar, spreads quickly and overruns fishponds.

Some of these fish and seaweed species were introduced in an uncontrolled manner. After seeing their effects on oceans surrounding Hawai'i, Leslie is glad that potentially beneficial species are far more rigorously tested than they were before. Regarding the USDA assessment for *P. coffea*, he wonders what would happen if the parasitoid wasp is successful in eliminating CBB in Hawai'i. Would *P. coffea* also eliminate the other three species that the USDA identified as parasite targets? Or are there other environmental factors that would prevent their elimination?

He stressed the importance of using biocontrols such as *P. coffea* instead of chemical sprays, provided the proper research is conducted. Says Leslie: "If the wasp can control the CBB, that's better."

Wally Young Sr., Ka'u Coffee Farmer

Wally Young, 79, was born in the Ka'u District's town of Waiohinu and has lived there almost his entire life. His father moved the family from Kona to Ka'u to join the sugarcane industry. At the time, there were two separate sugar mills in Ka'u: Hawaiian Agricultural Company in Pahala and Hutchinson Plantation in Na'alehu.

Coffee has positively contributed to Hawai'i's larger cultural history, Young says. It's now one of the top agricultural industries in Hawai'i. The biggest negatives are the arrival of CBB, and now coffee leaf rust.

Young believes in attacking pests as soon as they arrive in Hawai'i. As a conventional farmer, he sees the benefits of both chemical and biocontrol methods for pests. "If it's invasive, I think you should control it right away," he said.

Young had no specific recommendations for testing the effectiveness of new pest controls. He trusts that the process is more stringent than in the 1950s, when the *ta'ape*, an invasive fish, was released into Hawai'i. "Now, they check 'em out real good and make sure it doesn't screw up the environment," Young said.

He welcomes *P. coffea* as an additional tool in the fight against CBB. But he wonders about its resiliency against various sprays on the farm: the fungus *B. bassiana*, a biocontrol for CBB; anti-fungal copper sprays for coffee leaf rust; herbicides and pesticides. Just *B. bassiana* alone requires spraying every two weeks. At the time of this writing, one local vendor was selling a gallon of this fungus for $198.00, with a price increase expected soon. "It's really expensive," Young said.

He worries about killing *P. coffea*, but he can't reduce spraying to accommodate the wasp -- unless *P. coffea* demonstrates a strong ability to kill the CBB on its own.

Espinoza, J.C.; Infante, F.; Castillo, A.; Pérez, J.; Nieto, G.; Pinson, E.P.; Vega, F.E. (2009) The biology of *Phymastichus coffea* LaSalle (Hymenoptera: Eulophidae) under field conditions. Biol. Control

Flint, Maria Louise & Dreistadt, Steve H. (1998). Clark, Jack K. (ed.). Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control. University of California Press. ISBN 978-0-520-21801-7.

Greene, Linda, (1993) A Cultural History of Three Traditional Hawaiian Sites on the West Coast of Hawai'i Island. United States Department of the Interior National Park Service Denver Service Center

Handy, E.S.C. & Pukui, Mary K. (1998). The Polynesian Family System in Ka'u, Hawai'i. Mutual Publishing. Honolulu HI.

Hawai'i Department of Agriculture. (2013). History of Agriculture in Hawai'i. Ag Resources. https://hdoa.hawaii.gov/blog/ag-resources/history-of-agriculture-in-hawaii/

Hamilton, L.J.; Hollingsworth, R.G.; Sabado-Halpern, M.; Manoukis, N.C.; Follett, P.A.; Johnson, M.A. (2019) Coffee berry borer (*Hypothenemus hampei*) (Coleoptera: Curculionidae) development across an elevational gradient on Hawai'i Island: Applying laboratory degree-day predictions to natural field populations. PLoS ONE, 14, e0218321.

Hopkins, A.D. (1915) Classification of the Cryphalinæ, with Descriptions of New Genera and Species; Contributions from the Bureau of Entomology, Report No. 99; United States Department of Agriculture: Washington, DC, USA; p. 75.

I'i, John P. (1959). Fragments of Hawaiian History. Bishop Museum Press. Honolulu HI.

Jaramillo, J.; Chabi-Olaye, A.; Kamonjo, C.; Jaramillo, A.; Vega, F.E.; Poehling, H.; Borgemeister, C. Thermal tolerance of the coffee berry borer *Hypothenemus hampei*: Predictions of climate change impact on a tropical insect pest. PLoS ONE 2009, 4, e6487.

Johnson, A.J.; Hulcr, J.; Knížek, M.; Atkinson, T.H.; et al. (2020). "Revision of the Bark Beetle Genera Within the Former Cryphalini (Curculionidae: Scolytinae)". Insect Systematics and Diversity. 4 (3). doi:10.1093/isd/ixaa002

Johnson, Melissa A et al. "Coffee Berry Borer (*Hypothenemus hampei*), a Global Pest of Coffee: Perspectives from Historical and Recent Invasions, and Future Priorities." *Insects* vol. 11,12 882. 12 Dec. 2020, doi:10.3390/insects11120882

Kirch, Patrick V. (1985). Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory. University of Hawaii Press, Honolulu HI.

Kirch, Patrick V. (2011). When Did the Polynesians Settle Hawai'i?: A Review of 150 Years of Scholarly Inquiry and a Tentative Answer. University of Hawai'i System, Honolulu HI.

Kamakau, Samuel M. (1992). Ruling Chiefs of Hawai'i, Revised edition. Kamehameha Schools Press, Honolulu HI.

Appendix A: Public Notice

OHA
OFFICE OF HAWAIIAN AFFAIRS

LIST OF OFFICES

HONOLULU
560 N. Nimitz Hwy., Ste. 200,
Honolulu, HI 96817
Phone: 808.594.1888
Fax: 808.594.1865

EAST HAWAI'I (HILO)
(effective 7/1/21)
434 Kalanikoa St.
Hilo, HI 96720
Phone: 808.933.3106
Fax: 808.933.3110

WEST HAWAI'I (KONA)
75-1000 Henry St., Ste. 205
Kailua-Kona, HI 96740
Phone: 808.327.9525
Fax: 808.327.9528

MOLOKA'I
Kūlana 'Ōiwi, P.O. Box 1717
Kaunakakai, HI 96748
Phone: 808.560.3611
Fax: 808.560.3968

LĀNA'I
P.O. Box 631413,
Lāna'i City, HI 96763
Phone: 808-295-3498
Fax: 808.565.7931

KAUA'I / NI'IHAU
4405 Kukui Grove St., Ste. 103
Līhu'e, HI 96766-1601
Phone: 808.241.3390
Fax: 808.241.3508

MAUI
737 Lower Main St., Ste. B2
Kahului, HI 96793-1400
Phone: 808.873.3364
Fax: 808.873.3361

WASHINGTON, D.C.
211 K Street NE
Washington D.C., 20002
Phone: 202.506.7238
Fax: 202-629-4446

MĀKEKE
THE MARKETPLACE

Classified ads only $12.50 - Type or clearly write your ad of no more than 175 characters (including spaces and punctuation) and mail, along with a check for $12.50, to: *Ka Wai Ola* Classifieds, Office of Hawaiian Affairs, 560 N. Nimitz Hwy., Suite 200, Honolulu, HI 96817. Make check payable to OHA. (We cannot accept credit cards.) Ads and payment must be received by the 15th for the next month's edition of *Ka Wai Ola*. Send your information by mail, or e-mail kwo@oha.org with the subject "Mākeke/Classified." OHA reserves the right to refuse any advertisement, for any reason, at our discretion.

GOT MEDICARE? With Medicare you have options. We compare those options for you! No Cost! No Obligations! Call Kamaka Jingao 808.286.0022, or visit www.kamakajingao.com. Hi Lic #433187

HAWAIIAN MEMORIAL PARK CEMETERY Kaneohe, Garden-Devotion. Lot #106, Section-D. Price $6,000 or B/O. Great Feng Shui plot located on a hill facing ocean. Contact #808-885-4501 landline or 808-345-7154 cell

HOMES WITH ALOHA - Hot Hot Market! Thinking of making a move? Relocating or life changes, Hawaiian Homes Lands, Fee Simple, Neighbor islands properties, we can help you through the process from beginning to end and into your replacement property. Contact the expert,Charmaine I. Quilit Poki(R) (RB-15998) Keller Williams Honolulu (RB-21303) (808) 295-4474.

HOMES WITH ALOHA - Kula/Maui 43,429 sq.ft. res lot with a 600 sq.ft. structure $390,000. This is a Leasehold property- Charmaine I. Quilit Poki(R) (RB-15998) Keller Williams Honolulu (RB-21303) (808) 295-4474.

HOMES WITH ALOHA - Waianae 3 bedroom, 2 bath, Great potential! $219,000 This is a Leasehold property- Charmaine I. Quilit Poki(R) (RB-15998) Keller Williams Honolulu (RB-21303) (808)295-4474.

KEOKEA-KULA, MAUI/DHHL HOME OWNERS! Are you looking to sell your 1,2,3 or more bedroom home in the near future? **LET'S TALK!** I'm approved for AG & Pastoral with DHHL on Maui. Please call Marcus Ku-760-310-5645, Mahalo!

NEED TO BUY OR SELL A HOME? Are you relocating, moving, or downsizing? I'm here to assist your real estate needs! Chansonette F. Koa (R) (808) 685-0070 w/ HomeSmart Island Homes LIC: #RB-22929 | LIC: #RB-22805 call, email, or checkout my online info at: www.chansonettekoa.com

THINKING OF BUYING OR SELLING A HOME? Call Charmaine I. Quilit Poki (R) 295- 4474 RB-15998. Keller Williams Honolulu RB-21303. To view current listings, go to my website HomeswithAloha.com. Call or email me at Charmaine.QuilitPoki@kw.com to learn more about homeownership. Mahalo nui! Specialize in Fee Simple & Homestead Properties for over 30 years.

VALLEY OF THE TEMPLES MEMORIAL PARK. Kaneohe, Oahu. Memory Slope Map 1, Lot 114, Site 4. Includes concrete urn and bronze marker. Valued at $10,500, selling at $9,500. Text or call (808) 987-9201. ■

HO'OLAHA LEHULEHU
PUBLIC NOTICE

CULTURAL IMPACT ASSESMENT: INVASIVE COFFEE BERRY BORER BEETLE

At the request of the University of Hawaii, the Synergistic Hawaii Agriculture Council is preparing a Cultural Impact Assessment for the statewide release of a wasp (Phymastichus coffeea) to control the invasive Coffee Berry Borer beetle. The wasp is harmless to humans. Please contact Suzanne Shriner at 808-365-9041 or suzanne@shachawaii.org to share your mana'o about any cultural or historical resources relating to the lands now in use for coffee growing or any other information you feel is relevant. This could include mo'olelo, history, or knowledge of traditional and customary practices (both past and present). Letters can be sent to 190 Keawe St, Suite 25, Hilo, 96720. ■

Response to HDoA PPC comments provided in email on 8 February 2022:

COMMENT:

Needs supplemental studies to safeguard several biological control agents established in Hawaii for controlling invasive weed populations around the State, all of them in the same size range as the target pest CBB. None of them are tested, some are of African origin as the target pest and the proposed parasitoid.

- Acythopeus coccinea [correct spelling: *cocciniae*] O'Brean & Pakaluk biocontrol agent of ivy gourd, Coccinia grandis, native to Kenya
- Microlarinus lareynii (Jacquelin du Val) biocontrol agent of Puncturevine, Tribulus terrestris.
- Microlarinus lypriformis (Wollaston), biocontrol agent of Puncturevine, Tribulus terrestris.
- Apion scutellare Kirby, biocontrol agent of Gorse, Ulex europaeus.
- Exaprion ulicis (Forster) biocontrol agent of Gorse seeds, Ulex europaeus.
- Perapion antiquum (Gyllenhal), biocontrol agent of devil's-thorn, Emex spinosa, native to Africa.
- Perapion violaceum (Kirby), similar in size, no vouchers at HDOA

RESPONSE: The non-target host range testing (Yousuf et al. 2021) included a diversity of Curculionidae from the Subfamilies Anthribinae, Brentinae, Patypodinae, Curculioninae, Cossoninae, and Scolytinae. Emphasis was placed on native endemic species in the Scolytinae. This represents a broad sample of taxa from the family Curculionidae, see attached phylogeny from Shin et al. (2018).

The Subfamily designation of the species listed in the comment above is as follows:

Acythopeus cocciniae: Baridinae = Conoredinae
Microlarinus lareynii: : Lixinae = Molytinae
Microlarinus lypriformis: Lixinae = Molytinae
Apion scutellare: Apioninae
Exaprion ulicis: Apioninae
Perapion antiquum: Apioninae
Perapion violaceum: Apioninae

The phylogenetic placement of these subfamilies (and other Curculionidae), including estimates of the time since their shared ancestors existed, is shown in the attached annotated figure 1 from Shin et al. (2018). Subfamilies included in the comment above are underlined in red.

Annotated on the Shin et al. (2018) Fig. 1 are also the Subfamilies included in the non-target screening reported by Yousuf et al. (2021) and presented in the DEA, with TNP indicating tested never parasitized. The phylogenetic relationships among the only non-target hosts parasitized in the non-target screening study (all non-native *Hypothenemus* spp., phylogeny from Johnson et al. 2018), are shown to the right of the appended Curculionidae phylogeny, indicated by the green arrow. This shows that even among closely related Scolytinae in the same genus, *Hypothenemus*, *Phymastichus coffea* was unable to parasitize the species most phylogenetically distant (*H. eruditus*) from CBB. No other Scolytinae were parasitized, including species from the exotic genera *Xylosandrus*, *Xyloborinus*, *Euwallacea*, *Hypochryphalus*, *Chryphalus*, and *Ptilopodius*,

Rojas JC, Castillo A, Virgen A (2006) Chemical cues used in host location by *Phymastichus coffea*, a parasitoid of coffee berry borer adults, *Hypothenemus hampei*. Biological Control 37(2):141–147.

Shin et al. 2018. Phylogenomic data yield new and robust insights into the phylogeny and evolution of weevils. Molecular Biology and Evolution 35: 823-836.

Wapshere, AJ. 1974. A strategy for evaluating the safety of organisms for biological weed control. Annals of Applied Biology 77: 201-211.

Yousuf, F, Follett, PA, Gillett, CPDT, Honsberger, D, Chamorro, L, Johnson, TM, Jaramillo, MG, Machado, PB, Wright, MG. 2021. Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii. *Journal of Pest Science* https://doi.org/10.1007/s10340-021-01353-8

Attachment 6

Response to HDoA PPC comments provided in email on 8 February 2022:

COMMENT:

Needs supplemental studies to safeguard several biological control agents established in Hawaii for controlling invasive weed populations around the State, all of them in the same size range as the target pest CBB. None of them are tested, some are of African origin as the target pest and the proposed parasitoid.

- Acythopeus coccinea [correct spelling: *cocciniae*] O'Brean & Pakaluk biocontrol agent of ivy gourd, Coccinia grandis, native to Kenya
- Microlarinus lareynii (Jacquelin du Val) biocontrol agent of Puncturevine, Tribulus terrestris.
- Microlarinus lypriformis (Wollaston), biocontrol agent of Puncturevine, Tribulus terrestris.
- Apion scutellare Kirby, biocontrol agent of Gorse, Ulex europaeus.
- Exaprion ulicis (Forster) biocontrol agent of Gorse seeds, Ulex europaeus.
- Perapion antiquum (Gyllenhal), biocontrol agent of devil's-thorn, Emex spinosa, native to Africa.
- Perapion violaceum (Kirby), similar in size, no vouchers at HDOA

RESPONSE: The non-target host range testing (Yousuf et al. 2021) included a diversity of Curculionidae from the Subfamilies Anthribinae, Brentinae, Patypodinae, Curculioninae, Cossoninae, and Scolytinae. Emphasis was placed on native endemic species in the Scolytinae. This represents a broad sample of taxa from the family Curculionidae, see attached phylogeny from Shin et al. (2018).

The Subfamily designation of the species listed in the comment above is as follows:

Acythopeus cocciniae: Baridinae = Conoredinae
Microlarinus lareynii: : Lixinae = Molytinae
Microlarinus lypriformis: Lixinae = Molytinae
Apion scutellare: Apioninae
Exaprion ulicis: Apioninae
Perapion antiquum: Apioninae
Perapion violaceum: Apioninae

The phylogenetic placement of these subfamilies (and other Curculionidae), including estimates of the time since their shared ancestors existed, is shown in the attached annotated figure 1 from Shin et al. (2018). Subfamilies included in the comment above are underlined in red.

Annotated on the Shin et al. (2018) Fig. 1 are also the Subfamilies included in the non-target screening reported by Yousuf et al. (2021) and presented in the DEA, with TNP indicating tested never parasitized. The phylogenetic relationships among the only non-target hosts parasitized in the non-target screening study (all non-native *Hypothenemus* spp., phylogeny from Johnson et al. 2018), are shown to the right of the appended Curculionidae phylogeny, indicated by the green arrow. This shows that even among closely related Scolytinae in the same genus, *Hypothenemus*, *Phymastichus coffea* was unable to parasitize the species most phylogenetically distant (*H. eruditus*) from CBB. No other Scolytinae were parasitized, including species from the exotic genera *Xylosandrus*, *Xyloborinus*, *Euwallacea*, *Hypochryphalus*, *Chryphalus*, and *Ptilopodius*,

Rojas JC, Castillo A, Virgen A (2006) Chemical cues used in host location by *Phymastichus coffea*, a parasitoid of coffee berry borer adults, *Hypothenemus hampei*. Biological Control 37(2):141–147.

Shin et al. 2018. Phylogenomic data yield new and robust insights into the phylogeny and evolution of weevils. Molecular Biology and Evolution 35: 823-836.

Wapshere, AJ. 1974. A strategy for evaluating the safety of organisms for biological weed control. Annals of Applied Biology 77: 201-211.

Yousuf, F, Follett, PA, Gillett, CPDT, Honsberger, D, Chamorro, L, Johnson, TM, Jaramillo, MG, Machado, PB, Wright, MG. 2021. Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii. *Journal of Pest Science* https://doi.org/10.1007/s10340-021-01353-8

Other comments are:
Throughout this Draft Environmental Assessment, authors argued that Phymastichus coffea is one of the most promising agents of CBB, citing conflicting information on its status in Latin America (i.e., the degree of parasitism by P. coffea was more than 95%).

- Authors did not make it clear that this result came from sleeve experiment and cage tests where branches of coffee plant with non-infested fruits with entomological sleeve placed on the branch, then branch was infested with CBB adults and exposed to the parasitoids.

RESPONSE: In Colombia both cage and field studies have been conducted with *Phymastichus coffea.* In a recent field study carried out by Cenicafe, early season release of the larval-pupal parasitoid *Prorops nasuta* followed by multiple releases of *P. coffea* during CBB flights resulted in a 70-83% reduction in CBB populations compared to no-release fields, demonstrating the potential for augmentative biological control using this parasitoid. Also, *P. coffea* parasitism of CBB was estimated at 15% at 4 months after the last release, suggesting it has the ability to persist when CBB are available.

- Field parasitism in Mexico was reported shortly after a mass release. Further surveys in Mexico and other countries after the release showed no permanent establishment of parasitoids.

RESPONSE: In Colombia and Mexico, coffee berries are only available part of the year because of clear-picking during harvest and wide area stumping after harvest. In Hawaii, some coffee growing areas e.g. Kau, Kona, have infested coffee berries on the tree year-round which may facilitate establishment and persistence of *P. coffea.*

COMMENT: Aside from its susceptibility to the fungus, Beauveria bassiana, life cycle of P. coffea is too long for a good biocontrol agent, varies from 30-47 days. Adult female parasitoid lives for 2–3 days only and does not enter the fruit searching for CBB for parasitism as in Bethylid and Braconid parasitoids. There is a very short window of opportunity of 8 hours (time of CBB adult to enter the fruit and escape parasitism) for female P. coffea to encounter the host CBB.

RESPONSE: Thanks for your opinions. *P. coffea* is clearly well adapted to survive on its sole known natural host in the wild in its native Africa. It is possible that asynchronous/overlapping generations will occur, increasing likelihood of adult wasps encountering hosts in variable windows of opportunity. The window of opportunity for *P. coffea* parasitism is often much longer than 8 hours, depending on the age of the fruit: during times of adult CBB activity, beetles may wait in the exposed 'A' position for days or even weeks in young berries. Also, we have observed *P. coffea* entering the fruit searching for CBB in the laboratory. How effective *P. coffea* will be in Hawaii is hard to predict. Cenicafe in Colombia first released *P. coffea* 30 years ago and although it did not become established, *P. coffea* is still the main focus of their CBB biocontrol research program.

With regard to the statement that *Beauveria bassiana* poses risk of impact to *P. coffea*: Like integrating biocontrol with pesticides, one would time the *B. bassiana* applications with care, or hopefully avoid them to a large extent. That would be a benefit of biocontrol with a parasitoid. If the wasp is effective, farmers can reduce their dependance on *B. bassiana*, potentially quite significantly. This would result in considerable economic benefits to growers.

Attachment 7

Journal of Pest Science
https://doi.org/10.1007/s10340-021-01353-8

ORIGINAL PAPER

Check for updates

Limited host range in the idiobiont parasitoid *Phymastichus coffea*, a prospective biological control agent of the coffee pest *Hypothenemus hampei* in Hawaii

Fazila Yousuf[1,2] · Peter A. Follett[1] · Conrad P. D. T. Gillett[2] · David Honsberger[2] · Lourdes Chamorro[3] · M. Tracy Johnson[4] · Marisol Giraldo-Jaramillo[5] · Pablo Benavides-Machado[5] · Mark G. Wright[2]

Received: 2 August 2020 / Revised: 7 February 2021 / Accepted: 15 February 2021

Abstract

Phymastichus coffea LaSalle (Hymenoptera:Eulophidae) is an adult endoparasitoid of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera:Curculionidae:Scolytinae), which has been introduced in many coffee producing countries as a biological control agent. To determine the effectiveness of *P. coffea* against *H. hampei* and environmental safety for release in Hawaii, we investigated the host selection and parasitism response of adult females to 43 different species of Coleoptera, including 23 Scolytinae (six *Hypothenemus* species and 17 others), and four additional Curculionidae. Non-target testing included Hawaiian endemic, exotic and beneficial coleopteran species. Using a no-choice laboratory bioassay, we demonstrated that *P. coffea* was only able to parasitize the target host *H. hampei* and four other adventive species of *Hypothenemus*: *H. obscurus, H. seriatus, H. birmanus* and *H. crudiae*. *Hypothenemus hampei* had the highest parasitism rate and shortest parasitoid development time of the five parasitized *Hypothenemus* spp. Parasitism and parasitoid emergence decreased with decreasing phylogenetic relatedness of the *Hypothenemus* spp. to *H. hampei*, and the most distantly related species, *H. eruditus*, was not parasitized. These results suggest that the risk of harmful non-target impacts is low because there are no native species of *Hypothenemus* in Hawaii, and *P. coffea* could be safely introduced for classical biological control of *H. hampei* in Hawaii.

Keywords Coffee berry borer · Host specificity testing · Non-target · Biocontrol · Endoparasitoid · Scolytinae

Key message

- *Phymastichus coffea* is an idiobiont adult parasitoid of the coffee pest *Hypothenemus hampei*.
- In host range testing, *P. coffea* parasitized only five *Hypothenemus* spp.
- The parasitism rate was highest and parasitoid development time was shortest in *H. hampei*.
- No Hawaiian native species was parasitized by the parasitoid.
- *Phymasticus coffea* can be introduced safely for biocontrol of coffee berry borer in Hawaii.

Communicated by Antonio Biondi.

✉ Peter A. Follett
peter.follett@usda.gov

1 U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS), Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, 64 Nowelo Street, Hilo, HI 96720, USA

2 Entomology Section, Department of Plant and Environmental Protection Sciences, University of Hawaii At Manoa, 3050 Maile Way, Honolulu, HI 96822, USA

3 Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, Smithsonian Institution, MRC-168, P.O. Box 37012, Washington, DC 20013-7012, USA

4 U.S. Forest Service, Institute of Pacific Islands Forestry, and Hawaii Volcanoes National Park Quarantine Facility, Volcano, HI, USA

5 Centro Nacional de Investigaciones de Café - Cenicafe, Manizales, Colombia

introduced biological control agents are likely to occur on species closely related to the target pest species (Van Driesche and Murray 2004), but not always (Messing 2001), and thus, phylogenetically closely and distantly related species should be included in non-target screening efforts. This is an important element of biological control, particularly in Hawaii, where classical biological control may have had significant negative impacts on native species in the past (e.g., Howarth 1991; Henneman and Memmott 2001). While some studies have suggested that this is true (see references in Messing and Wright 2006), a number of carefully crafted field studies of population level impacts on non-target species have suggested that introduced parasitoids have had minimal, or sometimes moderate, impacts on endemic species (Johnson et al. 2005; Kaufman and Wright 2009). Where higher impacts have been detected, they are typically from accidentally introduced parasitoid species, and host insects in disturbed habitats are most susceptible to these impacts (Kaufman and Wright 2011). However, the potential for non-target impacts must be carefully considered, and outcomes of exposures of unintended hosts to prospective biological control agents can provide insights into host range patterns and determinants.

In this paper, we present new insights into the host specificity of *P. coffea*, a prospective biological control agent of *H. hampei* in Hawaii, by testing it against 43 different species of Coleoptera. Non-target testing included Hawaiian endemic, exotic and beneficial coleopteran species. There are currently no records of native Hawaiian *Hypothenemus* spp. except for an old record (1913) of *H. ruficeps* (Swezey 1954), which has never been collected or reported since and is possibly a synonym with the adventive species *H. eruditus* or *H. crudiae* (C. Gillett, unpublished). There are, however, many native species in another scolytine genus, *Xyleborus* (Samuelson 1981; Gillett et al. 2019), which may potentially be impacted by release of an exotic parasitoid against a scolytine pest such as *H. hampei*. We test the hypothesis that *P. coffea* is host specific and will not attack native Hawaiian Scolytinae species.

Materials and methods

Parasitoid, Phymastichus coffea

Phymastichus coffea used in this study were obtained from an established stock maintained at the National Coffee Research Center-Cenicafé, Manizales (Caldas) Colombia, which was started from *P. coffea* collected in Kenya and shipped to Colombia in 1996 and has been maintained in colony in large numbers since that time (Orozco-Hoyas and Aristizábal 1996). *Phymastichus coffea* has been mass reared by Cenicafé for field releases on multiple occasions and the colony receives frequent infusions of field-collected material. *Phymastichus coffea* was shipped from Cenicafé in its larval stage in parasitized *H. hampei* hosts under USDA APHIS PPQ, permit no. P526P-18-00,696 to a certified quarantine insect containment facility managed by the USDA Forest Service at Hawaii Volcanoes National Park, Volcano, Hawaii. Parasitized *H. hampei* were incubated in controlled climate chambers at 25° ± 1 °C, 75 ± 10% relative humidity and 8:16 h light:dark photocycle at the quarantine containment facility.

Emerged male and female parasitoid adults were collected using a manual aspirator into a clean glass container. Parasitoids were held for mating and oocyte maturation and provided with 50% (w/v) honey (raw organic) solution for ~ 2 h before being used in the experiments (López-Vaamonde and Moore 1998). Infante et al. (1994) reported that *P. coffea* does not go through a preoviposition period and exhibits facultative arrhenotokous-type parthenogenesis, where the female parasitizes its host before or after copulation, producing haploid males (Portilla and Grodowitz 2018). Feldhege (1992) reported a preoviposition period of between 5 min and 4 h. The adult parasitoids are very short-lived: males (~ 8–48 h) and females (~ 16–72 h) (Vergara et al. 2001; Rojas et al. 2006; Espinoza et al. 2009; Portilla and Grodowitz 2018). The ability to parasitize hosts decreases with age, so it was important to use freshly emerged parasitoids (< 12 h old) in all experiments.

Coffee berry borer, Hypothenemus hampei

Field-collected *H. hampei* were used in all no-choice host specificity experiments. *Hypothenemus hampei*-infested coffee berries were collected from coffee trees (*Coffea arabica*) at OK Coffee Farm in Hilo, Hawaii (19.727583, − 155.111186, elevation 156 m). These collections were transported in cold boxes to the USDA-ARS laboratory and placed in a custom-made extraction unit lined with tissue paper (Tech wipes 1709/7052, Horizon) to absorb condensation and prevent mold growth. Adult *H. hampei* were collected directly from the infested coffee berries by dissecting the berries or from the extraction unit using an aspirator. All the collected *H. hampei* were provided with artificial diet (modified from Brun et al. 1993) until use in the experiments.

Collection of non-target coleopteran species

The selection of non-target hosts was based on phylogenetic relatedness to the target host, sympatry of target and non-target species, and size. Species commonly occurring in the coffee landscape and species in culture at USDA-ARS in Hilo, Hawaii, were also tested. There are 21 native and 38 non-native scolytine species in Hawaii (Samuelson 1981;

Table 3 Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on beneficial Coleoptera species

Family	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Chrysomelidae:Cassidinae	*Uroplata girardi*	Exotic	60	0	0
Coccinellidae	*Scymnodes lividigaster*	Exotic	40	0	0
Coccinellidae	*Rhyzobius forestieri*	Exotic	60	0	0
Coccinellidae	*Halmus chalybeus*	Exotic	40	0	0
Laemophloeidae	*Leptophloeus* sp.	Unknown	60	0	0
Silvanidae	*Cathartus quadricollis*	Exotic	80	0	0

Table 4 Parasitism and parasitoid emergence rates in no-choice in vitro non-target host acceptance screening of *Phymastichus coffea* on Hawaiian native and introduced coleopteran species from families and subfamilies other than Curculionidae:Scolytinae

Family	Species	Insect status	Total beetles exposed	Parasitism (%)	Parasitoid emergence (%)
Anthribidae	*Araecerus simulatus* or *A. levipennis*	Unknown	6	0	0
Anthribidae	*Araecerus* sp. near *varians*	Unknown	15	0	0
Brentidae:Brentinae	*Cylas formicarius*	Exotic/Pest	80	0	0
Chrysomelidae:Bruchinae	*Acanthoscelides macrophthalmus*	Unknown	10	0	0
Curculionidae:Cossoninae	*Phloeophagosoma tenuis*	Unknown	8	0	0
Curculionidae:Cossoninae	*Nesotocus giffardi*	Native	12	0	0
Curculionidae:Curculioninae	*Sigastus* sp.	Exotic/Pest	6	0	0
Curculionidae:Platypodinae	*Crossotarsus externedentatus*	Exotic	60	0	0
Dryophthoridae:Dryophthorinae	*Sitophilus oryzae*	Exotic/Pest	60	0	0
Dryophthoridae:Dryophthorinae	*Sitophilus linearis*	Exotic	40	0	0
Nitidulidae:Carpophilinae	*Carpophilus dimidiatus*	Exotic	10	0	0
Nitidulidae:Carpophilinae	*Carpophilus zeaphilus*	Exotic	60	0	0
Tenebrionidae	*Tribolium castaneum*	Exotic/Pest	21	0	0
Tenebrionidae	*Hypophloeus maehleri*	Exotic	60	0	0

No-choice tests

In this study, we used no-choice tests because these would reflect physiological host range and the potential for parasitism in the field more accurately than choice tests (Van Driesche and Murray 2004). Choice tests that include the target host may mask the acceptability of lower ranked hosts, thereby producing false negative results (Withers and Mansfield 2005). Twenty individuals of each test species were placed in a sterilized glass Petri dish (80 mm in diameter) lined with filter paper and immediately afterward four *P. coffea* females (< 12 h old) that had not been exposed to adult hosts prior to the experiments were introduced. Therefore, when ample hosts were available, each replicate consisted of 20 hosts and four parasitoids for a 5:1 host–parasitoid ratio. However, due to difficulties in finding certain species live in adequate numbers, e.g., native scolytine bark beetles, and difficulties synchronizing parasitoid emergence with field collection or emergence from wood of live beetles, the host–parasitoid ratio and numbers of replicates were adjusted as needed. For example, if only 10 non-target beetles were available for screening, then two replicates each with 5 beetles and 1 parasitoid (maintaining the 5:1 host–parasitoid ratio) were performed. In all non-target host screening tests, *H. hampei* was included as a positive control to confirm parasitoid viability. The host–parasitoid ratio of the *H. hampei* controls was adjusted to match the non-target species in the test, whether it was 5:1 or otherwise. The generalized response of the parasitoids toward target and non-target hosts was also determined for a subset of parasitoids by visual observation and video recording of parasitoid behavior, e.g., any contact with the host by landing on the host or antennation, and/or walking on the host. Host acceptance was noted when the parasitoid adopted a characteristic oviposition position on top the elytra of the host (Lopez-Vaamonde and Moore 1998).

After *P. coffea* exposure, *H. hampei* and all other non-target species were incubated at 25 ± 1 °C, 75 ± 10% RH and 24:0 (L–D) photoperiod for 72 h. After 72 h, parasitoids and filter paper linings were removed and the beetles were species. *Hypothenemus hampei* had the highest percentage emergence of *P. coffea* at 70.4%, whereas *H. crudiae* had the lowest at 16.7% (Fig. 1). In *H. crudiae*, out of five parasitized hosts only one had emergence. Although *P. coffea* only parasitized *Hypothenemus* spp., it did inspect three other non-target scolytine hosts, *Hypothenemus eruditus*, *Xyleborus kauaiensis* and *Xyleborus ferrugineus,* but left hosts without initiating oviposition (i.e., no parasitism found). The phylogenetic relationship of five *Hypothenemus* species included in our tests, extracted from Johnson et al. (2018), is also shown in Fig. 1; *H. crudiae* is not included in the phylogeny because it was not included in Johnson et al (2018). Both parasitism and emergence in our tests decreased across *Hypothenemus* species with decreasing phylogenetic relatedness to *H. hampei*. *Hypothenemus eruditus*, the most distantly related species from *H. hampei* according to Johnson et al. (2018), was not parasitized (Fig. 1).

Parasitoid development time among the three different *Hypothenemus* spp. did not differ significantly compared with *H. hampei* ($\chi^2=0.17$, df$=4$, $p=0.997$), but did differ with *H. crudiae* (Table 1). The mean development time of *P. coffea* from oviposition to adult emergence was shortest in *H. hampei* (32.2 ± 0.5 days, mean ± SE), longest in *H. crudiae* (41.0 ± 0.0 days) and intermediate in the other three *Hypothenemus* spp. (Table 1), which generally agrees with the phylogenetic pattern observed for parasitism and emergence (Fig. 1). The percentage of female versus male *P. coffea* emerging from parasitized *H. hampei* was 50.8% ± 0.4 (mean ± SE), which was significantly different ($\chi^2=27.3$, df$=4$, $p=0.0001$) from *H. seriatus* and *H. birmanus* (Table 1). *Hypothenemus eruditus* was not parasitized by *P. coffea* and hence was not included in any statistical analyses.

Parasitized *H. hampei* had the lowest percentage of unemerged parasitoids compared to the other four *Hypothenemus* species (Fig. 1), indicating that *H hampei* is a superior host for *P. coffea* development. For each parasitized host beetle with unemerged parasitoids, invariably two parasitoids were present, and the parasitoids were of the same life stage (larva, pupa or adult). The frequency of the different life stages for parasitized hosts with unemerged parasitoids differed among *Hypothenemus* species (Fig. 2). Parasitized *H. hampei* had a significantly lower percentage of larval ($\chi^2=15.10$, df$=3$, $p=0.001$), and higher percentage of adult parasitoids that were unemerged ($\chi^2=18.36$, df$=3$, $p=0.0001$) compared to the other *Hypothenemus* species. The higher percentage of unemerged parasitoids developing to the adult stage again indicates that *H. hampei* is a superior developmental host than the other *Hypothenemus* spp. The percentage of unemerged pupae found in parasitized *H. hampei* was not significantly different from *H. obscurus*, *H. seriatus* and *H. birmanus*, but *H. crudiae* had a significantly higher percentage of pupae than *H. hampei* ($\chi^2=95.40$, df$=4$, $p=0.0001$) (Fig. 2). No eggs were found in any of the parasitized *Hypothenemus* hosts.

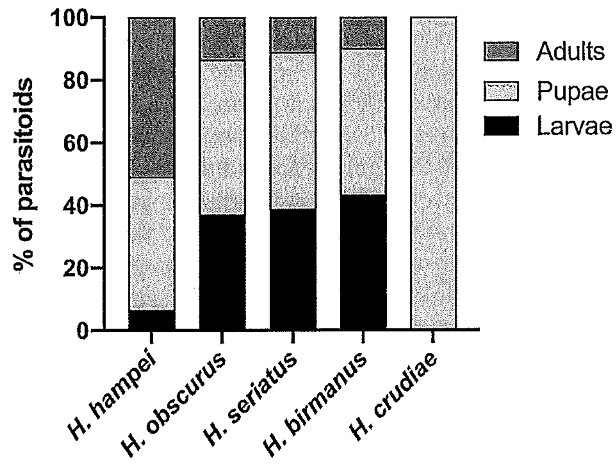


Fig. 2 Fate of unemerged *Phymastichus coffea* parasitoids from parasitized *Hypothenemus* spp. in no-choice in vitro non-target host selection screening. Parasitized *Hypothenemus* beetles with unemerged parasitoids were dissected to identify life stages (larva, pupa, adult)

Discussion

Phymastichus coffea is a potential biological control agent of *H. hampei* and was brought from Columbia into a quarantine containment facility in Hawaii for host range testing to determine whether the parasitoid might attack non-target species and therefore pose a risk to Hawaiian endemic species. Using no-choice tests, 43 different species of Coleoptera were exposed to *P. coffea* in vitro, including 23 scolytines (six natives, 17 non-native species including *H. hampei*), six beneficial species and 12 other species including one native weevil (*N. giffardi).* Only five species from the genus *Hypothenemus* were parasitized by *P. coffea,* including the two pest species *H. hampei* (coffee berry borer) and *H. obscurus* (tropical nut borer, a macadamia nut pest), and three other exotic species *H. seriatus*, *H. birmanus* and *H. crudiae* (Fig. 1). Thus, *P. coffea* appears to be host specific at the genus level and should pose no harm to endemic species if released in Hawaii coffee for classical biological control of *H. hampei*. Nevertheless, no level of host specificity testing can ensure zero risk to non-target organisms when introducing a natural enemy in a new habitat (Louda et al. 2003).

We observed that once the host and parasitoids were exposed in the Petri dish arena that *P. coffea* inspected *H. hampei* and other *Hypothenemus* spp. hosts by antennation before proceeding to oviposition or rejection. *Phymastichus coffea* did not show any oviposition response to other non-target hosts. This could be dependent on several factors facilitate detoxification of caffeine, permitting it to exploit *Coffea arabica* seeds as their host (Ceja-Navarro et al. 2015), and potentially other physiological adaptations to its unique host, possibly providing adaptive challenges to parasitoids, and mediating host specificity of *P. coffea*. Messing (2001) questioned the practicality of applying centrifugal phylogeny approaches to selecting species to examine in non-target studies of potential biological control agents, particularly parasitoids. Our results support the predictions of the latter approach, with more distantly related *Hypothenemus* species less susceptible to *P. coffea* attack and more distantly related genera (e.g., *Xyleborus* spp.) not attacked at all. However, Messing (2001) emphasized the fact that interactions between the host insect and its host plant may override host phylogenetic patterns, by providing the stimuli for parasitoids to attack hosts, a consideration which may play a role in this study system. If this is the case, it is possible that *P. coffea* will produce even higher levels of parasitism than recorded in the artificial environment we used in our study, when attacking wild *H. hampei* boring into coffee fruits, producing the full range of cues stimulating parasitism, and lower field parasitism of the non-target *Hypothenemus* spp. included here.

Among all the parasitized *Hypothenemus* species, *H. hampei* had the highest rate of parasitoid emergence. The total developmental time (from egg to adult) of *P. coffea* was shortest in *H. hampei* (32 days); parasitism of *H. crudiae* resulted in the longest developmental time (41 days). Another study reported a similar development time of the *P. coffea* in *H. hampei*, 38–42 days at 23 °C and 66% RH (Rafael et al. 2000). Castillo et al. (2004) reported a *P. coffea* development time of 42.6 days for *H. hampei* and 40 days for *H. crudiae* at 26 ± 2 °C and 70–80% RH. Total developmental time is directly related to the temperature. For example, the total development period of *Diglyphus isaea* (Hymenoptera:Eulophidae) decreased with increasing temperature between 15 and 35 °C and no development was found at 10 and 40 °C (Haghani et al. 2007). Temperature is a critical abiotic factor influencing the physiology and dynamics of insects. Therefore, in this study we selected a temperature for our no-choice assays which reflects the ambient field temperature the insects are expected to experience. In addition to temperature, age of the parasitoids and host play an important role in the subsequent development of parasitoid offspring (Pizzol et al. 2012). Hence, we used uniformly aged parasitoids and hosts throughout our experiments to minimize any impact on host parasitism and parasitoid development.

Phymastichus coffea commonly lays two eggs (a male and a female) per host (López-Vaamonde and Moore 1998). Both male and female develop in a single host, the female in the abdomen and the male in the prothorax (Espinoza et al. 2009). In this study, slightly fewer male parasitoids emerged as compared to females from parasitized hosts. The proportion of females emerging from *H. hampei* was 50.8% which is consistent with the results obtained by López-Vaamonde and Moore (1998) and Rafael et al. (2000). Likewise, sex ratios of *P. coffea* emerging from *H. obscurus* 54.8%, *H. seriatus* 51.1% and *H. crudiae* 50.0% were consistent with the sex ratio results reported by (López-Vaamonde and Moore 1998; Castillo et al. 2004) of 1.25:1, 1:1 and 1:1 (female–male), respectively, for these species. In our study, the proportion of females emerging from parasitized *H. birmanus* 57.7%, was the highest among all other *Hypothenemus* species tested. The slightly fewer males produced per host in our study could be due to either to some parasitoid's preference to lay one egg per host (Feldhege 1992) or the lower survivorship of male eggs or larvae. Preference to lay female eggs over male can be dependent on several factors such as host quality, host age, immune response, genetic factors, photoperiod and relative humidity, host density or host-related volatile composition (King 1987).

All the above tests were conducted in a quarantine laboratory with no field studies. We conducted no-choice tests because they may provide more accurate and conservative information on host preferences and physiological host range than choice tests because of lower levels of interference due to unexpected responses to multiple host cues (Van Driesche and Murray 2004). Sands (1997) showed that laboratory studies often overestimate the host range of the parasitoid and realized ranges under field conditions may be substantially less than predicted from no-choice tests, but they are necessary to give a worst-case prediction of the number of hosts at risk of being attacked in the field (Avilla et al. 2016). *Phymastichus coffea* attacked other non-target *Hypothenemus* species in our no-choice trials, but this does not necessarily mean that those species will be attacked in the field. For example, an idiobiont braconid wasp, *Bracon hebetor* is reported to parasitize a wide variety of moths within and outside in Phycitinae (Lepidoptera:Noctuidae) in the laboratory, but in the field it is restricted to only larvae of *Plodia interpunctella* (Lepidoptera:Noctuidae) (Antolin et al. 1995). This is because in the field, parasitoids use a spectrum of long- and short-range cues (chemical, visual, vibrational and tactile signals) to locate hosts (Strand and Pech 1995). Chemical cues (infochemicals) can play an important role in host location. A study conducted by Rojas et al. (2006) showed that *P. coffea* can distinguish between *H. hampei*-infested and uninfested coffee berries, and were highly attracted to the dust/frass originating from *H. hampei* infested berries, but showed no response to the dust/frass originated from the closely related non-target host, *H. crudiae*. This behavior depending on plant and host cues suggests that it is very unlikely that *P. coffea* will have any

Avila GA, Withers TM, Holwell GI (2016) Retrospective risk assessment reveals likelihood of potential non-target attack and parasitism by Cotesia urabae (Hymenoptera:Braconidae): a comparison between laboratory and field-cage testing results. Biol Cont 103:108–118. https://doi.org/10.1016/j.biocontrol.2016.08.008

Baker PS (1999) The coffee berry borer in Colombia:Final report of the DFID-Cenicafé-CABI Bioscience IPM for coffee project (CNTR 93/1536A). DFID-CENICAFÉ.

Barrera JF Investigación sobre la broca del café en México:logros, retos y perspectivas (2005) In: Simposio sobre Situación Actual y Perspectivas de la Investigación y Manejo de la Broca del Café en Costa Rica, Cuba, Guatemala y México. Sociedad Mexicana de Entomología y El Colegio de la Frontera Sur. Tapachula, Chiapas, México, pp 1–13

Barrera JF, Baker PS, Valenzuela JE, Schwarz A (1990) Introducción de dos especies de parasitoides africanos a México para el control biológico de la broca del café, *Hypothenemus hampei* (Ferrari)(Coleoptera:Scolytidae). Folia Entomológica Mexicana 79:245–247

Brill E, Follett PA, Kawabata AM (2020) Feeding habits, movement, and reproduction of the predatory flat bark beetles *Cathartus quadricollis* (Coleoptera:Silvanidae) and *Leptophloeus* sp. (Coleoptera:Laemophloeidae) in Hawaii coffee and macadamia nut. Int J Trop Insect Sci 2020:1–10. https://doi.org/10.1007/s42690-020-00205-9

Brun L-O, Gaudichon V, Wigley P (1993) An artificial diet for continuous rearing of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera:Scolytidae). Int J Trop Insect Sci 14:585–587. https://doi.org/10.1017/S1742758400017963

Burbano E, Wright M, Bright DE, Vega FE (2011) New record for the coffee berry borer, *Hypothenemus hampei*, in Hawaii. J Insect Sci 11:1–3. https://doi.org/10.1673/031.011.11701

Bustillo AE, Cárdenas R, Villalba D, Benavides P, Orozco J, Posada F, Manejo Integrado de la Broca Del Café, Hypothenemus hampei (Ferrari) en Colombia, 1st ed. Cenicafé: Chinchiná, Colombia, 1998; p 134

Castillo A, Gómez J, Infante F, Vega FE (2009) Susceptibilidad del parasitoide *Phymastichus coffea* LaSalle (Hymenoptera:Eulophidae) a *Beauveria bassiana* en condiciones de laboratorio. Neotrop Entomol 38:665–670. https://doi.org/10.1590/S1519-566X2009000500017

Castillo A, Infante F, López G, Trujillo J, Kirkendall LR, Vega FE (2004) Laboratory parasitism by *Phymastichus coffea* (Hymenoptera:Eulophidae) upon non-target bark beetles associated with coffee plantations. Fla Entomol 87:274–277. https://doi.org/10.1653/0015-4040(2004)087[0274:LPBPCH]2.0

Ceja-Navarro JA, Vega FE, Karaoz U, Hao Z, Jenkins S, Lim HC, Kosina P, Infante F, Northen TR, Brodie EL (2015) Gut microbiota mediate caffeine detoxification in the primary pest of coffee. Nat Commun 6:7618. https://doi.org/10.1038/ncomms8618

Chiu-Alvarado P, Rojas JC (2008) Host location behaviour by two Cephalonomia spp (Hymenoptera:Bethylidae) wasps associated with the coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae:Scolytinae). Int J Trop Insect Sci 28(4):179–184. https://doi.org/10.1017/S1742758408199660

Cognato AI, Rubinoff D (2008) New exotic ambrosia beetles found in Hawaii (Curculionidae:Scolytinae:Xyleborina). Coleopts Bull 62:421–424. https://doi.org/10.1649/1084.1

Damon A (2000) A review of the biology and control of the coffee berry borer, *Hypothenemus hampei* (Coleoptera:Scolytidae). Bull Entomol Res 90:453–465. https://doi.org/10.1017/S0007485300000584

Decazy B (1990) Descripción, biología, ecología y control de la broca del fruto del cafeto, *Hypothenemus hampei* (Ferr.). Paper presented at the 50 años de Cenicafé 1938–1988, Conferencias Conmemorativas, Chinchiná, Colombia.

Desneux N, Barta RJ, Hoelmer KA, Hopper KR, Heimpel GE (2009) Multifaceted determinants of host specificity in an aphid parasitoid. Oecologia 160:387–398. https://doi.org/10.1007/s00442-009-1289-x

Escobar-Ramírez S, Grass I, Armbrecht I, Tscharntke T (2019) Biological control of the coffee berry borer:main natural enemies, control success, and landscape influence. Biol Cont 136:103992. https://doi.org/10.1016/j.biocontrol.2019.05.011

Espinoza JC, Infante F, Castillo A, Pérez J, Nieto G, Pinson EP, Vega FE (2009) The biology of *Phymastichus coffea* LaSalle (Hymenoptera:Eulophidae) under field conditions. Biol Cont 49:227–233. https://doi.org/10.1016/j.biocontrol.2009.01.021

Feldhege M (1992) Rearing techniques and aspects of biology of *Phymastichus coffea* (Hymenoptera:Eulophidae), a recently described endoparasitoid of the coffee berry borer, *Hypothenemus hampei* (Coleoptera:Scolytidae) Café. Cacao 36:45–54

Follett PA, Duan J (1999) Nontarget effects of biological control. Kluwer Academic Publishers, Boston, p 316. https://doi.org/10.1007/978-1-4615-4577-4

Follett PA et al (2016) Predation by flat bark beetles (Coleoptera: Silvanidae and Laemophloeidae) on coffee berry borer (Coleoptera:Curculionidae) in Hawaii coffee. Biol Cont 101:152–158. https://doi.org/10.1016/j.biocontrol.2016.07.002

Fox CW, Mousseau TA (1995) Determinants of clutch size and seed preference in a seed beetle, *Stator beali* (Coleoptera:Bruchidae). Environ Entomol 24:1557–1561. https://doi.org/10.1093/ee/24.6.1557

Gillett CPDT, Honsberger D, Elliott C, Rubinoff D (2020a) Two endemic species of Hawaiian bark beetles newly recorded from the island of Moloka'i (Coleoptera:Curculionidae:Scolytinae). Trans Am Entomol Soc 146:251–257. https://doi.org/10.3157/061.146.0108

Gillett CPDT, Yousuf F, Rubinoff D (2020b) First host plant record for the endemic Hawaiian ambrosia beetle *Xyleborus pleiades* Samuelson, 1981 (Coleoptera:Curculionidae:Scolytinae). P Hawaii Entomol Soc 52:5–7. http://hdl.handle.net/10125/67801

Gillett CP, Elliott C, Rubinoff D (2019) Records of seven species of native and exotic bark beetles new to Pu'u Wa'awa'a Dry Forest Unit, Hawai 'i Island (Coleoptera:Curculionidae, Scolytinae). Fragmenta Entomologica 51:233–240. https://doi.org/10.4081/fe.2019.381

Gutierrez AP, Villacorta A, Cure JR, Ellis CK (1998) Tritrophic analysis of the coffee (*Coffea arabica*)-coffee berry borer [*Hypothenemus hampei* (Ferrari)]-parasitoid system. Anais da Sociedade Entomologica do Brasil 27:357–385. https://doi.org/10.1590/S0301-80591998000300005

Haghani M, Fathipour Y, Talebi AA, Baniameri V (2007) Temperature-dependent development of *Diglyphus isaea* (Hymenoptera:Eulophidae) on *Liriomyza sativae* (Diptera:Agromyzidae) on cucumber. J Pest Sci 80:71–77. https://doi.org/10.1007/s10340-006-0154-5

Hamilton LJ, Hollingsworth RG, Sabado-Halpern M, Manoukis NC, Follett PA, Johnson MA (2019) Coffee berry borer (*Hypothenemus hampei*) (Coleoptera:Curculionidae) development across a elevational gradient on Hawai'i Island: applying laboratory degree-day predictions to natural field populations. PLoS ONE. https://doi.org/10.1371/journal.pone.0218321

Hawkins BA, Shaw MR, Askew RR (1992) Relations among assemblage size, host specialization and climate variability in North American parasitoid communities. Am Nat 139:58–79. https://doi.org/10.1086/285313

Henneman ML, Memmott J (2001) Infiltration of a Hawaiian community by introduced biological control agents. Science 293(5533):1314–1316. https://doi.org/10.1126/science.1060788 coffee marketings final season estimates (2018) https://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Fruits_and_Nuts/201807FinalCoffee.pdf. Accessed 14 August 2020

Van Driesche RG, Murray TJ (2004) Overview of testing schemes and designs used to estimate host ranges, pp. 56–67, In: Van Driesche RG, Reardon R (eds), Assessing host ranges for parasitoids and predators used for classical biological control: a guide to best practice. United States Department of Agriculture Forest Health Technology Enterprise Team, Morgantown, West Virginia, USA FHTET-2004–03. https://www.fs.fed.us/foresthealth/technology/pdfs/HostRangeBook.pdf

Vega FE, Infante F, Johnson AJ (2015) The genus Hypothenemus, with emphasis on *H. hampei*, the coffee berry borer. In: Vega FE, Hfstetter R (eds) Bark beetles. Academic Press, Elsevier, pp 427–494. https://doi.org/10.1016/b978-0-12-417156-5.00011-3

Vergara JD, Orozco J, Bustillo A, Chavez B (2001) Dispersion de *Phymasticus coffea* en un lote de café infestado de *Hypothenemus hampei*. Rev Cenicafe 52:104–110

Withers TM, Mansfield S (2005) Choice or no-choice tests? Effects of experimental design on the expression of host range, pp. 620-633 In: Hoddle MS (ed), Proceedings 2nd international symposium of biological control of arthropods, 12–16 September 2005, Davos, Switzerland. USDA, Forest health technology enterprise team, Morgantown, West Virginia, USA

Yang Z-Q, Wang X-Y, Gould JR, Wu H (2008) Host specificity of *Spathius agrili* Yang (Hymenoptera:Braconidae), an important parasitoid of the emerald ash borer. Biol Cont 47:216–221. https://doi.org/10.1016/j.biocontrol.2008.08.001

Attachment 8

Hawaii Volcanoes National Park Quarantine Facility
Standard Operating Procedures

INTRODUCTION

The Hawaii Volcanoes National Park Quarantine Facility is the result of a cooperative agreement among federal and state of Hawaii agencies to implement a biological control program against alien weeds in Hawaii's forests. Participants in the cooperative agreement are: National Park Service; Biological Resources Division of the U.S. Geological Survey; U.S.D.A. Forest Service; Hawaii Department of Land and Natural Resources; Hawaii Department of Agriculture; and University of Hawaii. The Quarantine Facility was completed in March 1984 and certified in November 1984. The original 600 sq. ft. structure was modified in 1996 with addition of 600 sq. ft. of space for a workroom. The entire structure was modified with the addition of a metal roof and skylights in 2003. The facility is located at 3,800 feet elevation in Hawaii Volcanoes National Park, approximately 1 mile southeast of the park headquarters and visitor center.

This facility is designed to contain arthropod agents under evaluation for biological control of noxious forest weeds. Until approved for release by federal and state authorities, agents are considered restricted plant pests. They must be handled with appropriate caution to prevent escape because their establishment could have irreversible negative consequences for the environment. Containment of agents requires a secure, properly maintained building and strict adherence to precautionary protocols by all personnel. These Standard Operating Procedures (SOP) are meant to inform personnel on management policies and procedures to correctly and safely perform duties while working in this specialized structure.

PHYSICAL CONTAINMENT STANDARDS

Description of the facility and safeguards

(Refer to attached map and floor plan.)

The Quarantine Facility (Building #338) consists of two anterooms (A and B), the quarantine greenhouse (with walls and skylights made of Lexan polycarbonate), autoclave room, workroom (room 1 of the quarantine addition), temperature cabinet room (room 2), and handling room (room 3). A storage room is located at the external opening of the autoclave.

Entry and exit from the Quarantine Building is through the two anterooms enclosed by three airtight doors. The anterooms are completely dark except for insect light traps formed by windows looking into the Quarantine Greenhouse. There is an Emergency Exit Door in the workroom.

A. Walls, ceiling, and floors

The Quarantine Facility and adjacent glass greenhouse are surrounded by a water moat to prevent entry of unwanted organisms. Walls are double-walled plywood or Lexan mounted with flexible gaskets. Floors are cement painted grey. Drains in floors are covered with 100-mesh stainless steel screen. Ceilings are sealed wood with insulation. Skylights are sealed, double-

Liquid waste such as dishwashing water is eliminated through the plumbing system that feeds into a closed, covered cesspool. Floor drains covered with stainless steel mesh also are tied to the cesspool, which serves only the quarantine building.

I. Fire and chemical safety

Smoke detectors are installed on ceilings of the quarantine greenhouse, workroom, autoclave room, temperature cabinet room, and storage room. Fire extinguishers are hung in the quarantine greenhouse, quarantine workroom, outside Building 342 (plant containment building), outside the HAVO nursery office, and outside the Magma House office.

Emergency exits from quarantine include the main entrance doors and an emergency door in the workroom. An emergency eye-wash and shower are installed in the handling room. A first aid kit is located in the autoclave room. Ear plugs, full-face shields, and gloves are available on site. Chemicals are inventoried and their locations listed within the Chemical Safety Plan, together with material safety data sheets (MSDS). Inventories and MSDS are stored just inside entrances of the office, quarantine, and Building 342.

OPERATIONAL STANDARDS

1. Designation of Quarantine Officer and Assistant Quarantine Officer

Quarantine Officer: Dr. Tracy Johnson, Research Entomologist
Mailing Address: USDA Forest Service, P.O. Box 236, Volcano, HI 96785
Work tel: 808-967-7122; Fax: 808-967-7158; Cell: 808-938-7818

Assistant Quarantine Officer: Nancy Chaney, Biological Science Technician
Work tel: 808-967-7122; Home tel: 808-967-8581; Cell: 808-333-0433

2. Authorized personnel

Access to the Quarantine Facility is restricted to individuals authorized by the Quarantine Officer. Access is generally limited to individuals involved in biological control research. Visiting guests must be accompanied by the Quarantine Officer or his designee.

3. Signs

A. A sign permitting entry to authorized personnel only is posted at the entry to the Quarantine Building.

B. A sign with emergency contact information is posted at the entry to the Quarantine Building.

C. A sign indicating the emergency exit door is posted upon the door.

4. Access to the facility

A. Before entering quarantine

Plan your work in advance so that only required materials and equipment are taken into the quarantine facility. All plants, plant materials, supplies and equipment brought into quarantine

B. Removal of objects from the facility

Small items (pieces of paper, cameras) that can be thoroughly inspected can be wiped clean and removed.

Items such as plastic pots should be immersed in 5% bleach and held in Anteroom B for several hours, overnight if possible, before being removed.

Lab coats shall be periodically removed by the Quarantine Officer for washing in bleach and hot water. Coats must be shaken clean, visually inspected inside quarantine, and then sealed in a plastic bag for removal.

Equipment that cannot be autoclaved (microscopes, electrical equipment, etc.) shall be decontaminated with alcohol or placed in a plastic bag and fumigated with an appropriate insecticide within Anteroom A. If it is necessary to fumigate an object, this should be done at the end of the day after everyone has left in order to minimize pesticide exposure. Any use of pesticides must be performed in consultation with the Quarantine Officer and follow required safety procedures found in the Chemical Safety Plan.

Larger pieces of equipment (such as refrigerators and temperature cabinets) should be cleaned thoroughly, wrapped in plastic, and fumigated with insecticide for 24 hours. If it is possible to treat all surfaces, spraying with 95% alcohol can be used as an alternative to fumigation.

6. Facility maintenance and repairs

Maintenance personnel are authorized for entry only after notifying the Quarantine Officer or Assistant Quarantine Officer and receiving a pre-work briefing.

The quarantine facility will be inspected by the Quarantine Officer or Assistant Quarantine Officer once a month. Items to be checked include: 1) caulking around windows and greenhouse panels; 2) seals around all doors to be sure that latches close properly and that no light can be seen when they are closed; 3) caulking around the autoclave unit, and plumbing and electric lines entering the facility; 4) filters covering air intake and exhaust vents.

A complete inspection of all parts of the facility will be conducted annually. Based on the results of this inspection, maintenance needs will be identified and submitted in writing to the Chief of Resources Management of HAVO.

7. Emergencies and contingency plans

Before working in quarantine, familiarize yourself with the location and operation of smoke detectors, fire extinguishers, emergency exits, emergency eye-wash and shower, first aid kit, personal protective equipment and chemicals. Access to emergency equipment must remain unobstructed.

Earthquakes/Hurricanes

During an earthquake, leave the greenhouse, autoclave room, or temperature cabinet room immediately. Take cover under a metal desk in the workroom or evacuate the building.

Immediately following a minor earthquake (five and lower on the Richter scale) or major storm, the facility should be checked for breaches to quarantine. Areas to be checked include all seals checked in the course of monthly maintenance inspections (see above).

SPECIAL PROCEDURES FOR HANDLING ORGANISMS UNDER PERMIT

The Hawaii Volcanoes National Park Quarantine Facility is certified for containment of arthropods only. Pathogenic organisms are not tested in this quarantine facility unless they are found in the natural environment in Hawaii.

Only shipments of agents approved for introduction into the quarantine facility by the State of Hawaii and APHIS will be accepted. Approved shipments will be covered by a PPQ Form 526 signed by the appropriate officers for the State of Hawaii and APHIS/PPQ.

Under no conditions or circumstances will a package be opened before it enters the quarantine facility. State or Federal Inspection personnel may accompany the package to the quarantine facility and be present when it is opened. All arriving shipments shall be unpacked inside the handling room with the door completely closed. Each layer of wrapping as it is encountered will be individually examined for agents. Plant materials and packaging in which insects were received from a foreign country shall be bagged immediately and autoclaved. All instruments and work surfaces shall be sterilized with 95% alcohol.

Live agents shall be removed from the handling room in sealed containers and transferred to sleeve cages in the main quarantine area for rearing and study. Dead or weakened agents shall be checked for pathogens or parasitoids and then preserved or reared for inspection or for voucher specimens. All extraneous species shall be killed and saved.

After receiving and inspecting a shipment, the Hawaii Department of Agriculture and APHIS shall be notified in writing of the shipment, the type and exact number of insects it contained, and their condition. A log will be kept of each shipment received in the quarantine facility and contain all information pertaining to the shipment (i.e., original shipper, dates, number and condition of insects found (both the desired species and extraneous species.

Before transporting live insects to another quarantine facility, approval will be obtained in writing from the State of Hawaii or the APHIS/PPQ. Dead specimens may be removed from the quarantine to be used for voucher or other scientific purposes, but only in consultation with the Quarantine Officer and following appropriate treatment (e.g., alcohol, fumigant, freezing). The release of insects into the field in Hawaii requires state and federal approval. Voucher specimens will be prepared and submitted to both the Hawaii Department of Agriculture and the USDA ARS at Beltsville, Maryland.

Attachment 9

UNIVERSITY of HAWAI'I® MĀNOA

College of Tropical Agriculture and Human Resources
Founding College of the University of Hawai'i
Office of the Dean and Director of Research and Cooperative Extension

February 9, 2023

Mary Alice Evans, Director
State Office of Planning and Sustainable Development
Environmental Review Program
235 South Beretania Street, Room 702
Honolulu, HI 96813

Dear Ms. Evans:

Subject: Final Environmental Assessment and Finding of No Significant Impact for the Proposed Statewide Release of *Phymastichus coffea*

With this letter, the College of Tropical Agriculture and Human Resources (CTAHR), University of Hawai'i at Mānoa, transmits the Final Environmental Assessment and Finding of No Significant Impact (EA-FONSI) for the proposed statewide release of *Phymastichus coffea*, a biological control agent of coffee berry borer, *Hypothenemus hampei*, for publication in the next edition of the Environmental Notice.

The following documents are uploaded to the Environmental Review Program online submission system: publication form; EA-FONSI; published data demonstrating environmental safety of the proposed biological control agent; a cultural impact assessment; and, public comments on the Draft EA.

If any questions arise regarding this submission, please contact Dr. Mark G. Wright, Department of Plant and Environmental Protection Sciences, CTAHR at (808) 271-2037, or markwrig@hawaii.edu.

Yours sincerely

Ania Wieczorek
Digitally signed by Ania Wieczorek
Date: 2023.02.09 16:56:00 -10'00'

Dr. Ania M. Wieczorek
Interim Dean and Director

3050 Maile Way, Gilmore Hall 202 Honolulu, Hawai'i 96822-2271
Telephone: (808) 956-8234, Fax: (808) 956-9105
E-mail: ctahrdn@hawaii.edu

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESOURCE MANAGEMENT DIVISION
HONOLULU, HAWAII

April 25, 2023

Board of Agriculture
Honolulu, Hawaii

Subject: NON-ACTION ITEM: Update on Compliance with Act 90 (§166E, Hawaii Revised Statutes), Session Laws of Hawaii 2003, Transfer of Non-Agricultural Park Lands to State of Hawaii Department of Agriculture.

BACKGROUND:

Legislative Enactments

In 2003, the Legislature enacted Act 90, Session Laws of Hawaii 2003, which became §166E, Hawaii Revised Statutes (HRS). The purpose of this statute is "to ensure the long-term productive use of public lands leased or available to be leased by the department of land and natural resources (for agricultural purposes by allowing these lands to be transferred to and managed by the department of agriculture." See section 166E-1, HRS. The transfer section of the statute reads as follows:

[§166E-3] Transfer and management of non-agricultural park lands and related facilities to the department of agriculture.

(a) Upon mutual agreement and approval of the board and the board of land and natural resources:

(1) The department may accept the transfer of and manage certain qualifying non-agricultural park lands; and

(2) Certain assets, including position counts, related to the management of existing encumbered and unencumbered non-agricultural park lands and related facilities shall be transferred to the department.

(b) The department shall administer a program to manage the transferred non-agricultural park lands under rules adopted by the board pursuant to chapter 91. The program and its rules shall be separate and distinct from the agricultural park program and its rules. Non-agricultural park lands are not the same as, and shall not be selected or managed as are lands under agricultural park leases. Not withstanding any other law to the contrary, the program shall include the following conditions pertaining to encumbered non-agricultural park lands:

(1) The lessee or permittee shall perform in full compliance with the existing lease or permit;

(2) The lessee or permittee shall not be in arrears in the payment of taxes, rents, or other obligations owed to the State or any County;

(3) The lessee's or permittee's agricultural operation shall be economically viable as specified by the board; and

(4) No encumbered or unencumbered non-agricultural park lands with soils classified by the land study bureau's detailed land classification as overall (master) productivity rating class A or B shall be transferred for the use or development of golf courses, golf driving ranges, and country clubs. The transfer of non-agricultural park lands shall be done in a manner to be determined by the board of agriculture.

(c) For any encumbered or unencumbered non-agricultural park lands transferred to the department that are not being utilized or required for the public purpose stated, the orders setting aside the lands shall be withdrawn and the lands shall be returned to the department of land and natural resources. [L 2003, c 90, pt of §1]

Section 166E-3, HRS does not mandate that parcels be transferred, rather it allows the transfer of parcels with the mutual approval of both BOA and BLNR. Either DLNR may refuse to offer or DOA may refuse to accept the transfer of the land.

Since 2020, the Legislature has introduced various bills proposing amendments to Chapter 166E, to specifically address the issue of transfer of pasture leases from DLNR to DOA including mandating the transfer of pasture leases from DLNR to DOA by removing the "mutual agreement" provision from the statute and striking out BLNR approval from the process (see Senate Bill 77).

In 2021, the Legislature passed Act 139, SLH 2021, which established an Act 90 Working Group. This was comprised of Legislators as well as DOA and DLNR staff representatives. The Working Group's Final Report, authored by the House and Senate Water and Land committee chairs, is attached to this submittal as **EXHIBIT A**. The report stated that "certain agricultural lands under DLNR have multiple management objectives, which can include agricultural production, forestry, native forest restoration, watershed protection, habitat conservation, public recreation, fire fuel suppression, and other public purposes which clearly fall within DLNR's purview and mission. These multiple-use lands should remain under DLNR's management." The Working Group also maintained the requirement of mutual consent between DLNR and DOA.

In 2023, Senate Bill 77 (SB 77) was introduced to remove the requirement of mutual consent between DLNR and DOA, and it would have permitted DOA to unilaterally require the transfer of certain pasture leases to DOA without DLNR consent. SB 77 had strong support from the Hawaii Cattlemen's Council, Hawaii Farm Bureau, DOA, the Senate Water & Land Committee, and key members of the House Water & Land Committee. In response to the strong legislative momentum and growing public sentiment in support of the long-time ranchers, DOA and DLNR Directors agreed to revisit the transfer of some of the large pasture leases from DLNR to DOA, including Kapapala Ranch and KK Ranch on Hawaii Island. As a result of DLNR's reconsideration to transfer these pasture leases, SB 77 did not pass.

Transfer Status

Since the enactment of Chapter166E, DLNR has transferred to DOA crop lands and some pasture lands that primarily have agricultural value. §166E-3 sets forth the process to transfer DLNR agricultural leases to DOA. The process includes, 1) DLNR identifying available parcels either under lease or revocable permit to DOA, 2) DOA conducts due diligence to determine whether the lands meet the requirements of §166E-3, 3) once DOA agrees to accept the agricultural parcels, then the transfer recommendation goes before both boards. 4) If necessary, DOA will conduct a formal metes and bounds survey of the transferred property and DLNR prepares an Executive Order approved by the Governor transferring management authority to DOA. In total, 180 leases, revocable permits, and vacant parcels totaling over 19,000 acres have been transferred to DOA since 2003 to March 2023.

From the enactment of Chapter 166E through the present, DLNR offered DOA two-thirds of the pasture RPs and GLs that are still in DLNR's inventory. DLNR also published a publicly available interactive web map of these parcels and shared this with the Legislature and ranching community to provide transparency about DLNR's interests and completion of these transfers are pending due diligence by DOA: https://arcg.is/1DrmL1

Over the past few months, DOA and DLNR have met regularly to discuss implementation of Chapter 166E. With the change of Administration and the DLNR Director's willingness to transfer pasture leases, DLNR has updated its spreadsheet to increase the agricultural parcels, including certain pasture leases, that it agrees to transfer to DOA. DLNR has distributed the updated spreadsheet to DOA to review and conduct their due diligence. DOA must conduct due diligence on the lands before moving forward with BOA and BLNR approval. DLNR is making available their files on the agriculture leases to DOA to facilitate their due diligence. DOA's goal is have due diligence and the final batch of approved parcels sent to DLNR by the end of November. Due diligence involves reviewing files to ensure compliance with rent and other terms, as well as potential site visits, which also can confirm whether the land has agricultural value. DOA and DLNR are working together to process the transfers in three batches towards a completion date of December 31, 2023. Surveys will likely be needed for most, if not all, of the RPs because the executive orders require detailed maps and descriptions to be attached to them.

DISCUSSION:

Historically, DLNR has opposed bills that mandate the transfer of lands under DLNR management to DOA, even if those lands are in agricultural or pasture use. The primary reason is that these lands, especially certain pasture lands, possess significant resource values, such as forestry and watershed protection, that DLNR believes should be considered along with agricultural and pasture use. Another reason is that certain lands may have other uses that may provide significant public benefits above and beyond agricultural use. Furthermore, DLNR has historically considered pasture lands to be separate and distinct from agricultural lands and not subject to Act 90, as indicated by the different classes of land included in Section 171-10, HRS. However, as certain legislative committees have indicated that they will likely pass a measure to compel transfer of these lands to DOA, the DOA and DLNR Chairpersons have worked together to identify certain pasture lands that DLNR has previously desired to retain, and are proceeding with a proposed transfer to DOA, subject to certain conditions that ensure that DLNR fulfills its mission and public trust obligations. While DLNR staff would ideally prefer to retain these lands and not support such a transfer, they also recognize the potential consequences that could result from the alternative of a legislatively mandated transfer.[1]

As a compromise, DLNR proposes to retain certain lands and include reservations to protect public trust resources in other lands to be transferred to DOA. **EXHIBIT B** contains a list of the parcels that DLNR has offered to DOA, as well as the areas DLNR seeks to retain. As DOA and DLNR are working under the current terms and conditions of Act 90, any proposed transfer would require the approval of both boards. Therefore, it is possible that certain leases and revocable permits offered to DOA for transfer might not be approved by either BOA and BLNR for multiple reasons (such as lack of compliance), so it is important to note that a property's inclusion on this list does not guarantee transfer. There are now roughly 175 pasture revocable permits and leases that are in DLNR's inventory (excluding those that are pending a BOA or BLNR approved disposition). DLNR has offered approximately 70% of those dispositions to the DOA, which constitutes roughly 40,000 acres. The remaining 30% of those leases and revocable permits, which total approximately 54,000 acres, are intended to remain under DLNR's management because they are "multi-use" and have other important resource values in addition to agricultural use.

[1] DLNR Staff notes that a legislative mandate to transfer public lands without approval of the BLNR may not be consistent

VI.A-4

with Article XI, Section 2 of the Hawaii State Constitution and Section 26-15, Hawaii Revised Statutes.

Overall Management Considerations

DLNR oversight of these lands provides flexibility to re-evaluate areas for their highest and best use – which is key to changing land and climate conditions. Some lands might become unusable for pasture use due to threats such as Two-Lined Spittle Bug. Under DLNR, the use of these areas could be reconsidered to include reforestation, hunting use, or other purposes in addition to pasture. DLNR is seeking "reversion" clauses in the executive orders to require that if the land is no longer being used for pasture purposes, the land shall be returned to DLNR.[2] DLNR, in turn, will continue to re- evaluate its lands if they are more appropriate to be managed by DOA as conditions change.

Next Steps and Timelines

DLNR is negotiating with DOA and ranchers to determine which transfers are acceptable, develop reservations to ensure public access as well as public hunting, and withdrawals of lease areas that DLNR will retain due to resource value. After DOA confirms that they are willing to accept the transfers via BOA approval, DLNR will submit recommendations to the BLNR to approve the transfers. The departments have an ambitious schedule to process all the transfers through the two Boards that are mutually agreeable before the end of calendar year 2023. The departments will also work to process as many executive orders that finalize the transfers as possible, however that timeline depends on the capacity of other agencies that must assist with surveys and legal reviews, as well as Governor approval.

INTENTIONALLY LEFT BLANK

[2] This is consistent with statutory requirements of a set aside pursuant to Section 171-11, HRS.

The proposed schedule:

1. 1st 90 days (April – June 2023)
   - Informational Board briefings to BOA (April 25) and BLNR (April 28).
   - DLNR identifies parcels to be transferred to DOA, including priority transfers of KK Ranch and Kapapala Ranch to DOA, subject to DOA conducting due diligence.
   - June – KK Ranch and Kapapala Ranch on BLNR agenda for approval to transfer by executive order (EO) to DOA, subject to review by the Department of the Attorney General (AG), survey, and reverter clause when no longer in ranching.
2. 2nd 90 days (July – Sep 2023)
   - Aug – DOA completes their due diligence and notifies DLNR that they accept 2nd batch of parcels to be set aside to DOA.
   - Sep – 2nd batch of parcels goes to BLNR for approval to transfer by EO to DOA, subject to review by AG and survey.
3. 3rd 90 days (Oct – Dec 2023)
   - Nov – DOA completes their due diligence and notifies DLNR they accept a 3rd batch of parcels to be set aside to DOA.
   - Dec – 3rd batch of parcels goes to BLNR for approval to transfer by EO to DOA, subject to review by AG and survey.
   - Dec 31, 2023 – DLNR and DOA execute a letter of concurrence acknowledging completion of the implementation of Act 90.

Respectfully submitted,

BRIAN KAU, P.E.
Administrator and Chief Engineer
Agricultural Resource Management Division

Attachments - Exhibits "A" and "B"

APPROVED FOR SUBMISSION:

SHARON HURD
Chairperson, Board of Agriculture

VI.A-6

EXHIBIT A

HAWAI'I STATE LEGISLATURE
STATE OF HAWAII
STATE CAPITOL
415 SOUTH BERETANJA STREET
HONOLULU, HAWAII 96813

December 21, 2021

The Honorable Ronald D. Kouchi, President,
and Members of the Senate
State Capitol, Room 409
Honolulu, Hawaii 96813

The Honorable Scott K. Saiki, Speaker
and Members of the House of Representatives
State Capitol, Room 431
Honolulu, Hawaii 96813

Aloha President Kouchi, Speaker Saiki, and Members of the Legislature,

For your information and consideration, we are transmitting herewith our report conveying the process, findings, and recommendations of the Act 90 Working Group, pursuant to Act 139, 2021.

The report may also be viewed on the Act 90 Working Group webpage at:
https://www.capitol.hawaii.gov/specialcommittee.aspx?comm=act90wg&year=2021

Mahalo,

Lorraine R. Inouye

Senator Lorraine R. Inouye
Co-Chair, Act 90 Working Group
Chair, Senate Committee on Water and Land

David Tarnas

Representative David A. Tamas
Co-Chair, Act 90 Working Group
Chair, House Committee on Water and Land

Act 90 Working Group
Report to the Legislature

Introduction

Act 139, Session Laws of Hawaii ("SLH") 2021, established the Act 90 Working Group to:

(1) Ascertain the process and status of the transfer of non-agricultural park lands from the Department of Land and Natural Resources ("DLNR") to the Department of Agriculture ("DOA") pursuant to Act 90, SLH 2003, and Chapter 166E, Hawaii Revised Statutes ("HRS"), regarding non-agricultural park lands; and

(2) Determine the challenges and potential remedies necessary to facilitate the process of fulfilling the purposes of Act 90, SLH 2003.

The Act 90 Working Group ("Working Group") was tasked with conducting its work through meetings, informational briefings, and consultation with lessees of state non-agricultural park lands, lessees of state agricultural lands, and the public.

The members of the Working Group were as follows:

(1) The Chairs of the Senate Water and Land Committee (Senator Lorraine Inouye) and House Water and Land Committee (Representative David Tamas), who served as co-chairs of the Working Group;

(2) The Vice Chairs of the Senate Water and Land Committee (Senator Gilbert Keith-Agaran) and House Water and Land Committee (Representative Patrick Pihana Branco);

(3) The Chairperson of the Board of Land and Natural Resources (Chair Suzanne Case);

(4) The Administrator of the Division of Forestry and Wildlife of the Department of Land and Natural Resources (David Smith);

(5) The Administrator of the Land Division of the Department of Land and Natural Resources (Russell Tsuji);

(6) The Chairperson of the Board of Agriculture or the chairperson's designee (Deputy Morris M. Atta, Deputy to the Chairperson); and

(7) The Administrator of the Agricultural Resource Management Division of the Department of Agriculture or the Administrator's designee (Linda H. Murai, designee for the Administrator).

The Working Group met five times, on August 16th and 23rd, September 9th, October 14th, and November 17th. Meetings were publicly broadcast live and as recordings on the House of Representatives' streaming video channel. Written and live (audio and audiovisual) public testimony was accepted at each meeting. Public written testimony is publicly archived on the Working Group webpage at the State Capitol website.

The Working Group also received documents from DOA and DLNR that provide detailed updates on the status of Act 90 land transfers, the process of transfers, and the nature of DLNR and DOA engagement with lessees and lease contracts on non-agricultural park lands. These documents are also publicly archived on the Working Group webpage at the State Capitol website.

Background

In 2003, the Legislature found that public lands classified for agricultural use by DLNR should be transferred to and managed by DOA for the development of farms on a widespread of a basis as possible, consistent with Article XI, Section 10, of the State Constitution. Act 90 provides that non-agricultural park lands may be transferred from DLNR to DOA upon the mutual agreement of the Board of Agriculture ("BOA") and the Board of Land and Natural Resources ("BLNR").

Accordingly, Act 90, SLH 2003 (Act 90), was passed to transfer non-agricultural park lands from DLNR to DOA upon the mutual agreement of the BLNR and BOA. Since the passage of Act 90, over nineteen thousand acres have been transferred from DLNR to DOA, including 242 land parcels. Other agricultural lands classified as "non-agricultural park lands" or pasture lands remain held by DLNR.

DLNR and DOA then began to coordinate the transfer of lands. DOA asserted its discretionary authority to decline transfers pursuant to HRS§166E-3(b), for any parcel determined to be unsuitable for agricultural use, and if encumbered (i.e., those subject to a general lease or revocable permit), when:

(1) The lessee or permittee is not in full compliance with the terms and conditions of the lease or permit;

(2) The lessee or permittee is in arrears in the payment of rent or taxes or other obligations owed to the State or any county; or

(3) The lessee's or permittee's agricultural operation is not economically viable because the majority of their income is not from farming activity on the land or the land area is too small to support a viable agricultural operation.

While unencumbered and pasture lands were always contemplated for transfer under Act 90, DLNR and DOA initially prioritized the transfer of encumbered lands with existing agricultural operations, with a focus on lands used for crop production, nurseries, and other diversified agriculture, to provide existing agricultural operators the benefits of operating under DOA management as soon as possible.

To date, 242 parcels under 181 general leases or revocable permits have been transferred from DLNR to DOA. According to DLNR, over one hundred thousand acres of pasture and other agricultural land (183 revocable permits or general leases) remain under DLNR management statewide. Of these lands, DLNR considers **111** parcels eligible for potential transfer to DOA, subject to DOA's acceptance. DLNR has identified fifteen parcels which DLNR would consider eligible for transfer if an easement were provided to allow DLNR and/or the public to access an adjacent parcel. DLNR also considers fifty-seven encumbrances (general leases or revocable permits) ineligible due to DLNR priorities on those lands.

Challenges and Findings

The Working Group heard testimony from lessees of pasture lands held under DLNR, many who expressed frustration over the years they have spent for a transfer to DOA. Some expressed appreciation for DLNR's stewardship of multiple land uses, including historic preservation, reforestation, and conservation. Others expressed a lack of trust in DLNR's commitment to agriculture as a priority, stating their concerns that DLNR would reallocate the leased lands for reforestation purposes; DLNR's reforestation management is ineffective land stewardship; and short lease terms on state land limit the lessees' ability to invest in long-term improvements.

The Working Group finds that lands under DLNR used for the primary and substantial management objective of agricultural production should be transferred to DOA, following the processes and conditions pursuant to Act 90.

The Working Group further finds that certain agricultural lands under DLNR have multiple management objectives, which can include agricultural production, forestry, native forest restoration, watershed protection, habitat conservation, public recreation, fire fuel suppression, and other public purposes which clearly fall within DLNR's purview and mission. These multiple-use lands should remain under DLNR's management.

The Working Group also finds that improved collaborative working relationships between DLNR, DOA, and lessees of multi-use agricultural lands will facilitate the management or co-management of these DLNR multi-use parcels to benefit public values, including food production, conservation, and natural resource management.

The Working Group finds that multi-use lands can support sustainable land management, including natural resource conservation, at a reduced cost to the State. These "win-win-win" multi-uses are enhanced when DLNR and DOA collaborate with lessees of pasture lands to steward lands and harness additional funding to support multiple uses, such as by using Natural Resources Conservation Service programs and similar opportunities.

The Working Group further finds that maintaining easements to non-agricultural park lands under DLNR is a challenge impeding some Act 90 transfers. Preservation of a DLNR easement on these lands requires DLNR to procure and bear the cost of a professional land surveyor to prepare a map and metes and bounds description of the easement corridor.

Although the leases from both departments cannot exceed sixty-five years and allow the departments to, at the end of the lease term, take ownership of any improvements on the leased land or require the improvements' removal at the lessee's cost, the Working Group finds that two important differences between how the departments' manage their leases are how they extend lease terms and determine rent.

(1) Regarding lease extensions:

(A) Pursuant to Section 171-36(b), HRS, DLNR is authorized to amend and extend leases with BLNR's approval if the extension is needed to amortize the cost of improvements (e.g. a mortgage loan or cost of self-financed improvements);

(B) Under chapter 166E, HRS, and HAR chapter 4-158, DOA has greater flexibility to extend its leases. DOA leases can be extended if the lessee complies with the provisions of the current lease; and

(C) HAR §4-158-8 to §4-158-12 also specifically allow DOA to extend or convert the leases transferred under Act 90 to new DOA leases with terms that can range from thirty-five to sixty-five years.

(2) Regarding rent determination:

(A) For leases of lands under DLNR, all rents are set at fair market value according to an appraisal, and all leases are issued at public auction (Section 171-17, HRS). DLNR revocable permits, which are month-to-month dispositions that cover most of agricultural lands under DLNR, can be negotiated with lessees rather than requiring a public auction. Also, BLNR can approve any rent amounts under revocable permits that serve "the best interests of the State" (Section 171-55, HRS);

(B) For leases of lands under DOA, rents can either be set at the fair market value as determined by an independent appraisal, or the Administrator of the Agricultural Resource Management Division can recommend that the BOA adjust the appraised value or rent schedule based on the specific lease. For example, rent can be adjusted by factoring the uses of the lands (e.g. for crops which require heavy initial capital investments or are of low yield value) or by factoring in unproductive acreage on the lands (HAR §4-158-21). If significant improvements and/or preparation is required for commencing agricultural operations on a DOA-leased property, lease rent for up to two years may be waived or credited for the lessee; and

(C) DOA leases of non-agricultural park lands can be issued by negotiation rather than public auction if BOA finds that "the public interest demands the disposition as provided by section 171-18, HRS", the statute which describes the use of revenues from ceded lands (HAR §4-158-22).

Recommendations

The Working Group recommends proposing legislation that:

(1) Authorizes DOA to inquire with DLNR, prior to offering a lease, regarding any easements required for DLNR to access its landlocked forest reserves or other DLNR assets on the lands subject to the lease;

(2) Authorizes BLNR to:

(A) Amend and extend existing pasture leases for furtherance of public purposes that are the responsibility of the department to promote, including promoting sustainable food production and preserving and enhancing natural resource and public use values, for up to a sixty-five-year lease term;

(B) Issue new pasture leases by negotiation, if the lands are already under pasture use and lease issuance by negotiation furthers public purposes; and

(C) Develop agricultural and pastoral lease rents based on the value of the land's agricultural uses;

(3) Requires DLNR's Division of Forestry and Wildlife to seek BLNR's approval before taking land out of pasture leases for reforestation purposes, and requires the Division of Forestry and Wildlife to submit a funded action plan for reforestation purposes on current pasture lease land to the BLNR; and

(4) Facilitates collaborative relationships between DLNR, DOA, and lessees of multi-use agricultural lands by:

(A) Revising DLNR land classifications to include "agricultural multi-use," defined to include lands with agricultural value as well as natural resource, conservation, and/or public recreation values; and

(B) Creating and funding a multi-use lands specialist position to collaborate with DOA, DLNR, and multi-use land tenants and to leverage the Natural Resources Conservation Service and other funding sources to support natural land stewardship, reforestation, and other public purposes on agricultural multi-use lands.