PROCEEDINGS: 2015 COFFEE BERRY BORER SUMMIT

USDA-ARS DKI PBARC, Hilo, HI
May 14, 2015

EDITORS:
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Proceedings:
2015 Coffee Berry Borer Summit

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On May 14, 2015, thirty-three researchers, educators, government representatives, project investigators, and support personnel involved with coffee berry borer (CBB) research and education/outreach gathered at the United States Department of Agriculture-Agricultural Research Service Daniel K. Inouye Pacific Basin Agricultural Research Center (USDA-ARS DKI PBARC) in Hilo, at the Kauaʻi Cooperative Extension Service, and on the University of Hawaiʻi Mānoa campus to participate in the 2015 CBB Summit. This meeting was co-hosted by UH CTAHR coffee and orchard crop Extension agent Andrea Kawabata, UH CTAHR Extension economist Dr. Stuart Nakamoto, and HDOA entomologist Rob Curtiss.

Unlike in previous years, when CBB Summit meetings were utilized to update the CBB integrated pest management (IPM) recommendations provided to industry, the goal of the 2015 CBB Summit was for participants to learn about ongoing CBB research projects and Extension efforts and to provide networking opportunities. Fifteen speakers conducted PowerPoint presentations followed by question-and-answer sessions. The abstracts and presentations provided by the speakers are compiled into the following 2015 CBB Summit Proceedings.

Acknowledgements

Event co-hosts would like to thank funding agencies USDA, HDOA, and UH CTAHR for providing funding for this event, which supports the sharing of research and Extension/outreach activities that are so vital to Hawaiʻi's coffee industry. They would also like to thank USDA-ARS DKI PBARC and UH CTAHR staff and administration for providing the facilities, equipment, and support staff to host this meeting. In addition, they send their appreciation to all event participants and presenters, as their work is invaluable to the coffee industry, and to all industry and agency collaborators for their cooperation and generosity with CBB projects, research, and Extension/outreach. Finally, they would like to thank UH CTAHR Office of Communication Services for their assistance in the review and publication of these proceedings.

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Abstract: Administrative Update on the Area-Wide Mitigation and Management for CBB Control Project as Funded Under a USDA Specific Cooperative Agreement

Kelvin T. Sewake
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The roles of two principal investigators representing different institutions were explained. Dr. Lisa Keith, USDA-PBARC, oversees the research and technical aspects of the project. Dr. Keith coordinates all sub-projects with researchers, gathers proposals and writes the overall project proposal for submission to USDA, provides quarterly research progress report updates, and reports to USDA and Hawaiʻi's congressional delegation as needed. Dr. Keith communicates and coordinates the CBB Area-Wide Project with both USDA and CTAHR administration, while communicating with other agencies as needed. Dr. Keith cooperates with Mr. Kelvin Sewake, UH Mānoa, CTAHR, on all matters relating to the project.

Mr. Kelvin Sewake, UH Mānoa, CTAHR, is responsible for the overall project budget including accounting, re-budgeting, re-allocation, expenditures, etc. Mr. Sewake submits the Federal grant funding awarded by USDA into the UH My Grant system under a USDA/CTAHR Specific Cooperative Agreement (SCA). Once the agreement is finalized between parties, funding remains in the UH system for expenditures. Individual CTAHR researchers have funds allocated to them under an individual account number. The balance of funding for USDA-PBARC researchers remains under Mr. Sewake's account and authority: he is responsible for all of USDA-PBARC's sub-projects including the hiring and supervising of 6 employees to date, plus one more position currently in the hiring process; purchasing materials and supplies using a UH-issued Pcard; and making travel arrangements for visiting scientist collaborators. He works closely with Dr. Lisa Keith on all matters of the project and also works closely with all 12 sub-project investigators.

Thanks to strong industry support, Hawaiʻi congressional delegation support, and the support of many others, the CBB Area-Wide Project secured $1,000,000 ($949,367 to project) in September 2013 under an initial Specific Cooperative Agreement (SCA). This allocation included four scientists from USDA-PBARC & five from CTAHR. In September 2014, another $703,358 ($683,334 to project) was secured under an amendment no.1 to the initial SCA. Scientists added to the project included three from PBARC and one from CTAHR. Another $1,000,000 for the CBB Area-Wide Project (approx. $700,000 to Hawaiʻi & $300,000 to Puerto Rico) was recently approved. This award will need to be inputted into the MyGrant system and approved before Sept 30, 2015.

Abstract: UH CTAHR Coffee Berry Borer Educational Outreach Efforts

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In January 2013, the first Coffee Berry Borer (CBB) Summit was organized by Andrea Kawabata, Dr. Stuart Nakamoto (UH CTAHR) and Rob Curtiss (Hawaii Department of Agriculture) and held at the USDA Agricultural Research Service (Daniel K. Inouye) Pacific Basin Agricultural Research Center. The goal of this CBB Summit meeting was to coordinate and synthesize the best available information on CBB management for Hawaiʻi's coffee producers, which at times were confusing and conflicting. The resulting CBB Integrated Pest Management Recommendation document provided one voice from CBB researchers (UH CTAHR, USDA, and HDOA) and coffee grower representatives to the industry. Each year, the CBB IPM Recommendations are updated as necessary. The most current 2015 document can be downloaded at http://www.ctahr.hawaii.edu/oc/freepubs/pdf/IP-33.pdf. Educators, including Kona's coffee and orchard crop extension agent (Kawabata) and educational coordinators from coffee organizations are using these general guidelines to teach coffee growers how to best control CBB on their farms.

USDA, HDOA and UH CTAHR funding, has provided Kawabata the ability to increase educational efforts and include state-wide outreach to growers and the public regarding coffee production and management decisions, CBB IPM and prevention. Since 2012, she has increased the number of hosted or co-hosted CBB-related events from 14 events (402 participants) to 26 events (694 participants) in 2013, 23 events (535 participants) in 2014, and so far, 17 events (477 participants) in 2015. In addition, she has provided outreach with educational booths at industry conferences, expos, and festivals state-wide, resulting in the exposure of approximately 2,900 attendees annually to UH CTAHR Cooperative Extension Services as well as coffee and CBB information with educational posters, handouts and interactive materials. Kawabata's CBB IPM and educational efforts have also been provided to national extension conference and meeting participants in Colorado, Alabama, and Arizona via poster and PowerPoint presentations.

CBB IPM adoption and implementation has increased since 2011 and is substantiated by an annual CBB survey provided to coffee growers and processors by UH CTAHR. However, some challenges that extension and outreach face are: 1) keeping CBB IPM information new, exciting, attractive and relevant to event participants, 2) relaying the importance of coffee quality related to CBB IPM and the future of Hawaiʻi's coffee industry, and 3) continued understanding, adoption, and implementation of CBB IPM by all coffee producers. The CBB surveys and other coffee and CBB information can be obtained and downloaded at hawaiicoffee.weebly.com.

Kawabata provides one-on-one and small group farmer support via farm visits, email correspondence, phone calls, and walk-ins. In addition to extending research-based information to growers, Kawabata and cooperative extension staff conduct applied CBB research and provide support for CBB researchers by organizing meetings, maintaining research projects, collecting data, and connecting farmers with researchers for on-farm trials.

Coffee & CBB-related Educational Highlights by Andrea Kawabata

UH CTAHR Kona Cooperative Extension Service
Assistant Extension Agent for Coffee and Orchard Crops

- Co-hosted Coffee Berry Borer (CBB) Summits in 2013, 2014, 2015 to assist in organizing research-based information on CBB integrated pest management recommendations provided to the coffee industry. The 2015 CBB IPM Recommendations can be downloaded at http://www.ctahr.hawaii.edu/oc/freepubs/pdf/IP-33.pdf
- Hosted and co-hosted 81 coffee and CBB-related events since Nov. 2011, including 27 CBB integrated pest management workshops and field days throughout the Big Island and eight CBB IPM events held on other islands.
- Hosted 5 workshops on worker protection standards, spray calibration, and proper pesticide use and safety.
- Co-hosted 4 sessions with USDA on flat bark beetles, which are predators of CBB. Over 200 rearing kits were provided to farmer cooperators. This project was funded by HDOA, USDA, and UH CTAHR. Rearing and release videos can be viewed at https://www.youtube.com/watch?v=SOrumOHT2yU and https://www.youtube.com/watch?v=MxJgv4yjQDA, respectively.
- UH CTAHR Extension activities including CBB outreach and impact have been displayed via posters and presented to participants at the 2013 Extension Risk Management Education National Conference in Denver, Colorado, in 2013, the 99th Annual Meeting and Professional Improvement Conference National Association of County Agricultural Agents in Mobile, Alabama, in 2014, and at the Western Farm Management Extension Committee Annual Meeting in Phoenix, Arizona, in 2015.
- Locally, Kona Extension has participated in the following events:
  - Kaʻu Coffee Festival with an educational booth at their Hoʻolauleʻa and Coffee College in Kaʻu,
  - XV Pacific Entomology Conference with a flat bark beetle educational poster on Oʻahu,
  - Kona Coffee Council's Cream of the Crop with an educational booth in Kona,
  - Kona Coffee Farmers Association Expo with an educational booth and as a speaker at their seminar session in Kona
  - Kona Coffee Cultural Festival Booth Hoʻolauleʻa and Celebrate Kona Day with educational booths in Kona,
  - Maui Coffee Association's Seed to Cup Coffee Festival with an educational booth in Maui, and
  - Hawaii Coffee Association's Conference with educational booths and presentation in Kauaʻi, Maui, and Kona.
- Participated in the incident command system with the HDOA/USDA/UH CTAHR CBB rapid response team in Waialua and co-organized CBB survey and IPM updates in Kunia, Maui, and Molokaʻi between Dec. 5 and Jan. 20, 2015.
- Created and regularly update the hawaiicoffee.weebly.com website for coffee information. This site also provides events and announcements for all growers. Facebook updates are also available for social media users at Kona Orchard Crops.
- We continue to update our mailing and email lists and provide updates to clientele about monthly events and announcements.
- We continue to assist farmers via email, phone, walk-ins, and farm doctor visits.

- We continue to assist researchers with on-farm trials and research conducted at the Kona Research Station.
- We continue to conduct applied research to identify solutions to farm problems, questions, or concerns.
- We continue to apply for grant funding to conduct research and Extension activities.
- We continue to work with producers and processors, UH faculty and staff, industry organizations, and other agencies including, but not limited to USDA, County of Hawaiʻi, HDOA, and the private sector.

<u>On-the-Ground – 2015 Coffee Growers' Meeting</u>

January 22, 2015
Kona Cooperative Extension Service
Hosted by Andrea Kawabata – UH CTAHR Assistant Extension Agent for Coffee and Orchard Crops

Big Island coffee grower group representatives gathered for a meeting to discuss what they determined to be gaps in coffee berry borer (CBB) research and to provide observations of the 2013–2014 season and difficulties of CBB control. The following list is a summary of the thoughts, ideas, and opinions of meeting participants and not of the host.

<u>Research Gaps</u>

- Admire Pro – Test indirect control for CBB.
- How many days does it take after flowering for CBB to enter the bean?
- What is the ideal PSI, aperture and droplet size, and speed for spraying and getting optimum CBB kill?
- What is the impact of rain on CBB activity/movement?
- What is the impact of weather as a whole on CBB activity/movement – hot, dry, etc.?
- Research BAM on killing CBB.
- List all research results.
- What is the migration pattern of CBB with wind?
- On year-round production farms, when do you strip-pick and what is strip-picked off?
- On year-round production farms, do they have to spray year-round?
- Create a map with all coffee farms.
- What is the most effective rate of *Beauveria*? 10 oz? 15 oz? Is there a rate as effective as 32 oz per acre?
- What is the most effective rate of surfactant and type?
- Is spraying 1x per month still as effective as 2x a month?
    - Spray more/less often in a month?
- When is the right time to spray *Beauveria*?
- Where is the beetle going at lower elevations where there is a 3–4 month gap around Dec. to Mar.?
    - Hosts, ground?
- Does farm layout have an impact on CBB?
    - Intercropping, overstory, ground cover, etc.?
- Should you spray or not spray the ground with *Beauveria*?
- Should you spray the ground when there is ground cover or other organic matter on the ground?
- Is spraying *Beauveria* still 20% of the CBB IPM?
- What are the benefits or not of additives to *Beauveria* to increase spores or maximize the potential of *Beauveria*?
    - Aeration
    - Add molasses
    - Addition of other microorganisms; which are harmful to *Beauveria*?

Farmers' observations of the 2013–2014 season

- In Kāʻū, spraying 1x a month kept the CBB infestation level the same, whereas spraying 2x a month seemed to decrease the infestation.
- In Kona and Kāʻū, there was quick ripening where lots of red cherry were on the tree at once.
    - Created a lot of time for CBB to infest before the next harvest.
- Growers need a reminder of pesticide use as control for CBB.
    - Products need label and EPA registration to use in killing CBB.

Farmers' observations of difficulties in CBB control for 2013–2014 season

- Large/heavy harvest and farmers stopped spraying.
    - Increase in CBB infestation (holes in cherry).

Comparison of three years of CBB surveys (2012 to 2014): How are we doing in the war with CBB ?

HC Bittenbender <hcbitt@hawaii.edu>, A.M. Kawabata <andreak@hawaii.edu>, and S.T. Nakamoto <snakamo@hawaii.edu> CTAHR, UHM

Highlights of 2014 Survey.

This 2014 survey covers the 2013-14 harvest and the 2014 growing season and CBB control tactics used for the 2014-15 harvest season. The Marketable Green Bean Recovery Ratio (MGBRR) for the 2013-14 season as stated by farmers in Question 14 (Q14) of the 2014 survey was 6.2, equal to 19% loss of green bean. The ratio was essentially the same as the 2012-13 and 2011-12 crops. However, farmers who sell cherry (Q15) said processors who sampled for CBB damage estimated 13% cherry damage, a decrease from 26% in 2012 and 22% in 2011. These processors estimated the green bean loss at 20% (MGBRR = 6.3 (Q57)). This is a decrease to 20% from 28% damaged green bean in 2012-13 and 22% in 2011-12. In 2014 54% of farmers thought CBB damage was decreasing, vs. 60% in 2013 and 50% in 2012. **Only 10% thought CBB damage was increasing in 2014**. 63 farmers responded to the 2014 survey vs. 79 farmers in 2013. The survey was sent mid-August 2014, closed in mid-October, and analyzed in December 2014.

Sanitation.

The slogan "Contain and Kill" means managing all coffee cherry on your farm, beginning with the pre-harvest strip-picking, so that all CBB–adults, larvae, and eggs–in the cherries are destroyed during processing and after stripping all trees of remaining cherry of any age after harvest. Sanitation is the most effective strategy for reducing CBB damage in the current crop and in the following crop.

More farmers are pulping everything picked, including floating cherry and parchment. Less untreated pulping waste is returned to fields; instead, it is taken to a dump site. Strip-picking any cherry at the end of the harvest and treating to kill CBB has **increased to 75% of farmers who strip at least 90% of their trees**. **After the 2014-15 season, 85% of farmers say all trees will be strip-picked.** Only 7% of farms will return untreated processing pulping waste to coffee orchards.

Trapping to determine CBB flying.

2014 trapping (Q27) declined to 32% of farms; in 2013 trap use was 65% and in 2012, 76%. Farmers realize trapping is not an effective control tactic for CBB and there are more effective activities for their efforts.

30 Trees Sampling Method for CBB infestation in cherries.

The 30 Trees Sampling Method for detecting stage of infestation and evaluating the timing and effectiveness of the *Beauveria bassiana* sprays was introduced with workshops in 2012 and 2013. In 2014, 47% used it, an increase over the 17% of farmers in 2013. About 33% sample every 4 and 8 weeks, a decline from 2012, when 50% sampled every 4 weeks and 33% every 3 weeks. This probably reflects the required effort to sample and uncertainty with the method. Nonetheless 45% of farmers plan to use it in the 2015-2016 season.

Spraying commercial preparations of the fungus *Beauveria bassiana*.

Use has increased to 85% from a little more than 80% in 2013. In 2014, 28% began spraying in January and 90% before May. 75% of farmers rated the effectiveness of the fungal sprays as good or very good. 60% spray every 4 weeks and 20% more frequently. 5% use the 30 Trees Sampling Method for scheduling.

Spraying other insecticides to control CBB.

Farmers rate insecticides containing pyrethrins (Evergreen, Pyronyl) and kaolin clay (Surround WP) as very effective. The increased use of pyrethrin-pipernyl butoxide-based insecticides for rapid knockdown of CBB swarms has had an unexpected impact. Pipernyl butoxide (PBO) is a "activator" of the pyrethrins in the formulation.

Note: 4/2015. While these insecticides have are exempt from tolerances in the US for green coffee, this is not the case in Japan, which has not set a maximum residue level for them in green coffee. Therefore Japan used the minimal detectable level, which is 0.01 ppm, as the maximum limit. Coffee from Kona has been found to contain 0.02 ppm of pipernyl butoxide, making it twice the legal limit in Japan. OMRI-certified pyrethrins products like Evergreen Pyrethrum Concentrate® or Pyganic 5.0 EC products can be used instead, though the efficacy compared to Evergreen 6-6® is unknown.

Economic impacts.
About 90% of farmers reported "much more" or "somewhat more" costs for producing coffee in 2013-14. Only 35% had "much more" or "somewhat more" revenues from coffee in 2013-14. Profitability for the 2013-14 crop was mixed; 29% of farms made no profit, 36% made between 0 and $5,000, and 36% made between $5,000 and $100,000 in profit.

Are farmers leaving coffee due to CBB?
98% said they are not quitting; 56% of farmers said that no one they knew of was quitting coffee; 42% said they knew between 1 and 4 farmers that were quitting. This is an improvement over 2013 and may indicate increased morale.

In 2014, 63% of farms, about the same as 2013 and 2012, have neighbors not trying to control CBB; 54% of farms have border areas with feral or abandoned coffee, similar to 2013 and 2012.

Where do you get CBB information?
Most farmers use multiple sources to get CBB-control information.
The most important sources are:

- CTAHR workshops 72%
- Talking with other farmers 70%
- CTAHR webpage for CBB 66%
- Farmer's coffee organization webpage 62%
- Farmer's coffee organization workshops 57%
- Farmer's coffee organization newsletter 47%

Abstract: Synergistic Hawaii Agriculture Council

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The Synergistic Hawaii Agriculture Council (SHAC) is in the third year of its USDA Technical Assistance for Specialty Crops grant. In 2013, the grant began by focusing on the South Kona 8-4 tax map region, as well as the Kāʻū district. In 2014 it was expanded to include all CBB-impacted farms in Hawaiʻi.

To enroll in the grant, growers are required to attend a 1- to 2-hour training session on CBB IPM and sign a contract that they will perform sanitation on their trees and monitor their farms using a variation of the 30 Trees Sampling method. Participants are then eligible to receive a subsidy on the *Beauveria* products BotaniGard® ES or Mycotrol® O. In 2015, this subsidy covered 75% of the retail price of these products.

In 2014 and 2015, eleven classroom training sessions have been offered, and numerous farm visits made. Over 755 farmers have attended the trainings. To date, over 500 tax map keys (TMKs), representing over 4,000 acres, are registered in the grant program. According to a cross-reference of regional wet-mill data, the combination of an educational component with subsidy of the *Beauveria* products has driven an overall drop in crop damage.

Synergistic Hawaii Ag Council

A consortium of

Hawaii Coffee Association

Hawaii Papaya Industry Association

Hawaii Floriculture & Nursery Association

USDA TASC Grant

Technical Assistance to Specialty Crops

2013 – Pilot program in Kāʻū and South Kona (8-4 TMK)

- Data set complete
- Successful reduction in CBB when compared to wet mill data

2014 – Opened to all regions: June start due to late funding

- Data set complete, analysis not done
- Late-season start meant high initial numbers of CBB in CD position
- Analysis not yet done

2015 – Implementation at first of year

USDA TASC Grant
Technical Assistance to Specialty Crops

In order to receive the discounted *Beauveria*, each farmer must...

- undergo training in basic IPM (1-2 hours)
- strip-pick their trees before first spray
- commit to the monitoring program.

Participants

	2014			2015	
Region	TMK Contracts	TMK Acreage	#TMK Pickups	TMK Contracts	TMK Acreage
Kona	315	2563	211	450	3461
Kāʻū	47	560	22	48	561
Hilo	3	9	1	3	9
Oʻahu	1	150	1	1	150

Education and Outreach

Classes — 5 in 2014
5 in 2015, more planned

Farmers — 500 completed IPM training in 2014, either through classes or farm visits
255 additional in 2015 to date

iOs and Android "30 Trees" apps in development to ease complexity and paperwork burden to farmers.

2015 SHAC CBB Grant
Sampling and Monitoring Report

Farmer Name:_________________________________ Date of sampling:________________

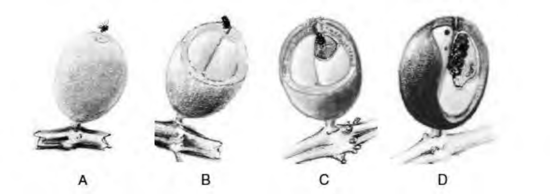
TMK or Field Name________________________________ Phone#______________________

Date of last Beauveria spray:________________ Other products sprayed?___________________

Tree #	Column A # Green Cherries	Column B # Cherries Infested	#Beauveria Noted
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
Total	*A*	*B*	

infestation percentage = (Total Column B) ÷ (Total Column A) x 100 = %

This is your infestion rate on your farm



AB / CD Green Bean Inspection – *pick 3 infested cherry from each tree to cut open for CBB position ↑*

# of live CBB in position AB =
# of live CBB in position CD =
# of dead CBB in AB or CD =
# of berries with no live or dead CBB =

NOTE: The AB/CD numbers should total to the number of berries cut (36).

Comments/Observations:

download this document at deadcbb.com
questions 365-9041 or info@deadcbb.com

CBB Research Gaps as Identified by Farmers

- Days after flowering when coffee endosperm reach sufficient density for CBB CD-position entry/egg-laying and how that relates to timing of first spray. *(Can growers wait until the rains start before spraying* Beauvaria*?)*
- Most effective dosage of *Beauveria* spray in ounces/acre, with consideration of number of trees.
- Impact of precipitation events on CBB movement prior to bean entry.
- Most effective sprayer equipment (e.g., PSI/GPM).
- Surfactant rates for efficacy as well as a secondary kill.

CBB Research Gaps as Identified by Farmers

- Surfactant rates for efficacy as well as a secondary kill agent.
- Additional potential local predators,
- How farm layout impacts IPM. Specifically, overstory, tree density, intercropping, and cover crops. *(For example, a farm manager with 10 TMKS uses Google Earth to pin his 30 Trees data. He reports consistently higher CBB infestations in overstory locations. Anecdotal, or important?)*
- Efficacy of spraying *Beauveria* on soil for control.

CBB Research Gaps as Identified by Farmers

- Location of beetle during “off-season” when cherry is not present on trees.
- Decision-making on when to strip-pick at locations with year-round flowering.
- How beetle disperses between locations, in both time and distance (e.g., between neighboring farms).
- Potential and legality of boosting *Beauveria* spores before spraying (e.g., “tank growout”).
- Development or use of alternate (local?) *Beauveria* strains.

Conclusions

- 2015 showing high numbers of grower buy-in
  - Educational turnout lower than last year **but** more new farmers.
  - Data quality is looking better than 2014.
- Preliminary observations:
  - 2014 growers whose 1st spray of the year was in June maintained but did not lower CBB percentage.
  - 2015 growers who sprayed in the dry period of late Feb/early March had a lower kill rate than desired.

Abstract: CBB Decision Tree Model

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The decision tree (DT) framework was used to develop a model of major coffee berry borer (CBB) management strategies described in the CBB Integrated Pest Management recommendations, for potential use by growers and to assist in developing and evaluating management strategies. The model focuses on pesticide spraying as the most significant activity but can also readily incorporate other management measures.

The DT provides a visual representation of all the decisions over the course of a year, determines the optimal decision path to maximize grower profits, and can support sensitivity and break-even analyses. Three DTs are incorporated into the model: infestation (crop damage) rate, net harvest rate, and projected net benefits from incorporating the CBB management decisions. The model requires information on a number of parameters on the farm and farm activities, pesticide spraying, CBB growth and infestation rates, and coffee harvest rates. Outputs determine whether or not to spray during each period over the course of the year in order to maximize net benefits.

Two scenarios are used to illustrate the use of the DT model. With an initial infestation rate of 8%, constant spraying in every period will result in a final infestation level of 48% and potential net benefits of $12,340. Changing only the initial infestation rate to 1% (perhaps by sanitation methods or block pruning), there is no spraying in the final period. The final infestation level is 6%, with net benefits of $21,615.

Targeted improvements to the model include more accurate information on model inputs, including dynamic coffee cherry pricing based on infestation rates of the harvest, and real-time modeling using farm data.

CBB Decision Tree Model

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Outline

- Motivation
- Decision Tree Model
- Setup
- Results
- Conclusion

Motivation

Given the data available and certain assumptions, can decisions be modeled...

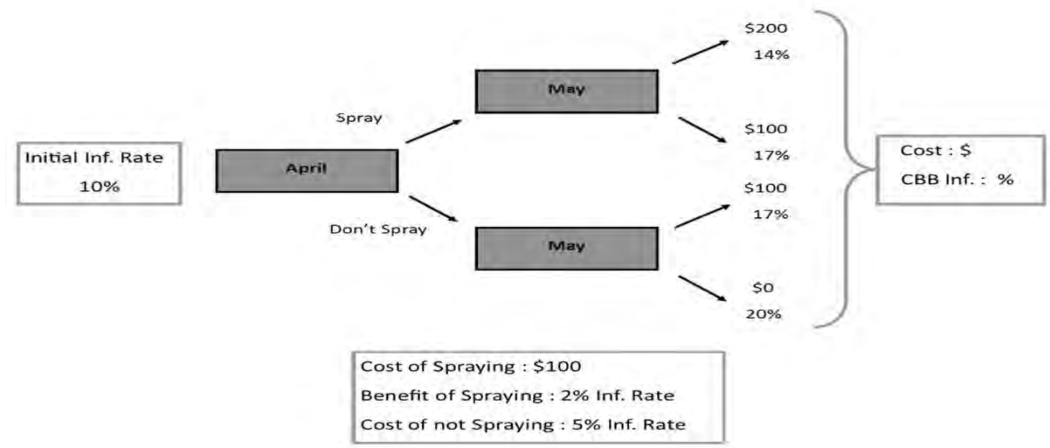
- ...to provide a baseline answer to a coffee farmer's questions?
- ...to assist in policymaking and evaluation?

Decision Tree Model

What is a decision tree?

- A visual representation of a process.
- An aid to map a wide variety of decisions.
- An aid to determine an optimal decision path.

Decision Tree Model



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Types of Decision Trees

Infestation Rate → **Harvest Rate** → **Net Benefit**

Infestation rate of CBB for 12 periods

Harvest rate of returns percent of infested cherry from previous tree

Projected net benefits based on decisions and previous tree responses

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Decision Tree Setup

Farm Level Decisions		
About the Farm or Plot:		
Total Number of Acres	1.67	Acre(s)
Average or Current Anticipated Pounds of Cherry Per Acre	7,500	Pounds
About Practices on Farm or Plot:		
Preseason Strip Pick? (0 : no or 1 : yes)	-	
Midseason Strip Pick? (0 : no or 1 : yes)	-	
Labor:		
Labor Cost Per Hour	$ 15.00	per Hour
Total number of Hours to Spray an Acre	1	Hour(s)
Market:		
Current Price of Cherry per Pound	$ 2.00	per Pound
Current Price of Cherry with CBB per Pound	$ 1.00	per Pound

All cells marked as follows can adjust model :

Spray Information		
Sprays	**Cost Per Acre**	
Beauveria	70.35	
Pyronyl	51.25	
Admire Pro	8.44	
Spray Requirements:		
Gallons of Water per Acre	100	Gallons
Cost of Water per 1000 Gallons	$ 1.00	per 1000 Gallons
Surfactant Used:		
Cost of Surfactant per Quart	$ 45.00	per Quart
Amount of Surfactant per Acre in Ounces	8	Ounces
Monthly Sprays	* NOT IN USE	
November	1	
December	1	
January	1	
February	1	
March	1	
April	1	
May	1	
June	1	
July	1	
August	1	
September	1	
October	1	

Decision Tree Setup

Constants

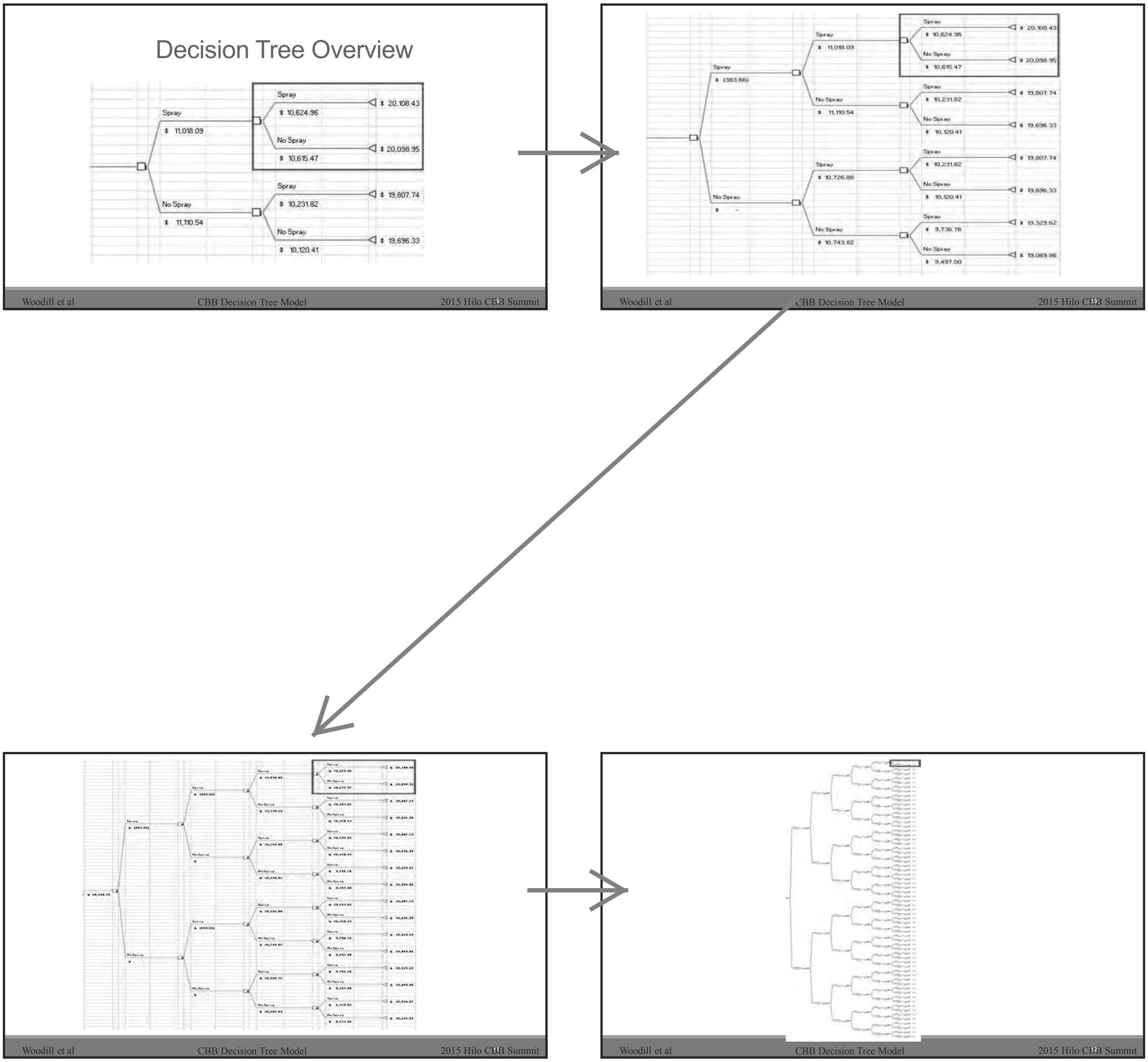
Initial Infestation Rate	1.00%
Spray	Effectiveness (%)
Beauveria	50%
Pyronyl	50%
Admire Pro	50%

Infestation and Harvest Parameters

Month	Time	Growth (%)	Spray Growth(%)	Harvest %	Harvest (lbs)
Dec	Period 1	35%	18%	0%	-
Jan		35%	18%	0%	-
Feb	Period 2	35%	18%	0%	-
Mar		35%	18%	0%	-
Apr	Period 3	35%	18%	0%	-
May		35%	18%	0%	-
Jun	Period 4	35%	18%	0%	-
Jul		35%	18%	0%	-
Aug	Period 5	35%	18%	25%	3,131.25
Sep		35%	18%	25%	3,131.25
Oct	Period 6	35%	18%	25%	3,131.25
Nov		35%	18%	25%	3,131.25
				100%	12,525.00

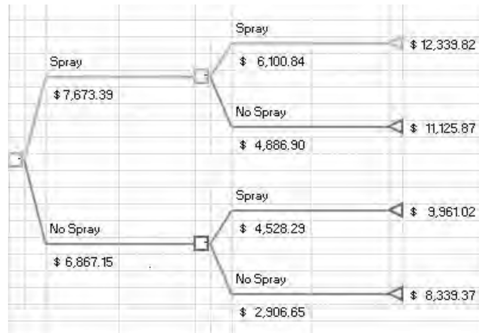
Infestation Levels

	Adjusted Infestation Level	
	No Spray	Beauveria
Dec / Jan	1.70%	1.35%
Feb / Mar	2.89%	1.82%
Apr / May	4.91%	2.46%
Jun / Jul	8.35%	3.32%
Aug / Sep	14.20%	4.48%
Oct / Nov	24.14%	6.05%


Decision Tree Overview
Spray
$ 11,018.09
No Spray
$ 11,110.54
Spray
$ 10,624.96
No Spray
$ 10,615.47
$ 20,108.43
$ 20,098.95
Spray
$ 10,231.82
No Spray
$ 10,120.41
$ 19,807.74
$ 19,696.33
Woodill et al
CBB Decision Tree Model
2015 Hilo CBB Summit
Spray
$ (383.66)
No Spray
Spray
$ 11,018.09
No Spray
$ 11,110.54
Spray
$ 10,726.88
No Spray
$ 10,743.82
Spray
$ 10,624.96
No Spray
$ 10,615.47
$ 20,108.43
$ 20,098.95
Spray
$ 10,231.82
No Spray
$ 10,120.41
$ 19,807.74
$ 19,696.33
Spray
$ 10,231.82
No Spray
$ 10,120.41
$ 19,807.74
$ 19,696.33
Spray
$ 9,736.76
No Spray
$ 9,497.00
$ 19,329.62
$ 19,089.86
Woodill et al
CBB Decision Tree Model
2015 Hilo CBB Summit
Woodill et al
CBB Decision Tree Model
2015 Hilo CBB Summit
Woodill et al
CBB Decision Tree Model
2015 Hilo CBB Summit

Results

Scenario 1



Assumptions :
- **Initial Infestation Rate: 8%**
- Constant Growth Rate: 35%
- *Beauveria* Effective Rate: 50%
- Constant Costs (spraying): $191.83
- Projected Benefit (w/o CBB): $25,050
- 1.67 acres, 7,500 cherry/acre, $2 per lbs.

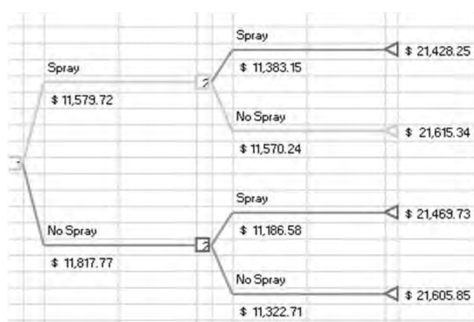
Recommendation:
- Constant spray to minimize infestation
- Constant spray to maximize profits

Projected Net Benefit (w/ CBB) : $12,339.82
Final Infestation Rate : 48.4%

Woodill et al | CBB Decision Tree Model | 2015 Hilo CBB Summit 14

Results

Scenario 2



Assumptions:
- **Initial Infestation Rate: 1%**
- Constant Growth Rate: 35%
- *Beauveria* Effective Rate: 50%
- Constant Costs (Spraying): $191.83
- Projected Benefit (w/o CBB): $25,050
- 1.67 acres, 7,500 cherry/acre, $2 per lbs.

Recommendation:
- Constant spray to minimize infestation rate
- No spray in final period to maximize profits

Projected Net Benefit (w/ CBB) : $21,615.34
Final Infestation Rate : 6%

Woodill et al | CBB Decision Tree Model | 2015 Hilo CBB Summit 15

Conclusion

What the Decision Trees Provide:

- Spray/not spray
- Mapping of decisions
- When to start/stop spraying
- Maximizing net benefits and minimizing infestation rate

Targeted Improvements

- More specific assumptions
- Dynamic cherry pricing based on infestation rate
- Real-time modeling with farm data

Thank you

Questions?

Abstract: Remote Sensing and Spatial Modeling of CBB on Hawai‘i Island

Nicholas C. Manoukis[1], Julie Gaertner[1,2], Christopher Potter[3], Vanessa Brooks-Genovese[3,4], and Raymond Carruthers[5]

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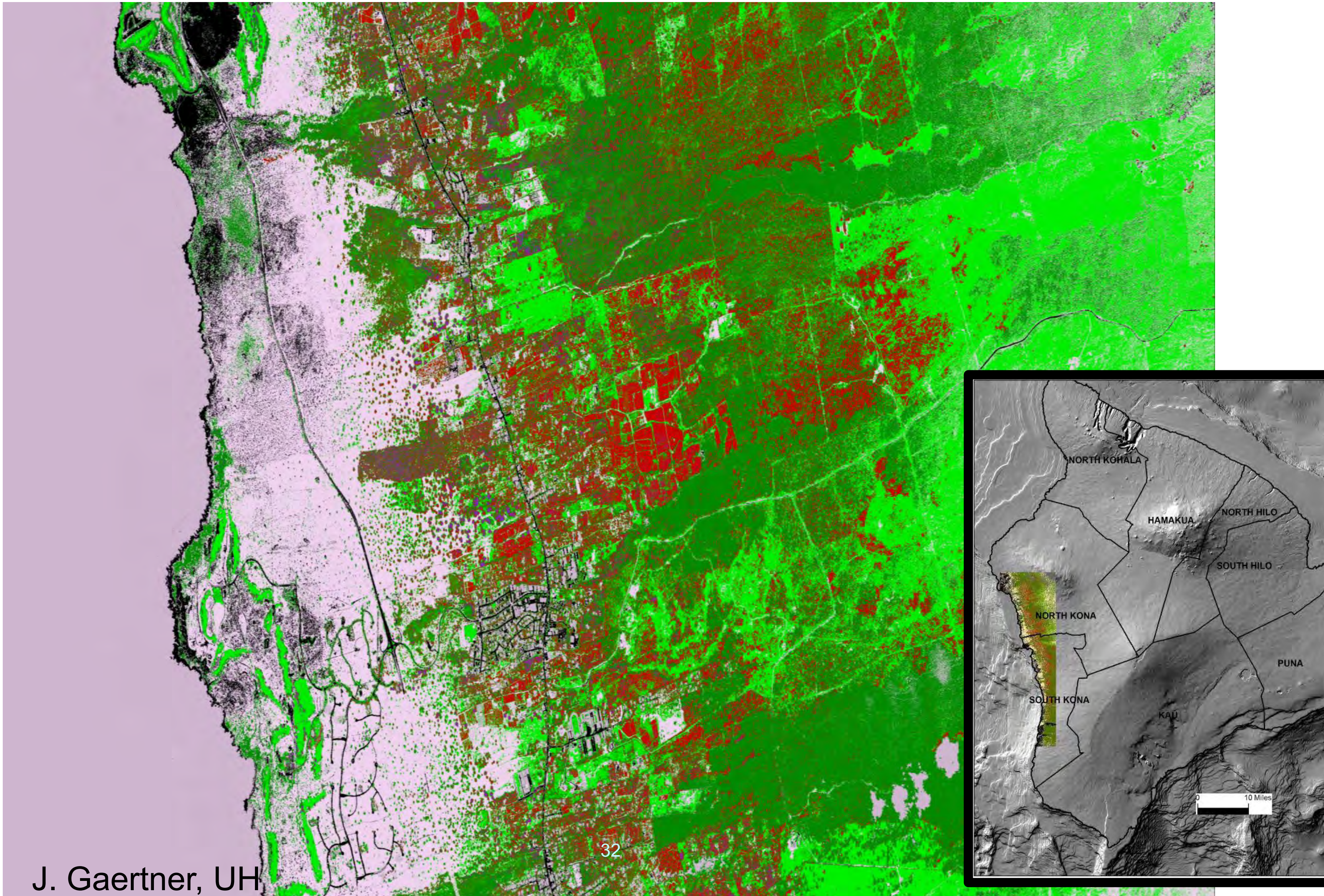
Two modeling tracks are presented: 1) a validated spatial model of coffee agroecosystems on the island, to serve as a broad background against which we can ask general questions (e.g., effect of climate change on coffee berry borer (CBB) distribution) and 2) models of a more limited scope to serve as tools to address specific research and management questions (e.g., effect of reducing flowering windows on CBB density, or questions on the persistence of *Beauveria bassiana* in the field). In addition, progress on remote sensing of coffee plants using Worldview-2 spectral data is presented. Our method currently has a 68% overall accuracy rate using spectral data; we plan to enhance it with object detection analysis. The resulting maps of coffee distribution will be an important input to modeling track 1). Finally, a spatial data viewer is shown that can be used to present modelled output to researchers and growers.

Remote Sensing and Spatial Modeling of CBB on Hawai'i Island

Nicholas C. Manoukis

USDA-ARS Daniel K. Inouye US Pacific Basin Agricultural Research Center

Detecting Coffee Patches in Hawai'i

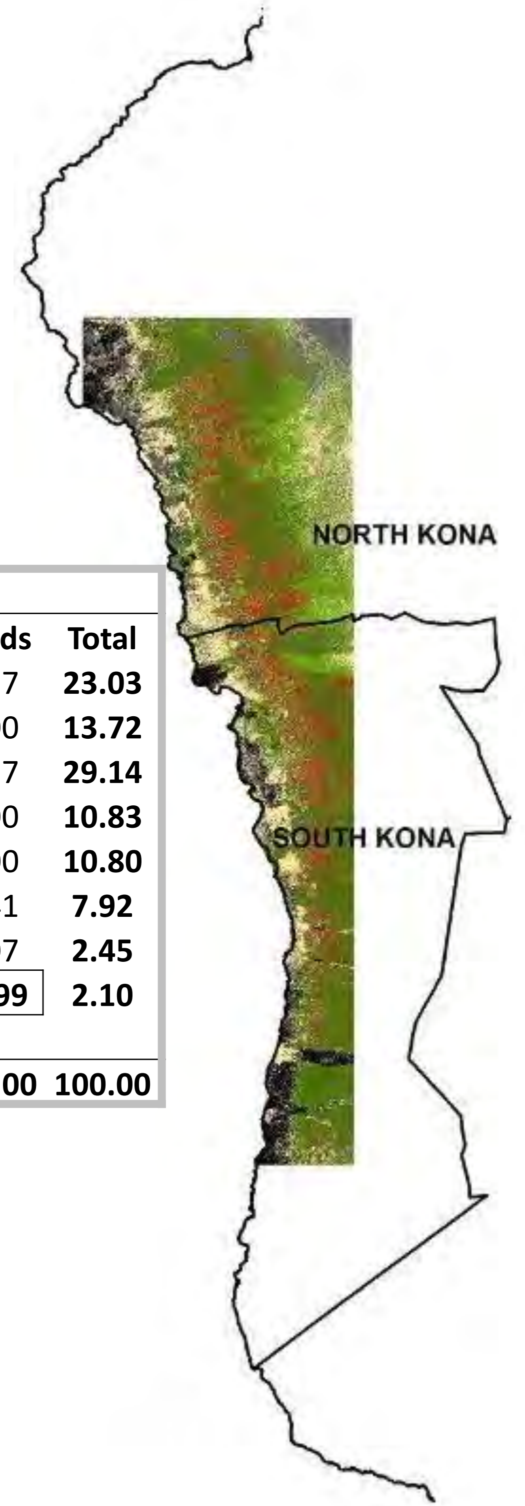


J. Gaertner, UH

Accuracy Assessment

Overall Accuracy %	68.15
Kappa	0.6081

Class	Ground Truth Percent %								
	Coffee	Mcnut	Forest	Grass	Mpod	No Veg	Urban	Roads	Total
Coffee	**71.82**	18.46	7.70	1.06	5.80	0.00	0.00	0.27	**23.03**
Macnut	10.11	**36.39**	5.88	4.41	9.01	0.00	0.00	0.00	**13.72**
Forest	3.38	24.01	**75.82**	12.39	5.80	0.00	0.27	0.27	**29.14**
Grass	7.29	1.35	2.03	**80.60**	0.15	0.67	0.00	0.00	**10.83**
Monkeypod	5.29	19.00	6.95	1.38	**79.24**	0.00	0.00	0.00	**10.80**
No Veg	0.32	0.48	1.32	0.16	0.00	**98.67**	2.69	2.41	**7.92**
Urban	1.79	0.31	0.18	0.00	0.00	0.07	**93.55**	1.07	**2.45**
Roads	0.00	0.00	0.12	0.00	0.00	0.59	3.49	**95.99**	**2.10**
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

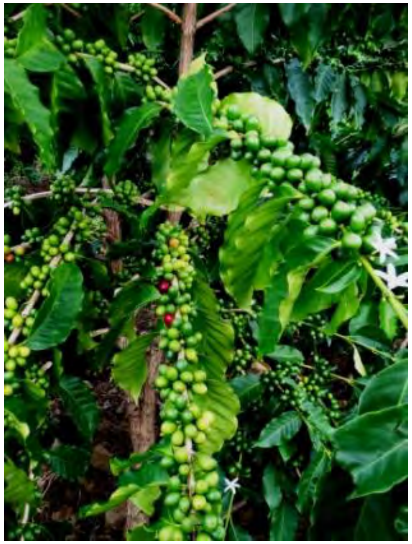


Two Modeling Tracks

1) We are producing a validated spatial model of coffee agroecosystems on the island. We would like this to serve as a broad background that will allow us to ask general questions.
2) We are developing models of a more limited scope to serve as tools to address specific research and management questions.

Model Components

- Coffee plants
- CBB populations
- Pathogens/parasites
- Other?
- Critical inputs:
  - Temperature
  - Solar irradiation
  - Rainfall
  - Management



J. Gaertner

Acuna et al., PNAS (2011)

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Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

A coffee agroecosystem model: I. Growth and development of the coffee plant

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ABSTRACT

This paper is the first of three on the coffee production system consisting of (1) the coffee plant, (2) coffee berry borer (CBB) and (3) the role of CBB parasitoids. A previous simulation model of the coffee plant was developed using data from Brazil where coffee phenology is characterized by distinct seasonal flowering (Gutierrez et al., 1998). In contrast, flowering in Colombia is continuous with low seasonality. To capture the differences in coffee phenology and growth in the two climatic regions, the Gutierrez et al. (1998) model was modified using new data from Colombia.

The modifications to the model include:

(1) The effect of solar radiation on floral buds initiation;
(2) An age structure population model to track the daily input and development of the floral buds;
(3) The effect of leaf water potential on breaking dormancy in flower buds, and hence on the timing and intensity of flowering;
(4) The incorporation of both the vegetative and the reproductive demands to predict the photosynthetic rate.
(5) The effect of low temperature on photosynthesis and defoliation.

Other aspects of the model were re-interpreted and refinements made to generalize its structure for use across coffee varieties and geographic areas. The model, without modification, realistically simulates field data from Brazil and two Colombian locations having different varieties, patterns of rainfall and hence flowering phenology.

The model will be used as the base trophic level for incorporating CBB and high tropic levels effects, and for the analysis of management options in the coffee production system.

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Contents lists available at SciVerse ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

A coffee agroecosystem model: II. Dynamics of coffee berry borer

Daniel Rodríguez[a], José Ricardo Cure[a], Andrew Paul Gutierrez[b,*], José Miguel Cotes[c], Fernando Cantor[a]

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Metabolic pool

ABSTRACT

This paper is the second of three on the coffee production system consisting of (1) the coffee growth and development, (2) coffee/coffee berry borer (CBB) dynamics, and (3) the role of the CBB parasitoids and complementary strategies for control of CBB. The CBB model is based on a prior model by Gutierrez et al. (1998) with the following modifications:

Refinements of the CBB model were made and the model linked to a revised plant model for coffee (Rodríguez et al., 2011). Several mortality factors for CBB and the effect of intraspecific competition were estimated and their importance evaluated.

CBB parameters were updated based on recent literature and field observations.

The effects of temperature and rainfall on the emergence of CBB adults were added.

A nonlinear rate of development function was used to calculate daily degree-days to estimate accurately the effects of temperature extremes on CBB development.

New field data from Colombia were used to test coffee fruiting phenology and the effect on CBB attack rates and age-structure population dynamics.

CBB preferences for the coffee berry stages were estimated for *cv.* Colombia.

1. Introduction

Coffee (*Coffea arabica* L.) is the main cash crop in many developing countries in the tropics (Duque and Baker, 2003). Approximately 10 million ha of coffee are planted in 80 countries

producing countries (State of Hawaii-Department of Agriculture, 2010).

CBB damage to coffee occurs when adult females colonize the berries for feeding and reproduction, with the costs of control being about 10% of production costs (Baker, 1999). The

Plant Model Components

Light interception & photosynthesis per branch and per plant

Effects of temperature

Water and nitrogen acquisition

Photosynthate allocation

Fruiting phenology and dynamics

Insect Model Components

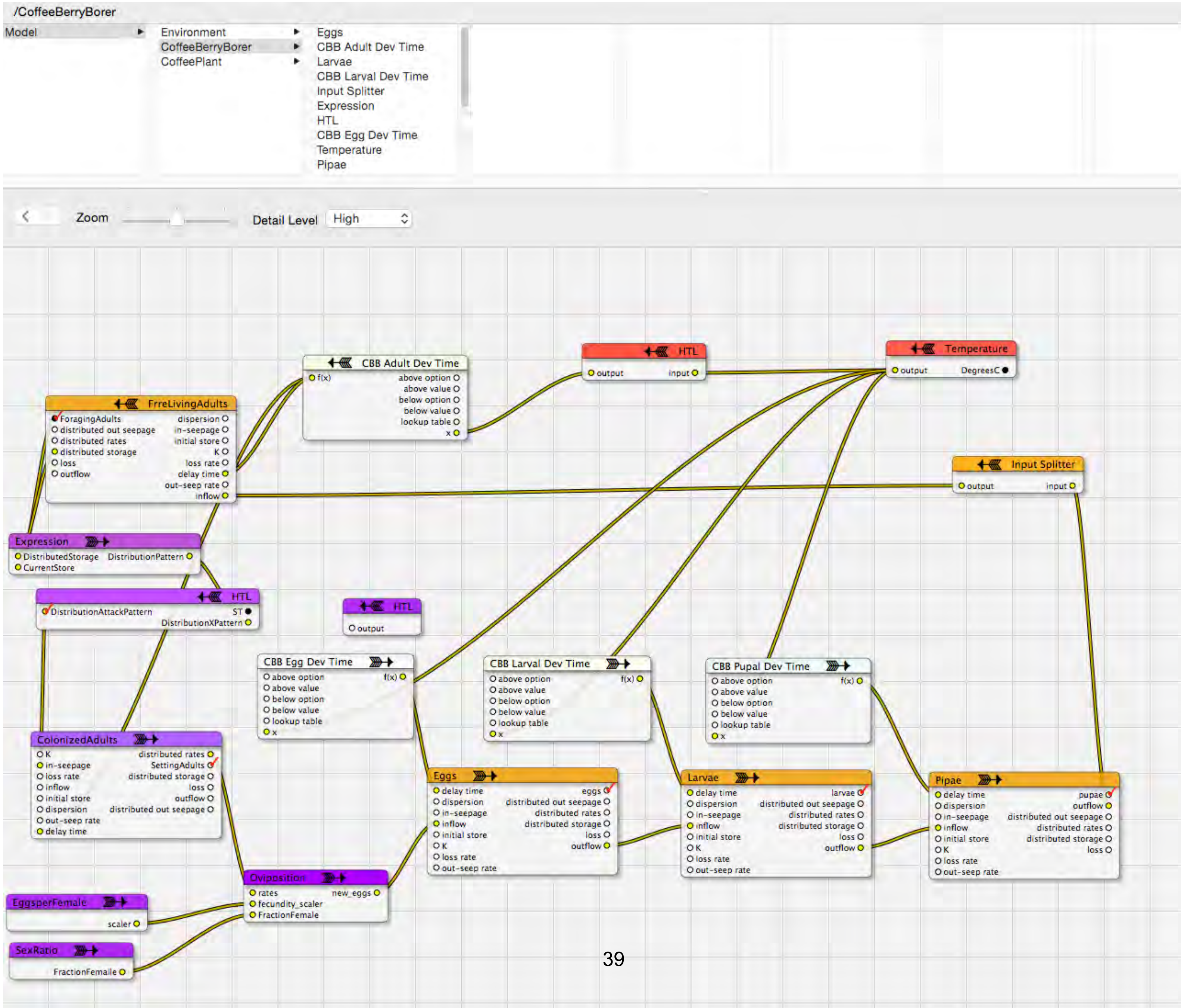
Development

Reproduction and mortality

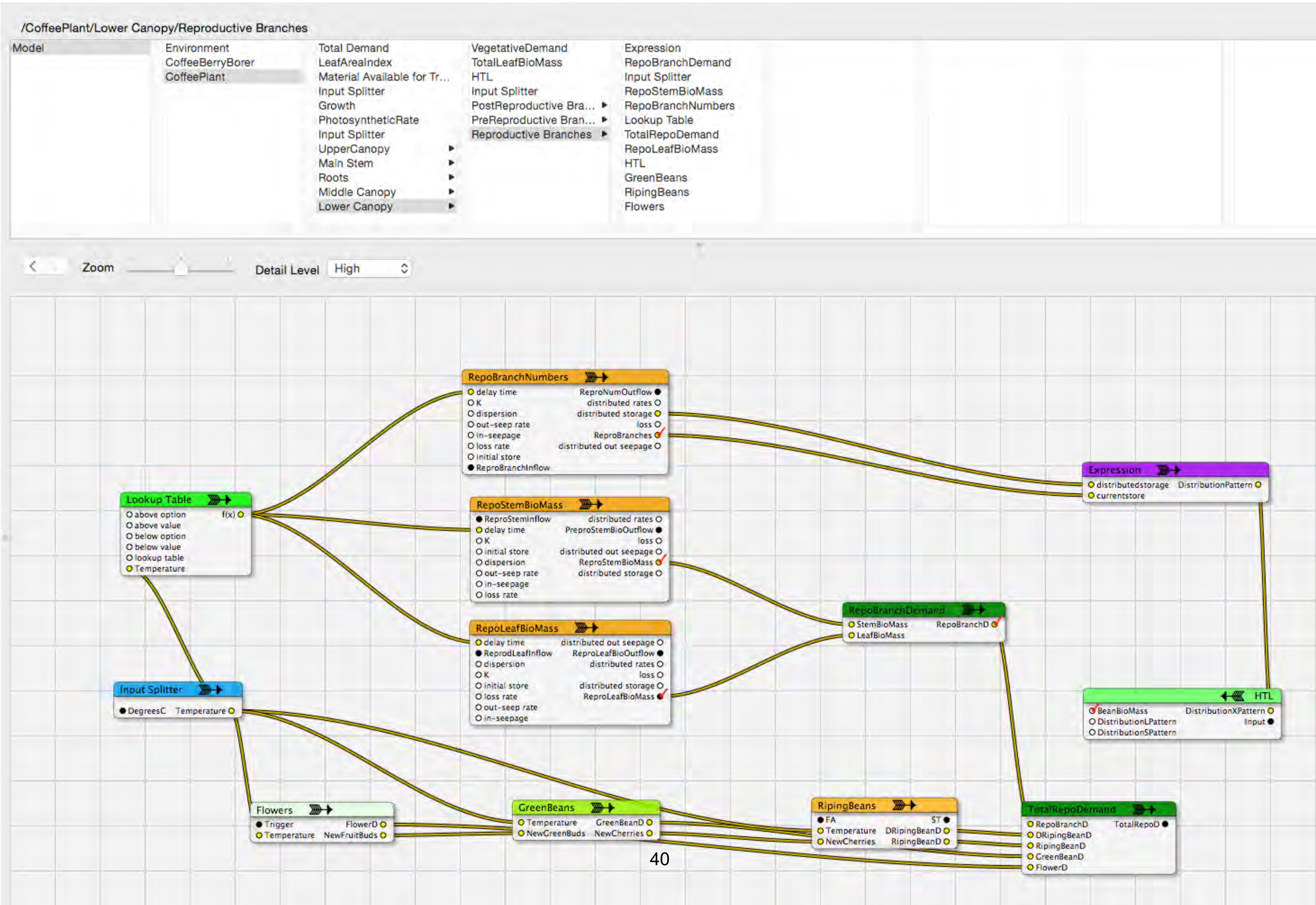
Migration and emigration

Disease/Management

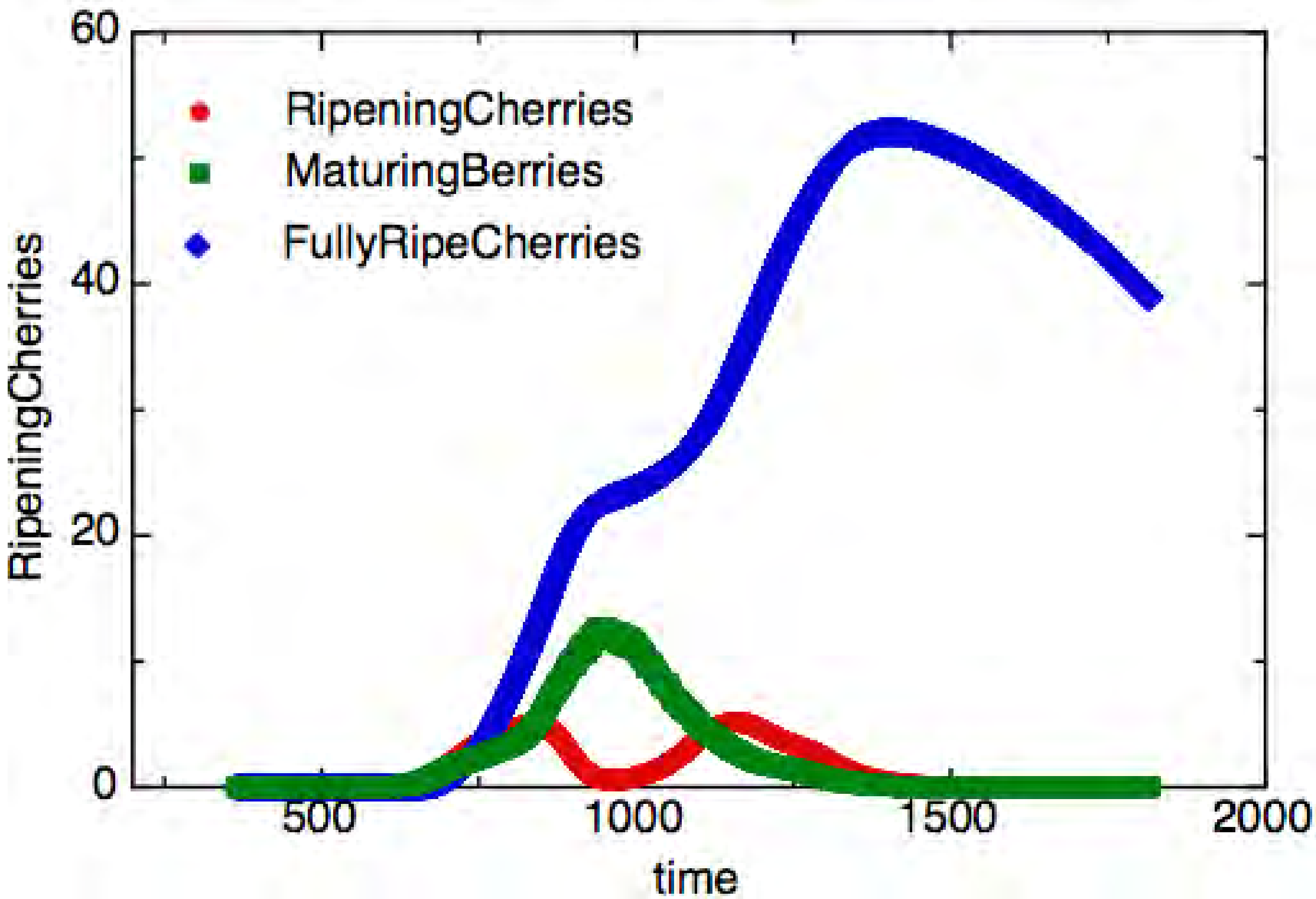
Model Construction (Hermes)



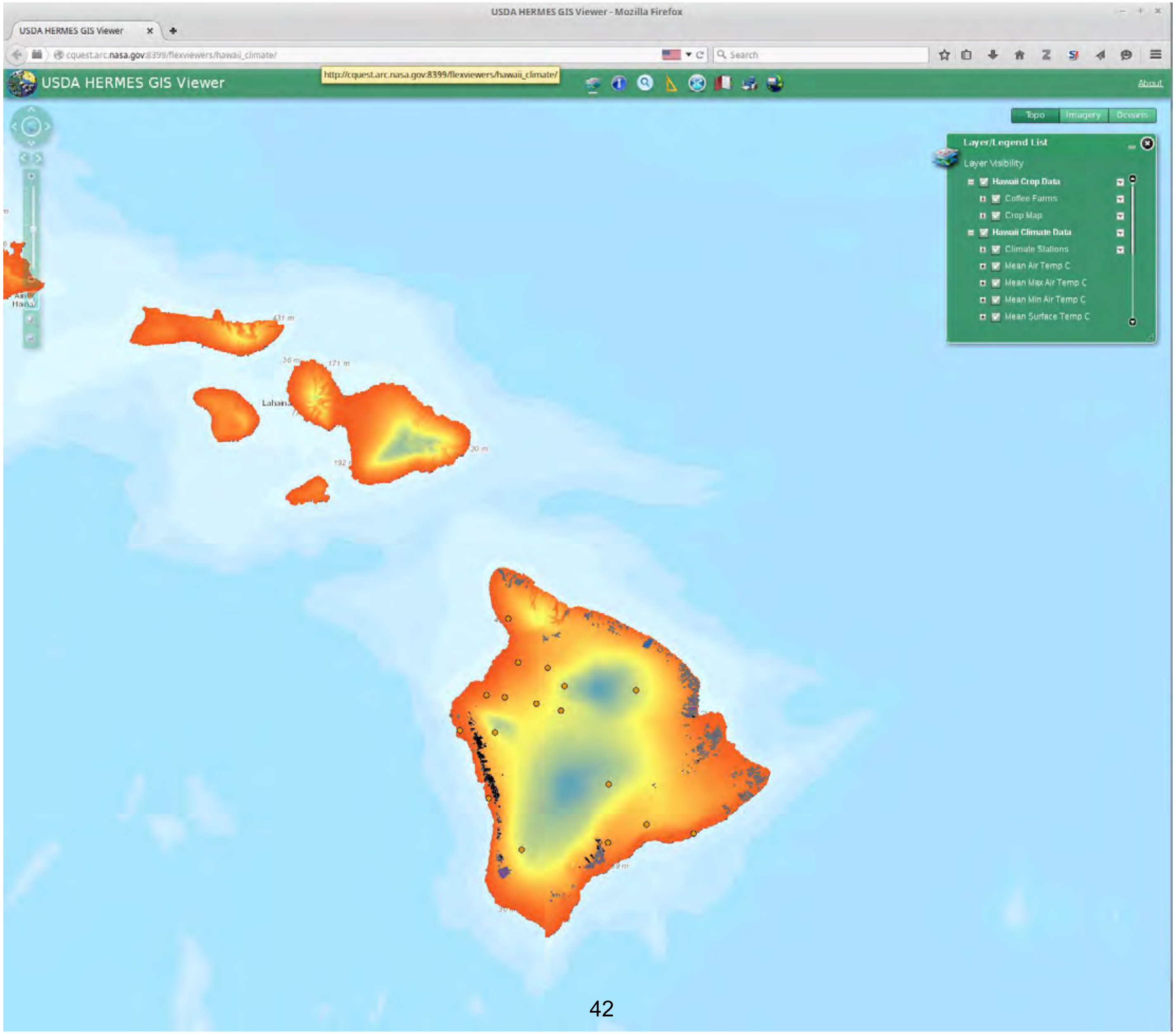
Model Construction (Hermes)



Quick Results



Model Interaction (Viewer)



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CBB Modeling Group

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Dave Bubenheim, NASA
Vanessa Genovese, CSUSB
Timothy Larkin, Cornell University

Andrea Kawabata, CTAHR, UH
Kelvin Sewake, CTAHR, UH
Julie Gaertner, CTAHR, UH/USDA-ARS
Lisa Keith, USDA-ARS

Abstract: Sampling and Spatial Distribution of Coffee Berry Borer in Coffee Orchards in Hawai'i Island

Ishakh Pulakkatu-thodi, Rosemary Gutierrez, and Mark G. Wright
Department of Plant and Environmental Protection Sciences, University of Hawai'i at Mānoa,
College of Tropical Agriculture and Human Resources, Honolulu, HI 96822

Coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae) is the most damaging insect pest of coffee worldwide. The pest was first detected in Kona District of Big Island in Hawai'i in 2010 and subsequently spread to O'ahu in 2014. The damage by the beetle is readily identifiable by the presence of a bore-hole at the floral end of a developing berry. Sampling coffee berries for monitoring the pest and estimation of the damage is an integral part of coffee berry borer management. Three methods of sampling—1) counting all berries on a single branch from a tree, 2) counting berries from five nodes from five different branches of a tree, or 3) counting berries from three nodes from three different branches of a tree—were compared to find a less rigorous sampling method.

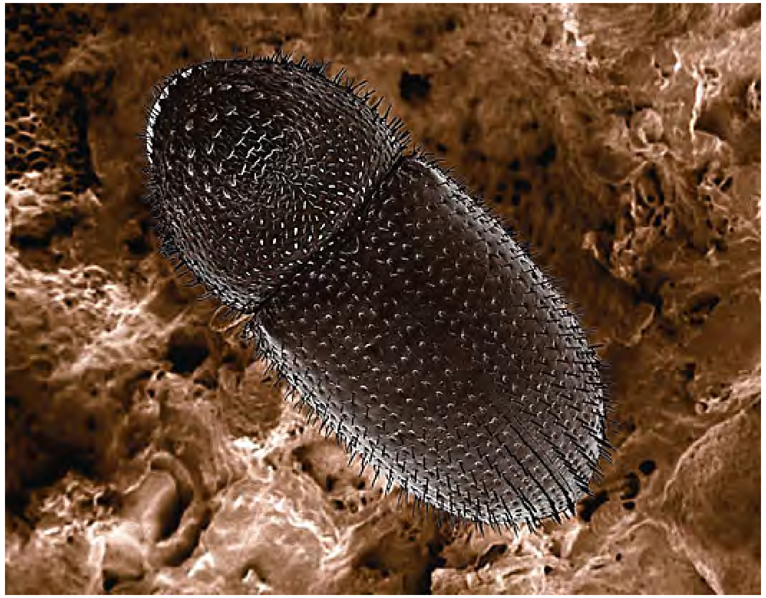
The study was conducted during the 2014 growing season in four fields from two locations. Two sets of data were collected from each field, separated by a two-week interval between sets of observations. Damage estimated using these three methods was statistically similar. On average, 10 to 13 berries were present on a node and about 50 to 90 berries were present per branch; therefore, sampling only 3 nodes per tree requires counting significantly fewer berries to determine infestation levels. We also sampled coffee berries from geo-referenced sampling grids in four fields from Kona and Kā'ū districts to understand the spatial behavior of the pest. The size of the fields varied from 2 to 3 hectares (5 to 7.5 acres). Taylor's Power Law (TPL) coefficients and spatial statistical tools were used to describe the spatial pattern of infestation. TPL coeffient '*b*' ranged from 1.02 to 1.42, an indication of the aggregated nature of infestation. Analysis by spatial statistical tools showed statistically significant aggregation in one field and random patterns in other fields.

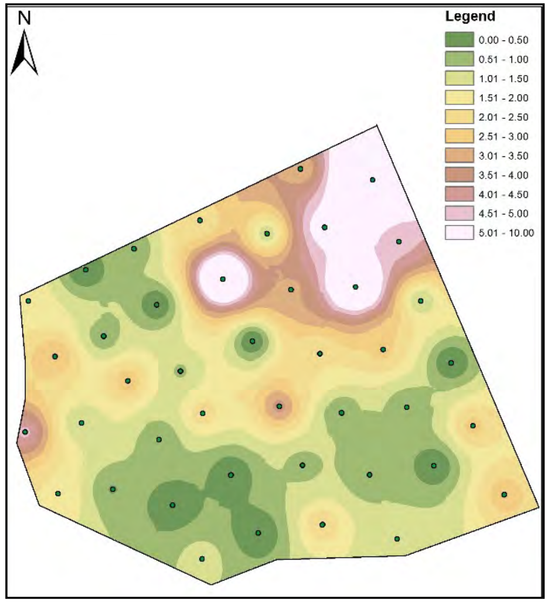
A considerable amount of variability in infestation was observed among three fields located adjacent to each other, suggesting differences in management practices by different owners. The range of mean infestation was between 2.15% and 33.19% among fields. TPL coefficients were also used to estimate minimum number of berries to be counted from a field to estimate infestation using "fixed precision sequential sampling." Preliminary analysis indicates that sampling 30 trees in a field requires counting about 600 berries to estimate the damage with 95% accuracy. These studies are being repeated in 2015 growing season.

Research Updates on

Coffee Berry Borer, *Hypothenemus hampei* (Ferrari)

Ishakh Pulakkatu-thodi, Rosemary Gutierrez, and Mark Wright
PEPS-CTAHR, University of Hawai'i Mānoa





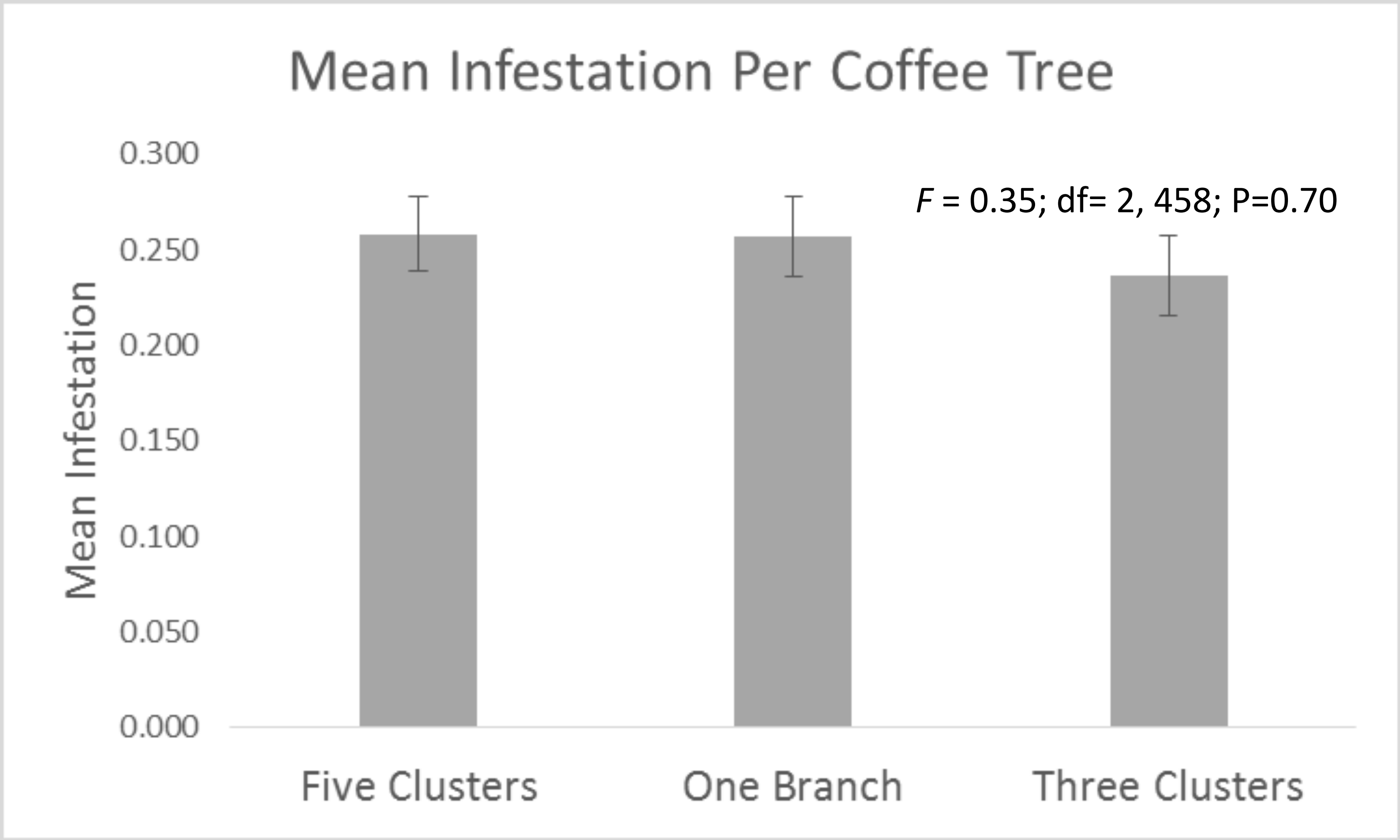
Primary Research Interests

- Sampling
  - How to sample
  - Where to sample
  - How much to sample
- Spatio-temporal distribution of CBB/damage within individual farms
  - Implications of sampling and management
- Alternative approaches
  - Effect of a terpene-based repellent on CBB infestation
- Population dynamics in relation to coffee phenology

Sampling

- Sampling possible at different levels
  - Tree: How many trees are infested?
  - Branch: How many branches per tree are infested?
  - Node: How many clusters (nodes) are infested?
  - Berry: How many berries are infested?
- Thirty Trees sampling method – recommended

Comparison of Different Sampling Methods



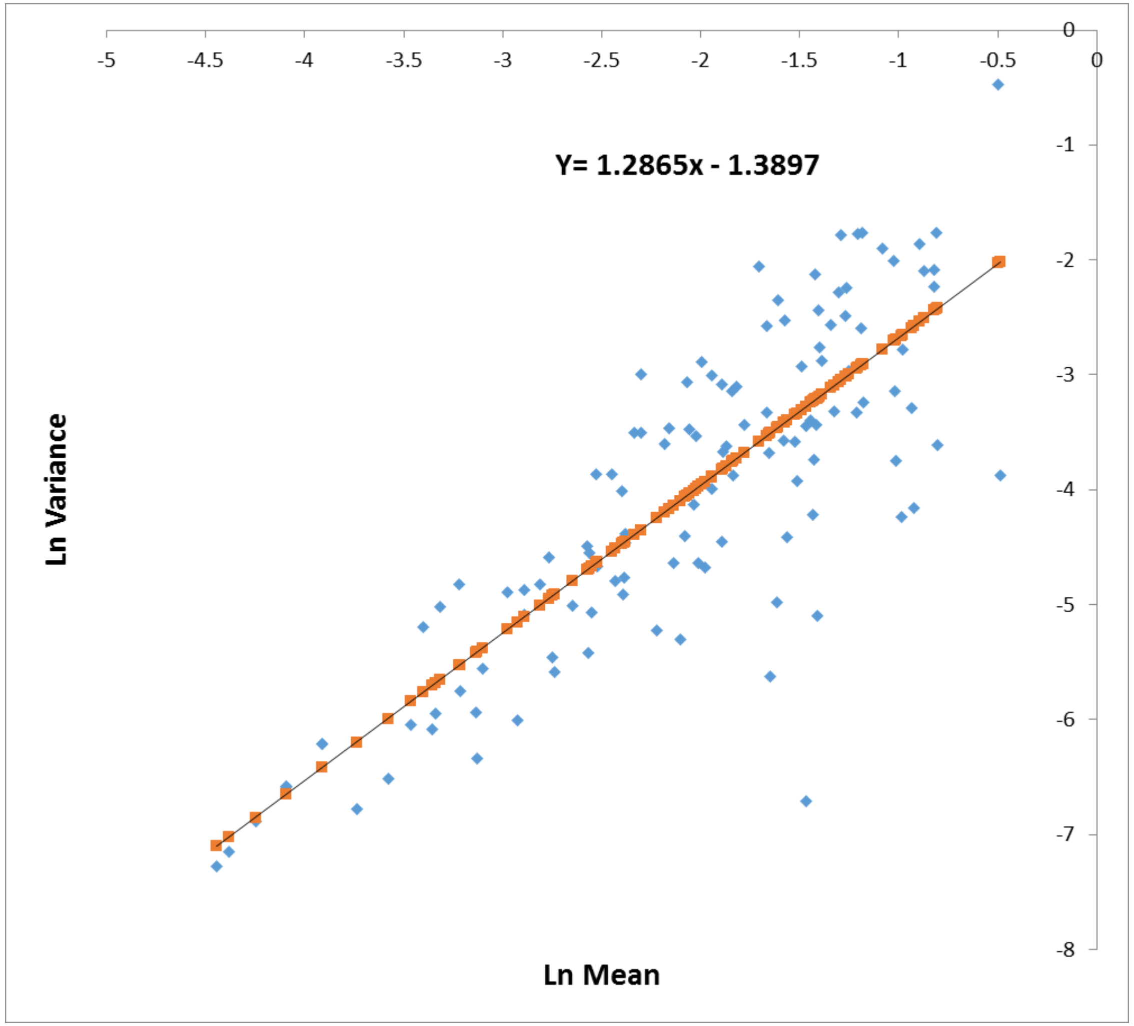
Berries/node: 10 to 13

Berries/branch: 50 to 90

Comparison of Different Sampling Methods

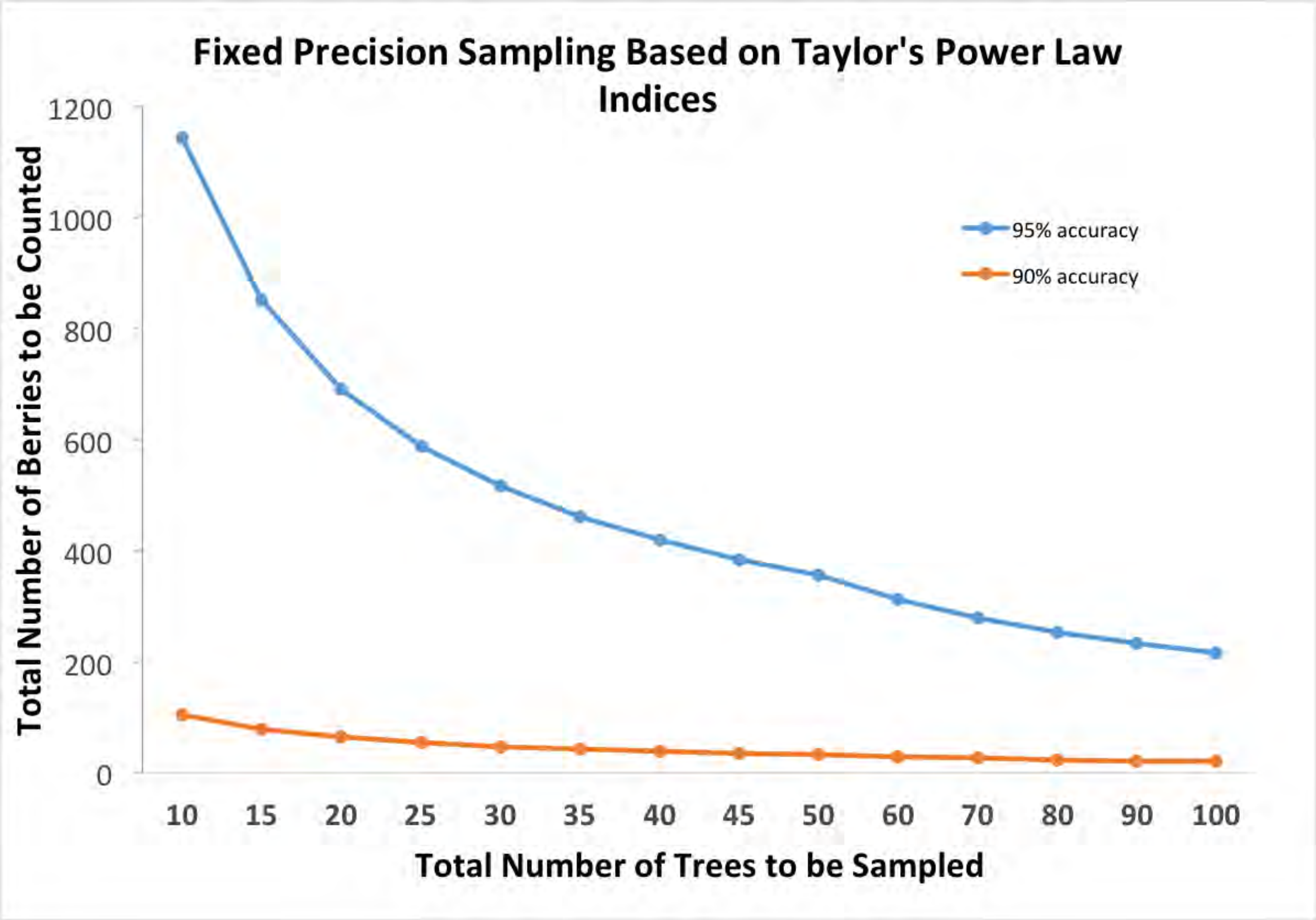
Field Name	Method of Sampling	N Obs	Mean	Std Error
Elizabeth	Five Clusters	40	0.023	0.004
	One Branch	40	0.015	0.004
	Three Clusters	40	0.026	0.006
John	Five Clusters	40	0.379	0.037
	One Branch	40	0.409	0.037
	Three Clusters	40	0.339	0.039
Nicky	Five Clusters	40	0.141	0.020
	One Branch	40	0.110	0.011
	Three Clusters	40	0.094	0.015
Valley	Five Clusters	40	0.488	0.028
	One Branch	40	0.492	0.041
	Three Clusters	40	0.485	0.040

Fixed Precision Sequential Sampling



Taylor's Power Law: $\ln S^2 = \log a + b \ln (m)$

Field	ln a	b
Elizabeth	-0.94	1.42
Heavenly	-0.63	1.48
Glory	-1.53	1.29
Young	-1.94	1.02
Zexto	-1.39	1.28



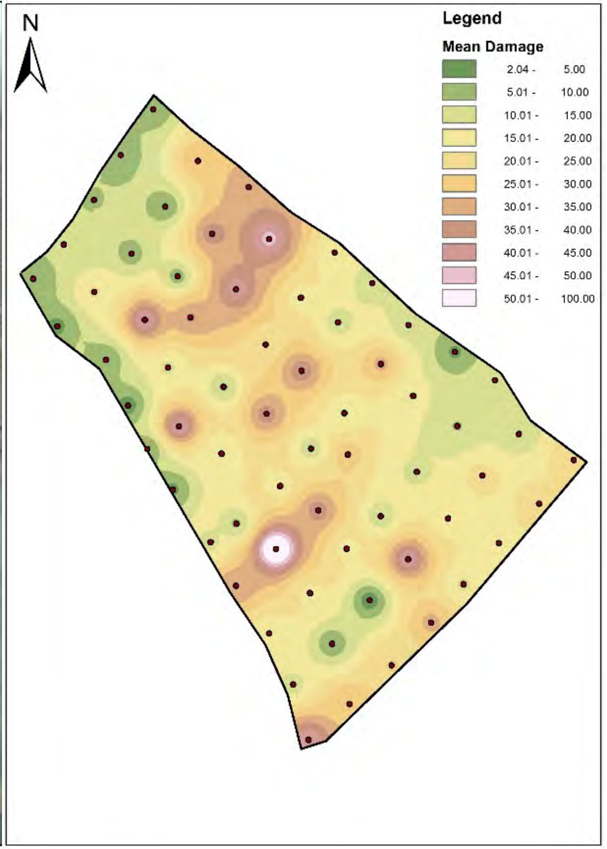
Fixed Precision Sampling Based on Taylor's Power Law Indices
Total Number of Berries to be Counted
1200
1000
800
600
400
200
0
95% accuracy
90% accuracy
10
15
20
25
30
35
40
45
50
60
70
80
90
100
Total Number of Trees to be Sampled

Spatial Distribution of CBB Infestation

Spatial Distribution of CBB Infestation

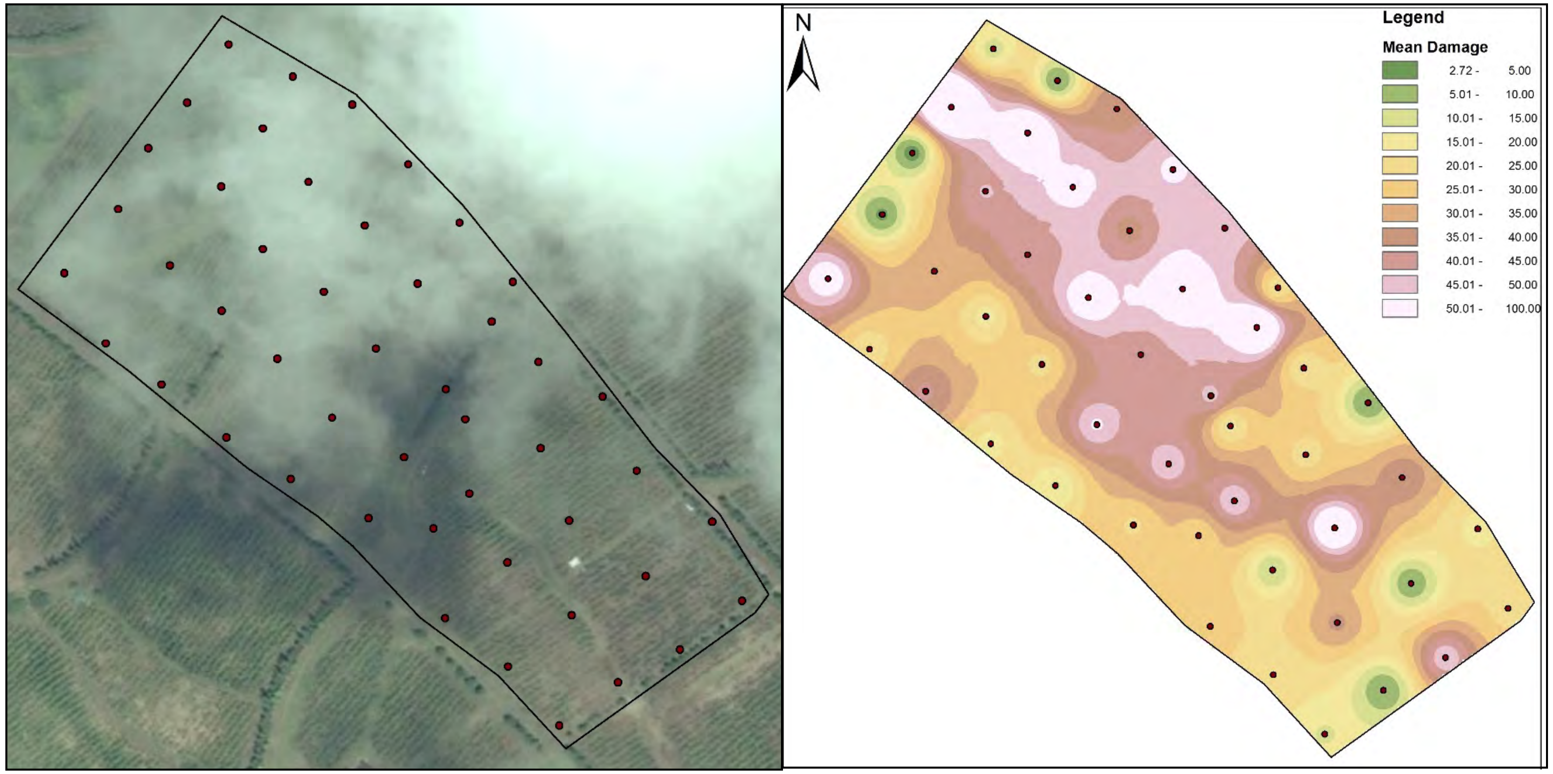
Count:	42
Minimum:	0
Maximum:	10.96
Mean:	2.15

Spatial Distribution of CBB Infestation



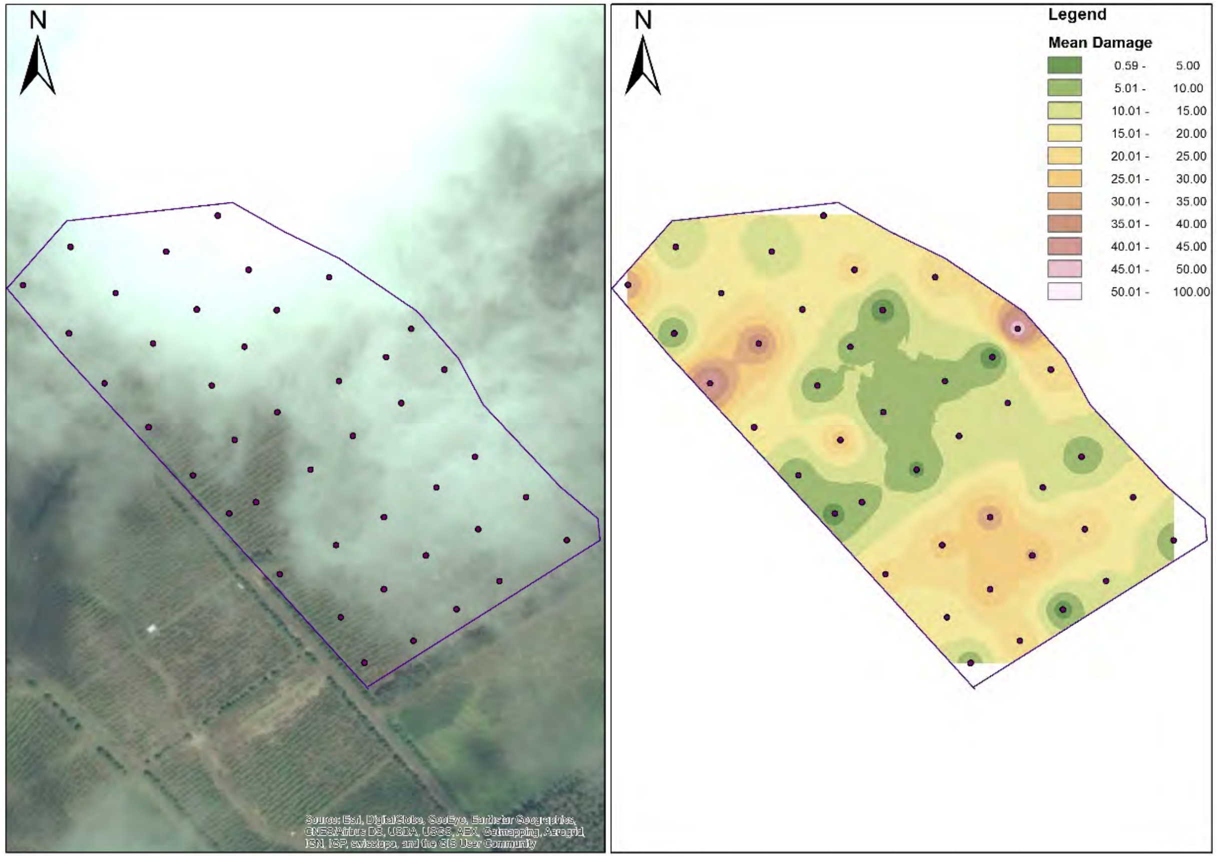
Count:	67
Minimum:	2.03
Maximum:	64.84
Mean:	19.95

Spatial Distribution of CBB Infestation



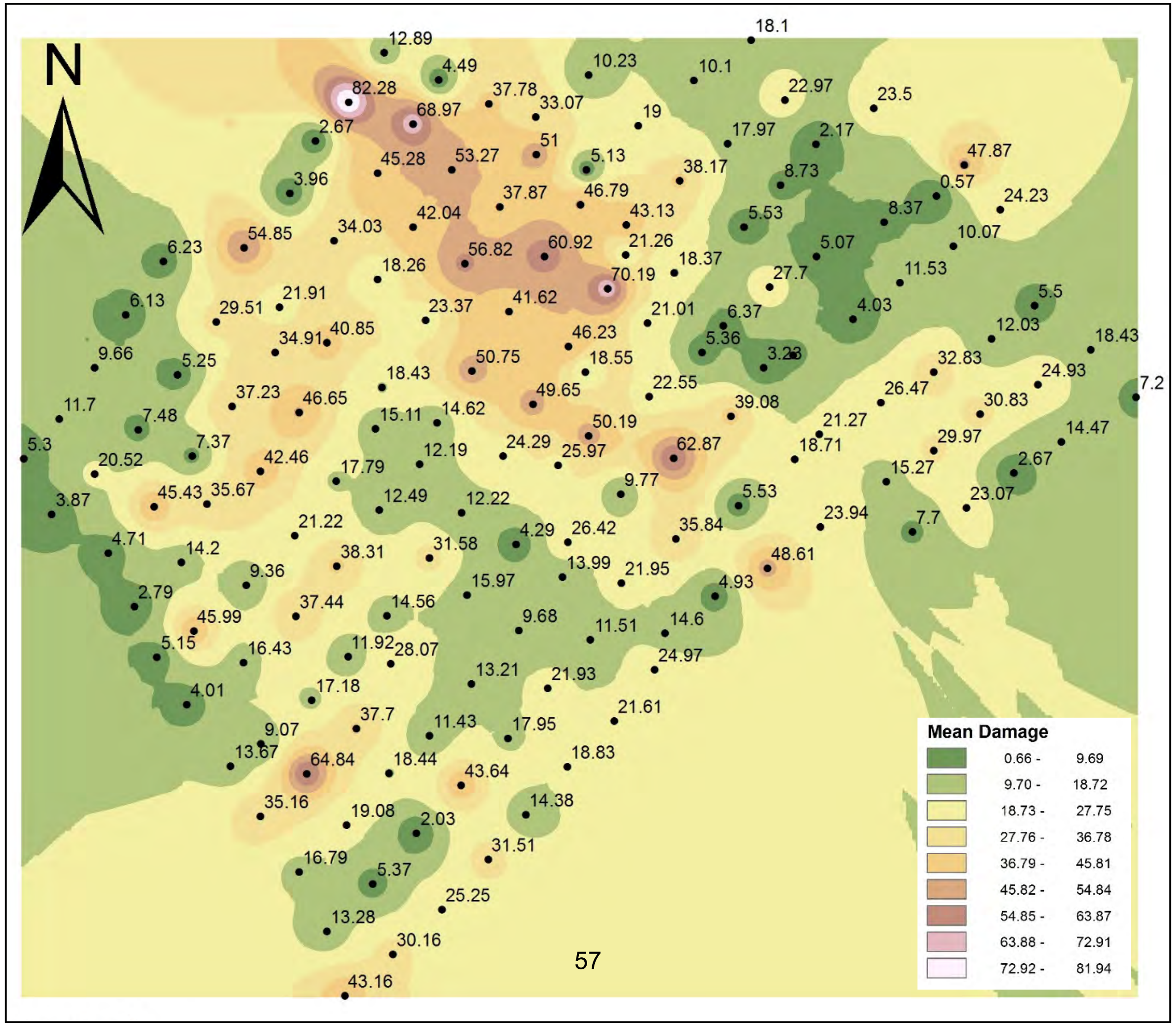
Count:	48
Minimum:	2.67
Maximum:	82.27
Mean:	33.19

Spatial Distribution of CBB Infestation



Count:	42
Minimum:	0.56
Maximum:	47.97
Mean:	16.82

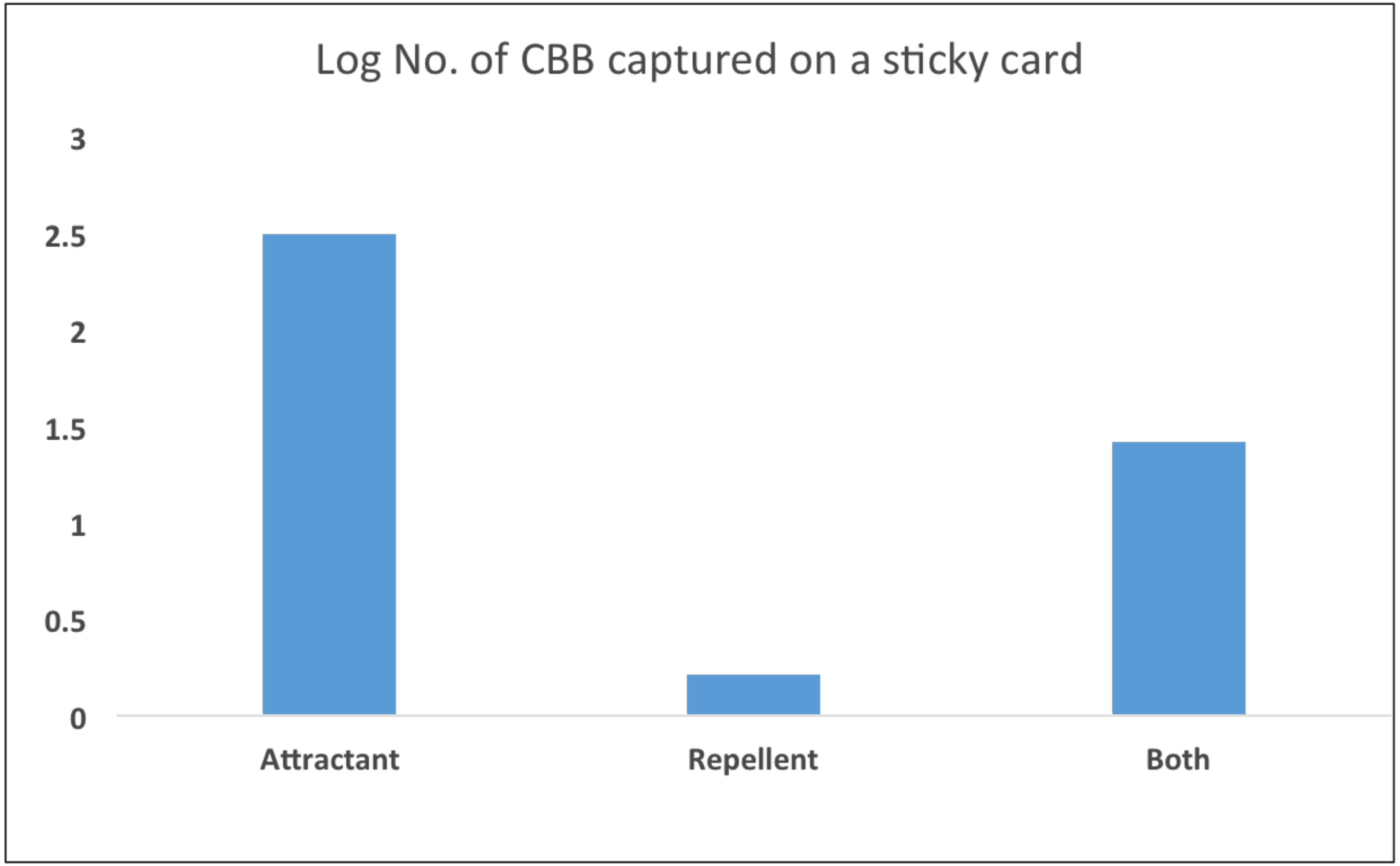
CBB Infestation in Adjacent Fields



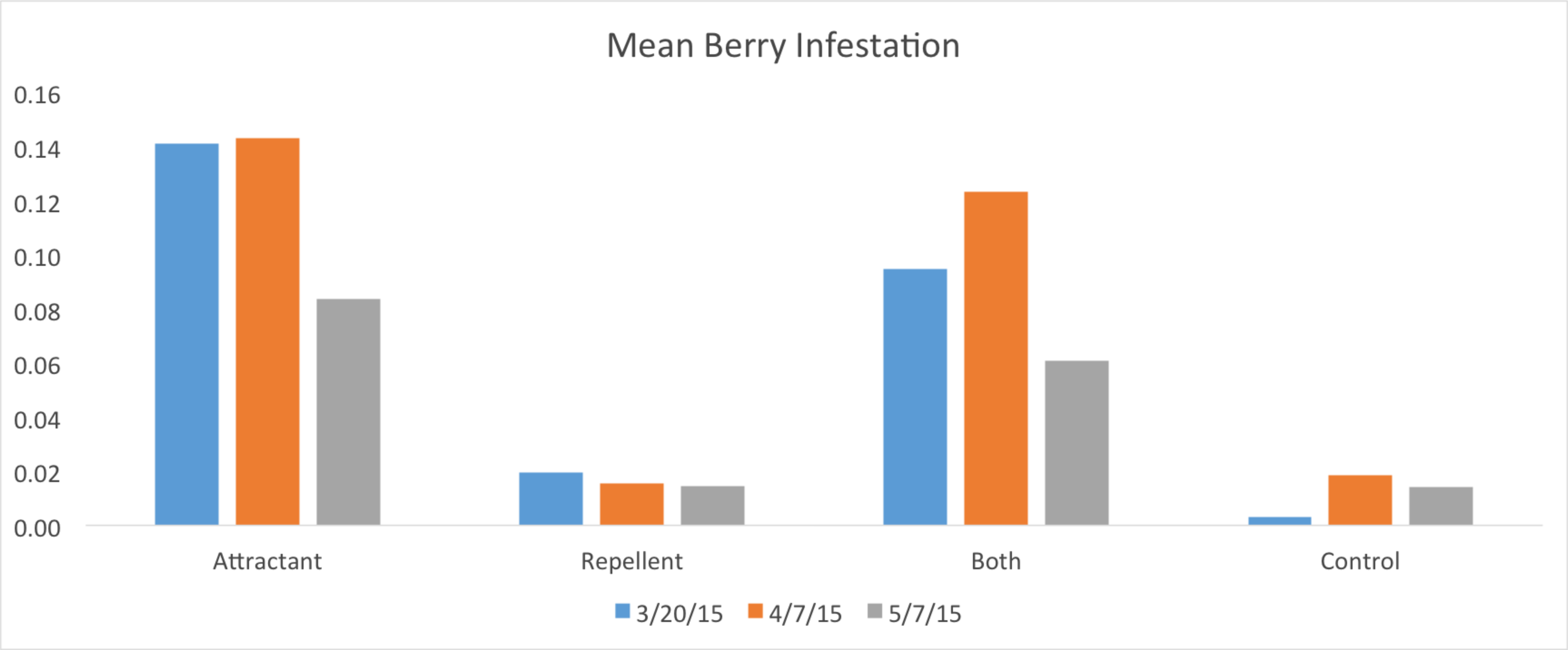
Effect of Terpene-Based Repellent




Effect of Terpene-Based Repellent



Effect of Terpene-Based Repellent



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Verna Dacalio
Heavenly Hawaiian Coffee
Valley Young
Gloria

Abstract: Persistence & Efficacy of *Beauveria bassiana* Strain GHA

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United States Department of Agriculture Agricultural Research Service,
Daniel K. Inouye Pacific Basin Agricultural Research Center, Hilo, HI 96720

Beauveria bassiana is the most important natural enemy of CBB. Although research with this fungal pathogen has been carried out in other countries, results are variable due to differences among strains of *B. bassiana* and environmental conditions. Research was needed to optimize the use of this entomopathogen for the Kona coffee-growing region of Hawaiʻi. Our goal is to determine how timing and frequency of commercial *Beauveria* applications effect persistence and efficacy to ultimately develop one component of an environmentally friendly and economically viable CBB management strategy for Hawaiʻi-grown coffee.

Beginning approximately 30 days after flowering and continuing until the final harvest, treated plots received applications of BotaniGard® ES applied by participating farmers. Three different types of samples were collected from each plot: (1) coffee berries for determining viability and persistence of *Beauveria* GHA spores, (2) infested coffee berries used for dissections for measuring *Beauveria* infection rates and (3) field counts of CBB-infested and uninfested coffee berries to monitor infestation levels. Certain conclusions could be made from the initial field persistence studies conducted in 2011/2012: 1) the commercial strain persisted longer in the fields in Kona, HI than expected (ie. GHA detected 22 days post spray, 2) a 1-2 log GHA decrease was observed within the first week after sprays, and 3) a cumulative effect was observed after additional sprays. By correlating densities of viable spores with percentages of fungus-killed beetles, we were able to deduce that spore densities somewhere between ~100 to 1000 spores/ml were probably not sufficient to maintain high infection levels given the environmental conditions of our study. Further field studies utilized this information to improve spray regimes.

Over the past three years, field trials for persistence and efficacy of BotaniGard® ES have been conducted for 2 seasons (years) at 6 different geographical locations varying in elevation (450 ft. to 1869 ft., including one field intercropped with macadamia). Spray regimes included early-season intensive sprays (3 weeks in a row), spraying once a month versus twice a month, and comparison of early-morning sprays versus late-afternoon sprays. More recently, strip-pick sanitation has been incorporated with the various spray regimes and will be evaluated to determine if sanitation is a critical component of the IPM strategy and if fewer sprays could be applied. Results indicated that a once-monthly late-afternoon spray regime provided good control of CBB resulting in reduced levels of infestation. This is currently the accepted management practice recommended by University of Hawaiʻi Extension and adopted by the majority of farmers in Kona.

The persistence and efficacy data and environmental data that have been collected from all field study locations, such as temperature, % relative humidity, UV, leaf wetness, and rainfall, will be used to improve CBB management and to strengthen the prediction model Dr. Manoukis is developing. Overall environmental, persistence, and efficacy results indicate that each location is unique, making it difficult to recommend a “one-size-fits-all” spray regime. Therefore, farmers should visually monitor their fields and spray when necessary.

Persistence & Efficacy of *Beauveria bassiana* Strain GHA

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CBB Summit 2015

Goals for 2014

- Determine how timing and frequency of commercial *Beauveria* applications effect persistence and efficacy.

- Strip-pick.

BioWorks

- Compare 2014 to 2013.

<u>Elevation</u>:
A. 1869 ft
B. 1547 ft
C. 624 ft (shade)

Coffee Data

- Field plot maps/strip-pick
- Persistence: *Beauveria* GHA
- Efficacy (destructive method)
  - % AB, % AB dead, % CD, % infestation
- Efficacy (non-destructive method)
  - % infestation, % *Beauveria*
- Environmental
  - Temp, % RH, leaf moisture, rainfall, UV
- Quality/Harvest

2014 Spray Schedule

Rate = 1 qt/100 gal

Spray late afternoon/
early evening

Once/month spray (#1)
Twice/month spray (#2)
Strip-pick + once/month spray (#3)

1st *Beauveria* spray
2013
Honaunau Low: 4/8
Honaunau High: 5/6
2014
Honaunau Low: 5/19
Honaunau High: 3/10

Sampling occurs before and after *Beauveria* sprays

.ŜI-dzØŜNJI-	Honaunau Low			Honaunau High			S
spray dates	#1	#2	#3	#1	#2	#3	#1
3/10/14				✓	✓	✓	
3/17/14				✓	✓	✓	3/20
3/24/14				✓	✓	✓	
4/7/14					✓		
4/21/14				✓	✓	✓	4/24
5/5/14					✓		
5/19/14	5/12	5/12	5/13	✓	✓	✓	
6/2/14					✓		6/1
6/16/14				✓	✓	✓	
6/30/14					✓		
7/14/14				✓	✓	✓	7/4
7/28/14	7/29	7/29	7/29		✓		
8/11/14				✓	✓	✓	8/4
8/25/14					✓		
9/8/14				✓	✓	✓	9/16
9/22/14	X	X	X		✓		
10/6/14				✓	✓	✓	10/9
10/20/14					✓		
11/3/14				✓	✓	✓	
11/17/14					✓		
12/1/14				✓	✓	✓	
12/15/14					✓		
12/22/15				✓	✓	✓	
12/29/15					✓		
1/5/15				✓	✓	✓	
Total sprays:	3	3	3	14	25	14	7
Total sprays:	9	15		11	19		

Data: Stripped

Honaunau Low

Stripped 2/20/14

14,619 sq ft; 13 people, 2 hours

weight (g)

	Hole	No-Hole	Unsorted	Total	**% Infested**
Raisin	-	-	1424.4	1424.4	
Red	736.9	61.4	-	798.3	92.3
Green	1424.4	3036.2	-	4460.6	31.9

6683.3 g

14.7 lb

Honaunau High

Stripped 3/7/14

8,404 sq ft; 8 people, 6 hours

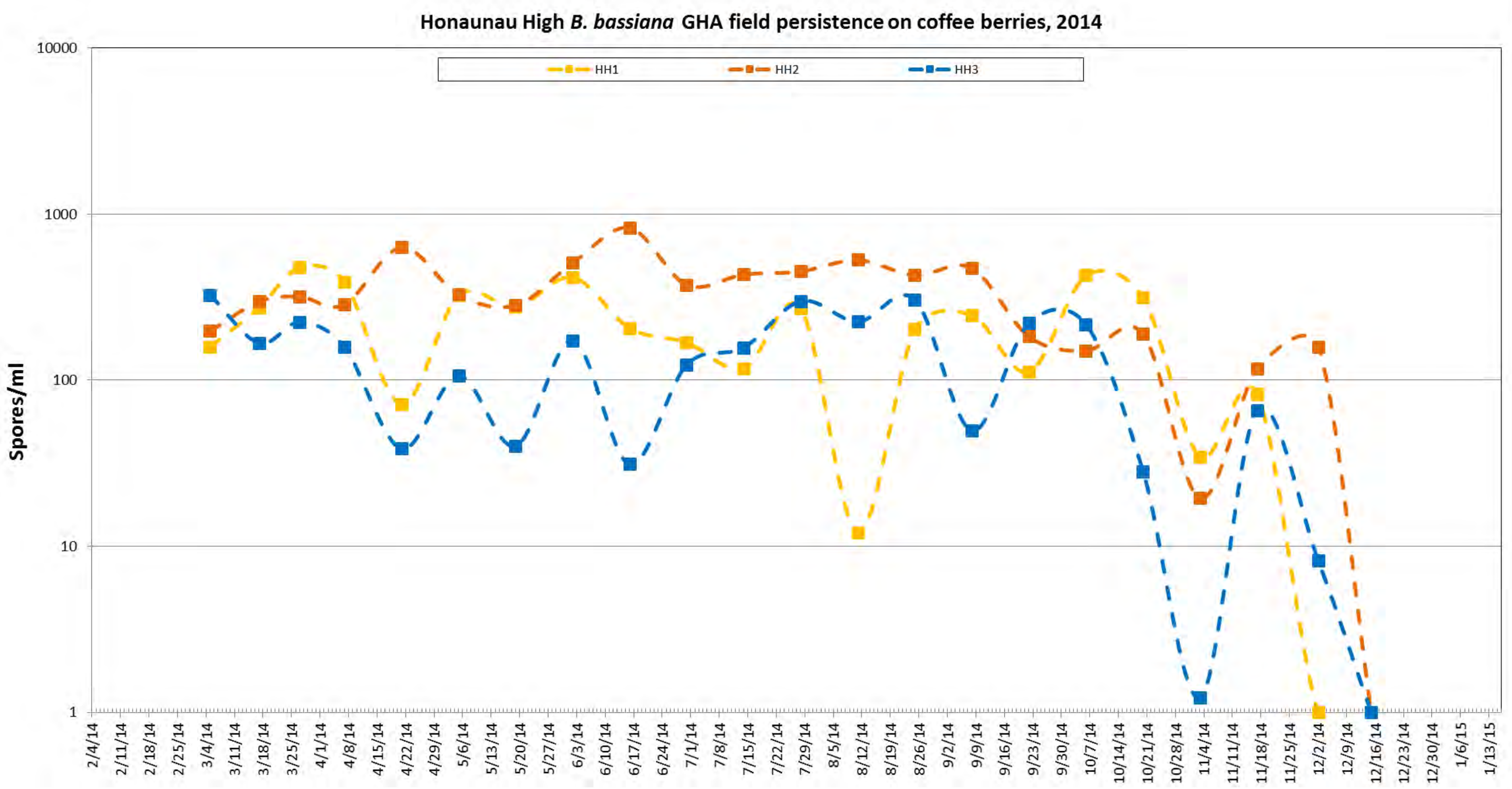
weight (g)

	Hole	No-Hole	Unsorted	Total	**% Infested**
Raisin	-	-	70.8	70.8	
Red	3008.7	1275.6	-	4284.3	70.2
Green	2907.6	4950.7	-	7858.3	37.0

12213.4 g

26.9 lb

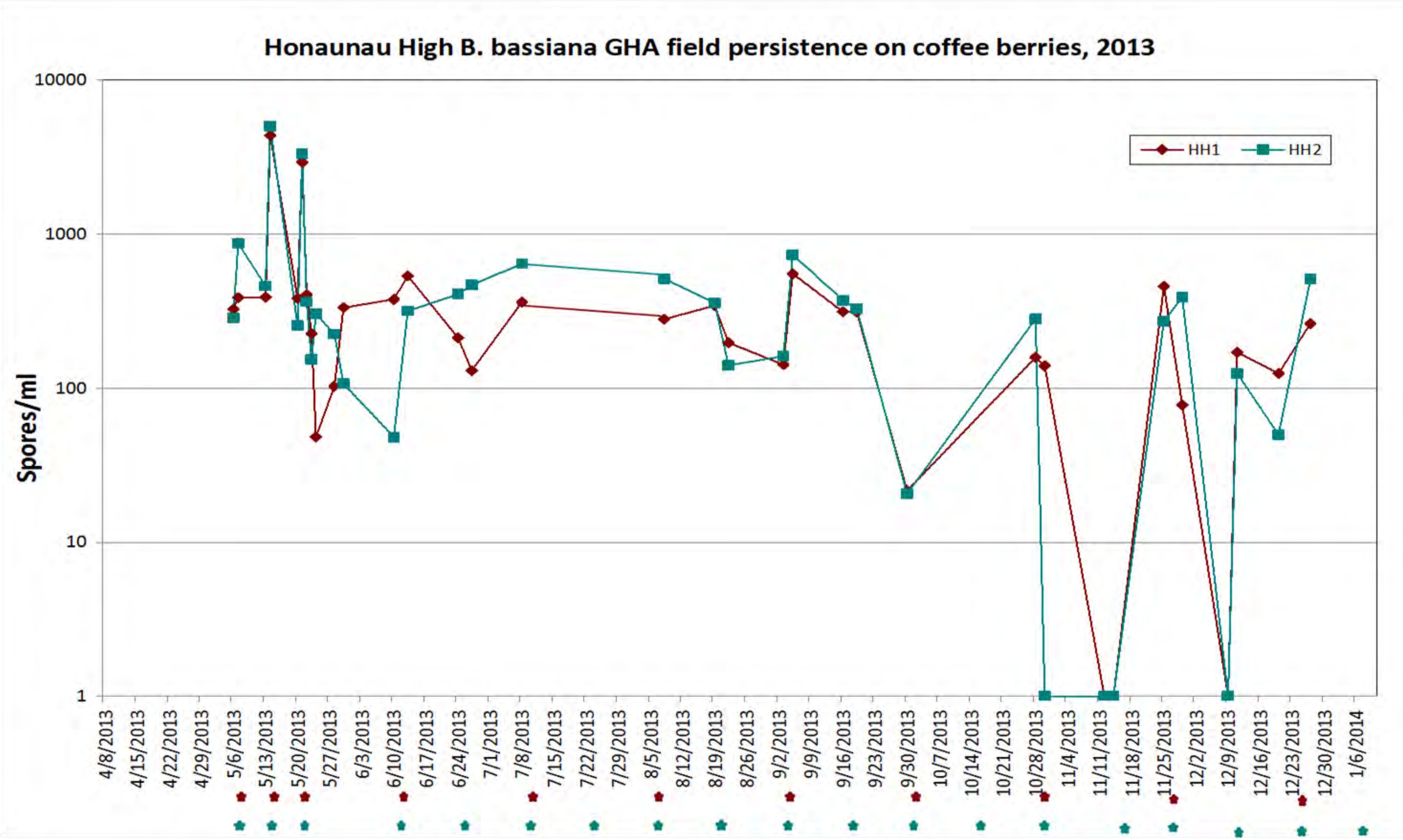
Persistence, 2014



14 or 25 sprays

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

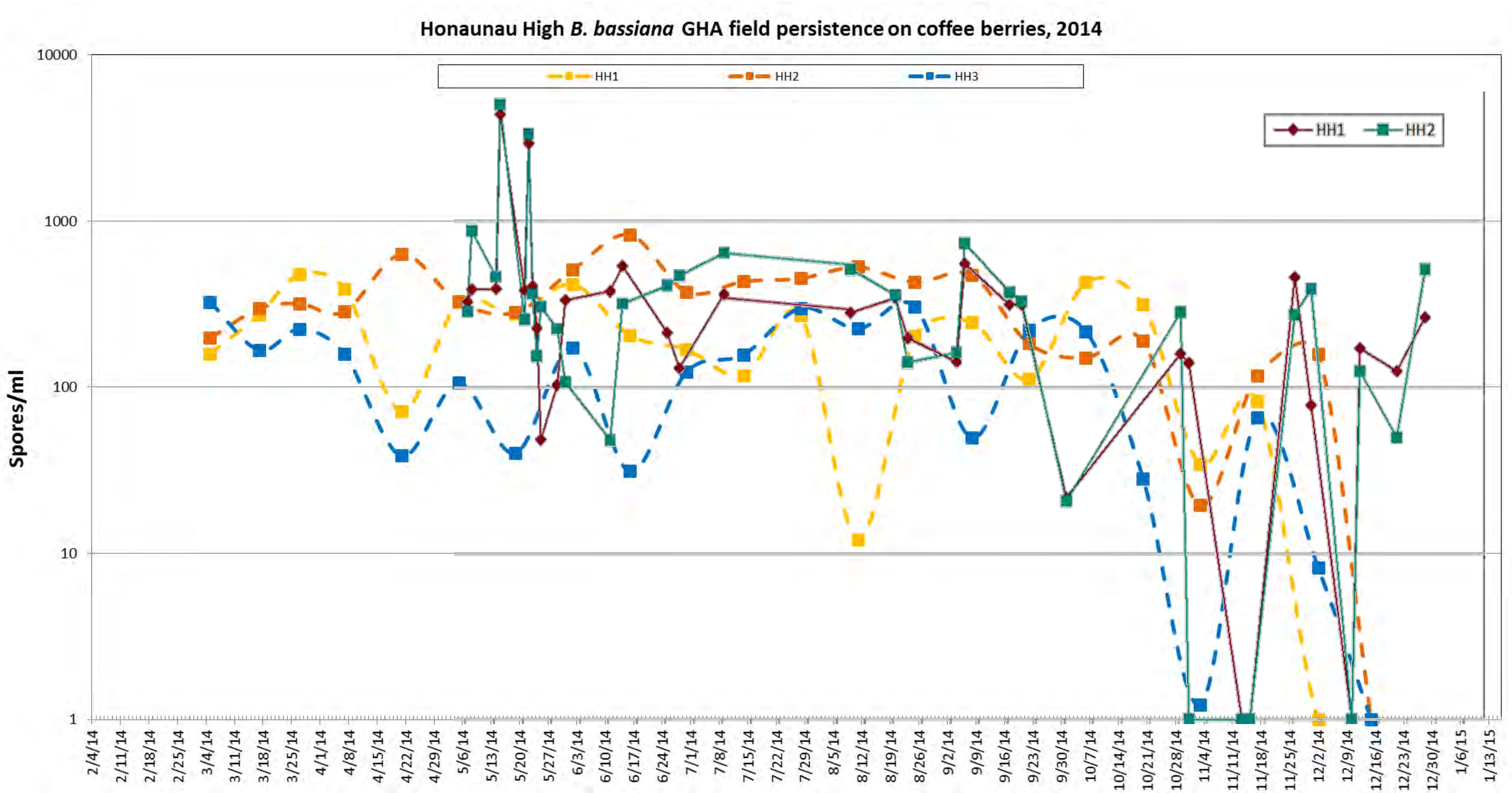
Persistence, 2013



11 or 19 sprays

Once/month spray (HH1)
Twice/month spray (HH2)

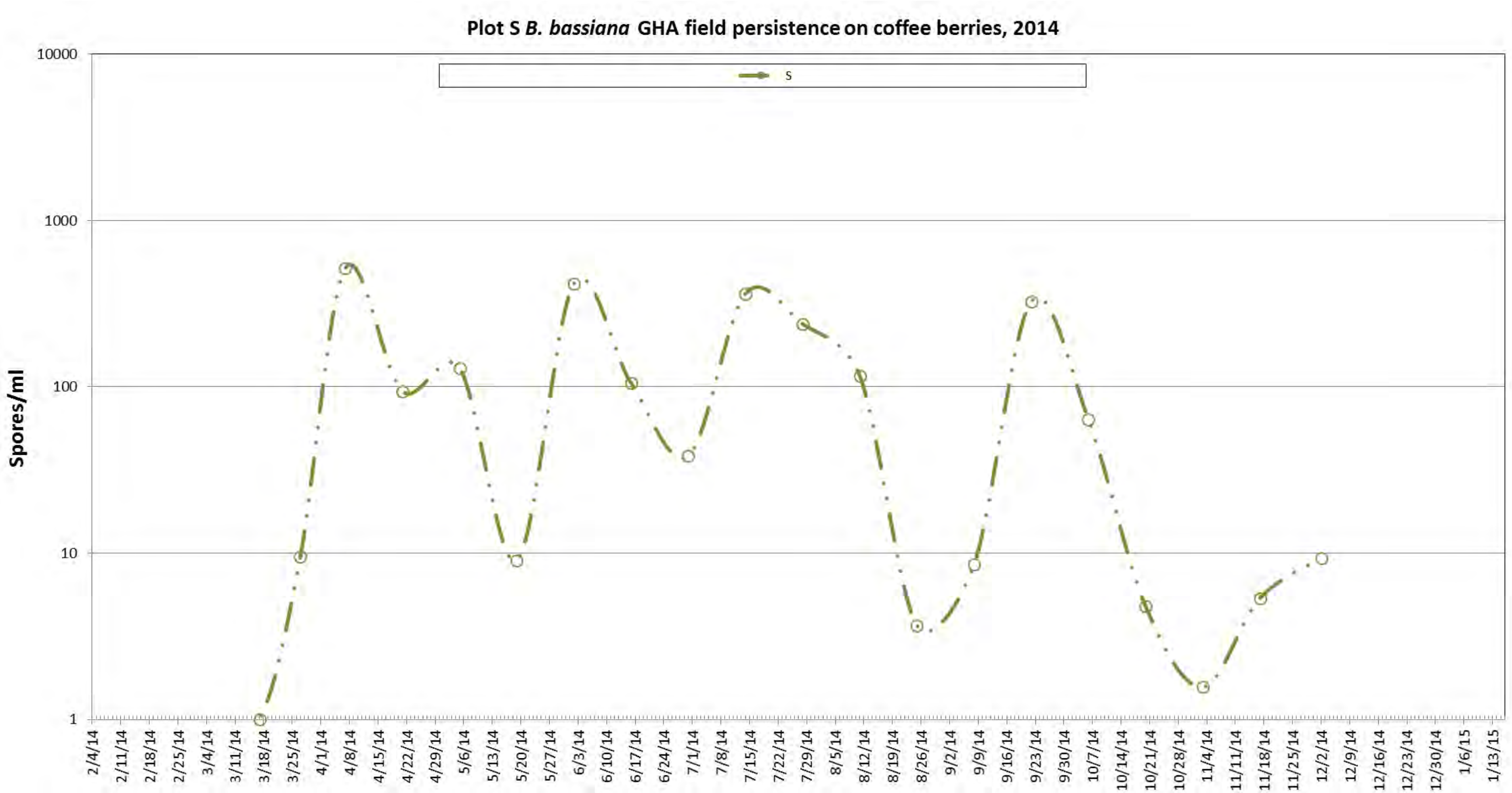
Persistence, 2014



14 or 25 sprays

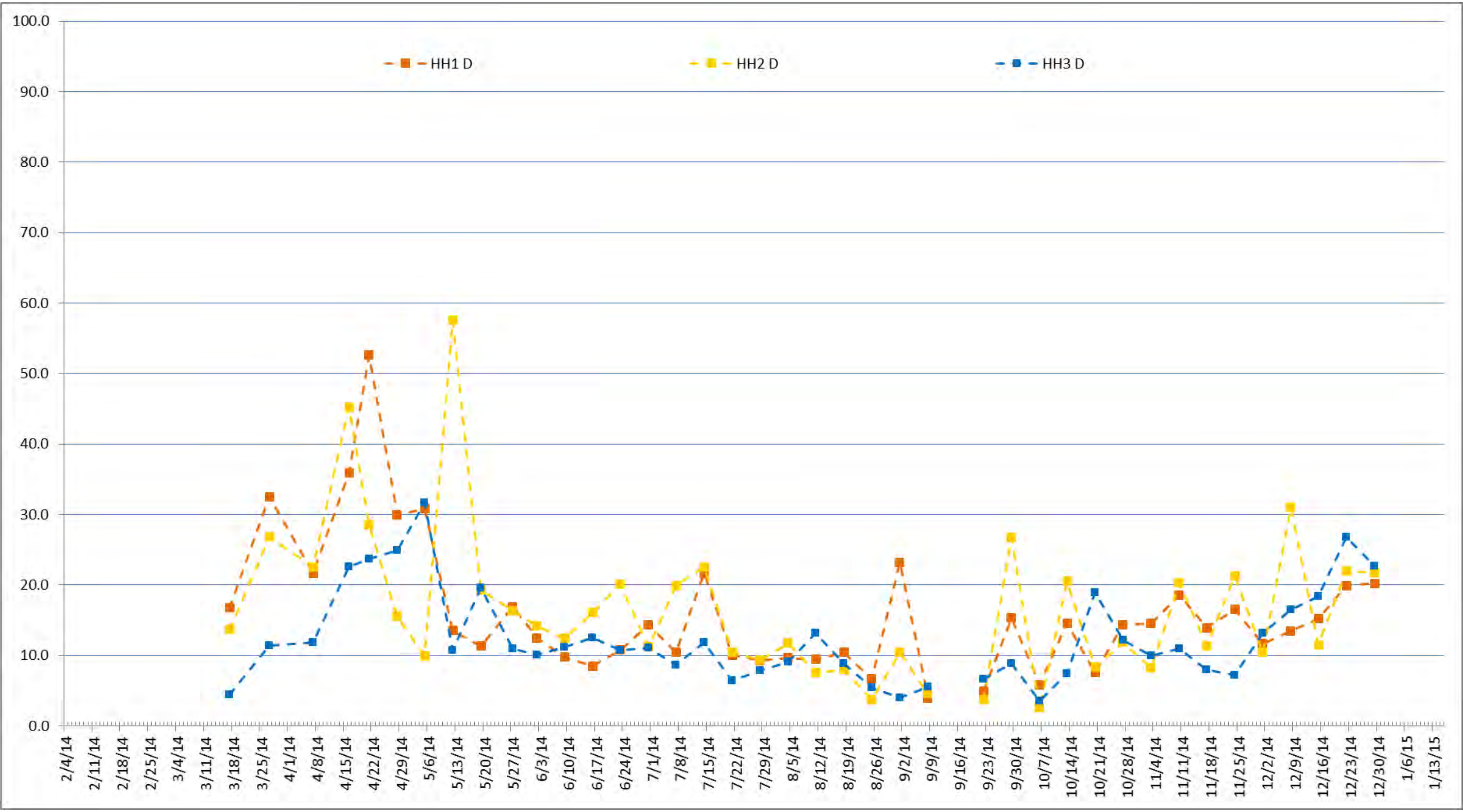
Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

Persistence, 2014



7 sprays

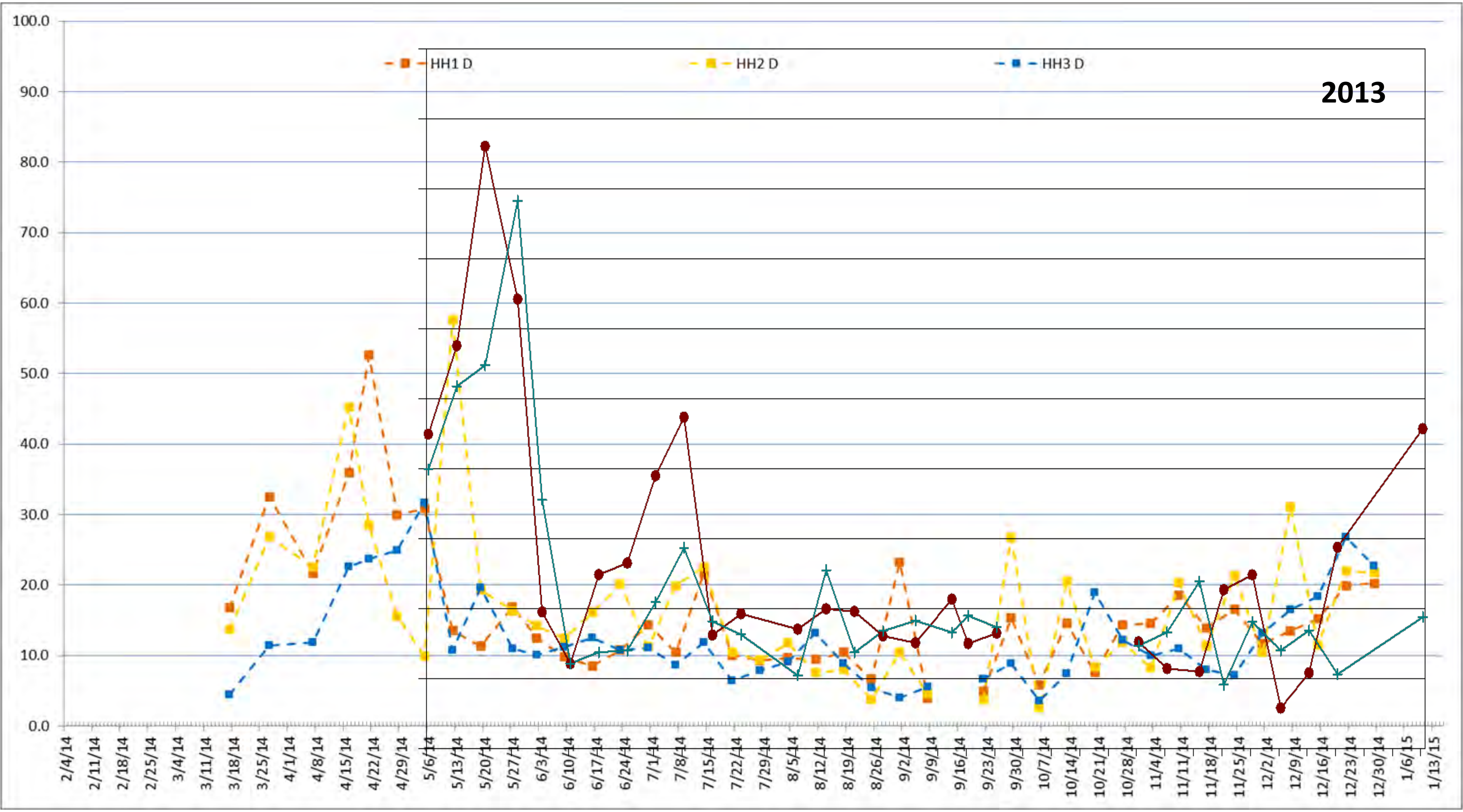
Efficacy: Destructive method, Honaunau High, 2014



% AB = Alive + Dead + Absent (hole only)

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

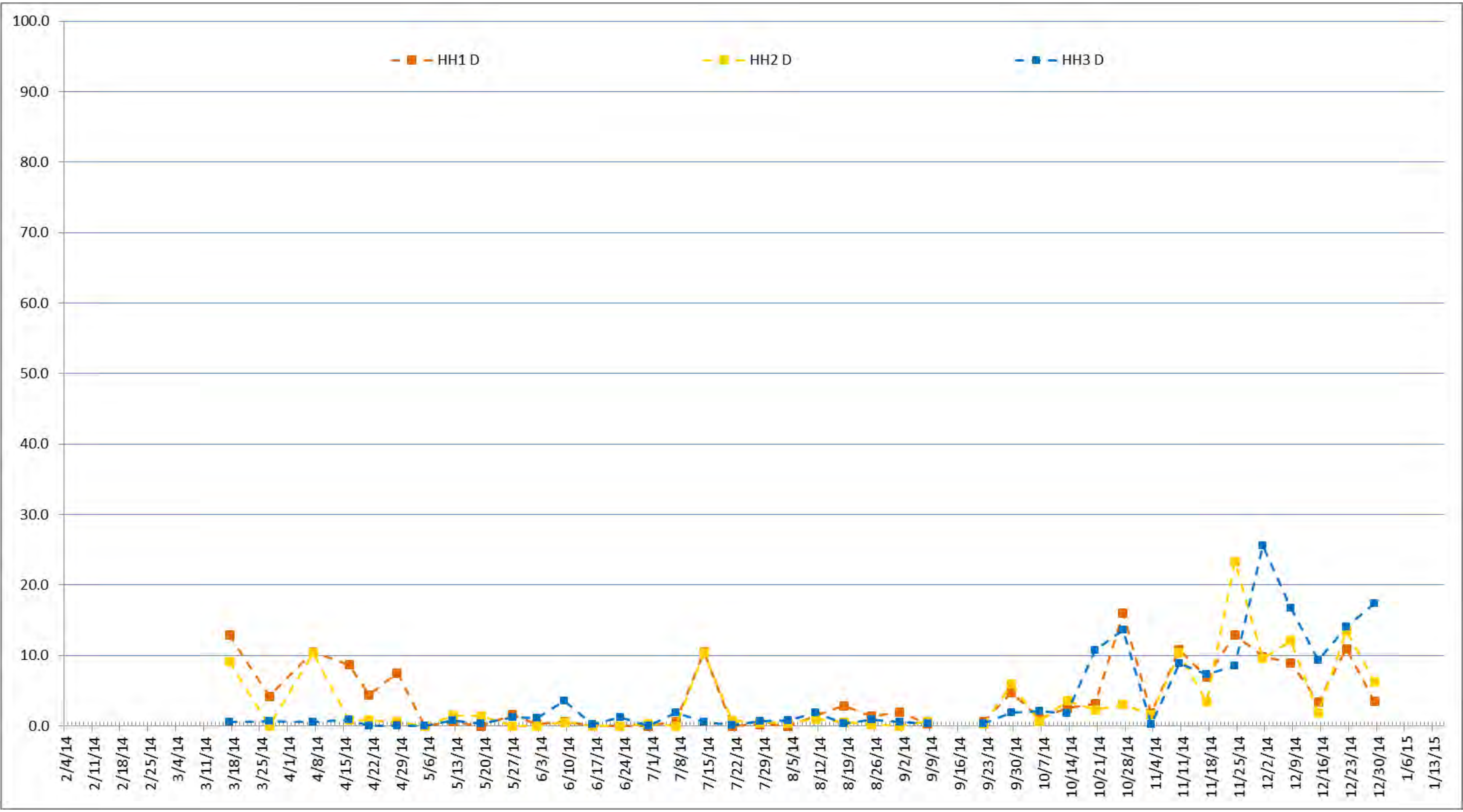
Efficacy: Destructive method, Honaunau High, 2014



% AB = Alive + Dead + Absent (hole only)

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

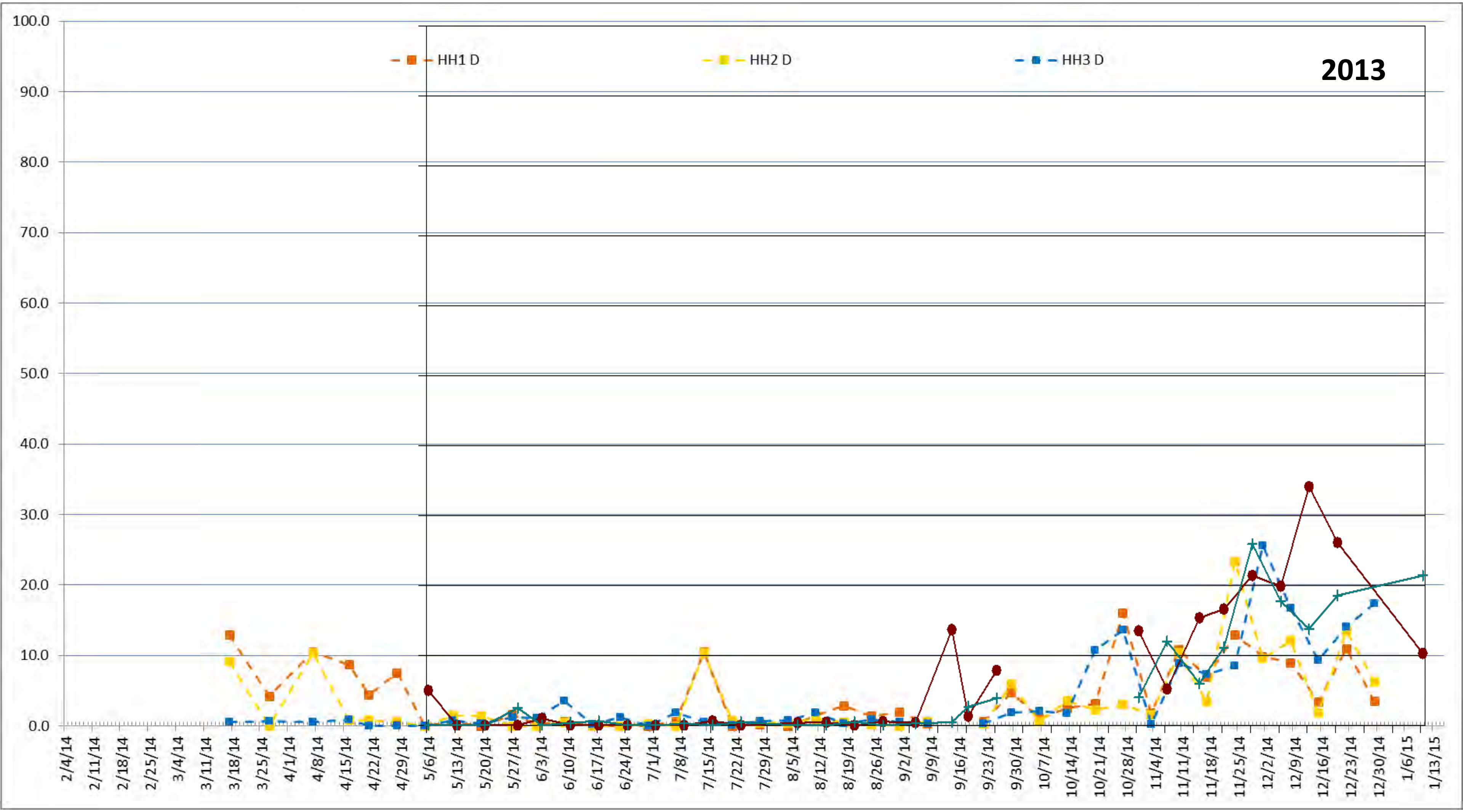
Efficacy: Destructive method, Honaunau High, 2014



% CD

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

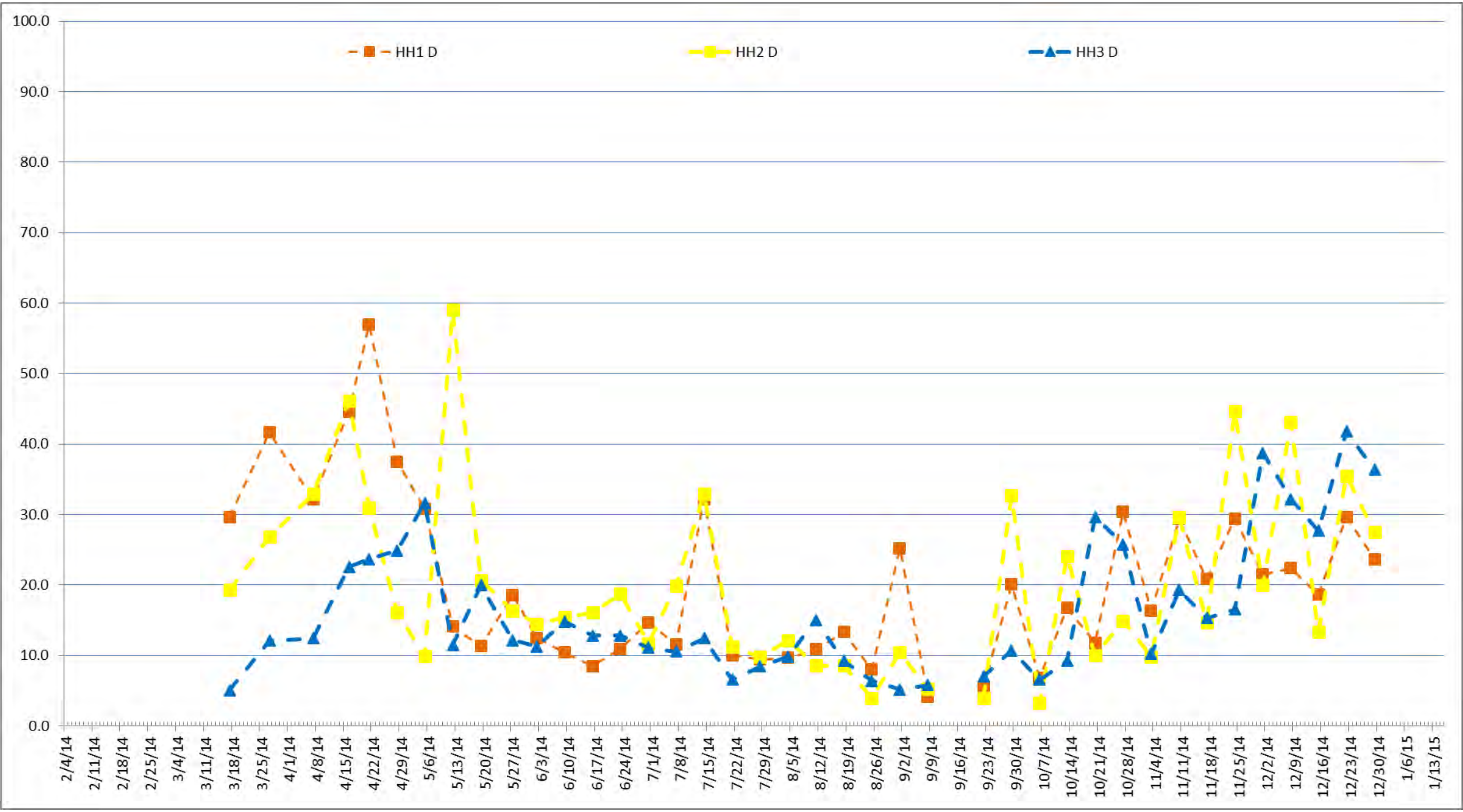
Efficacy: Destructive method, Honaunau High, 2014



% CD

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

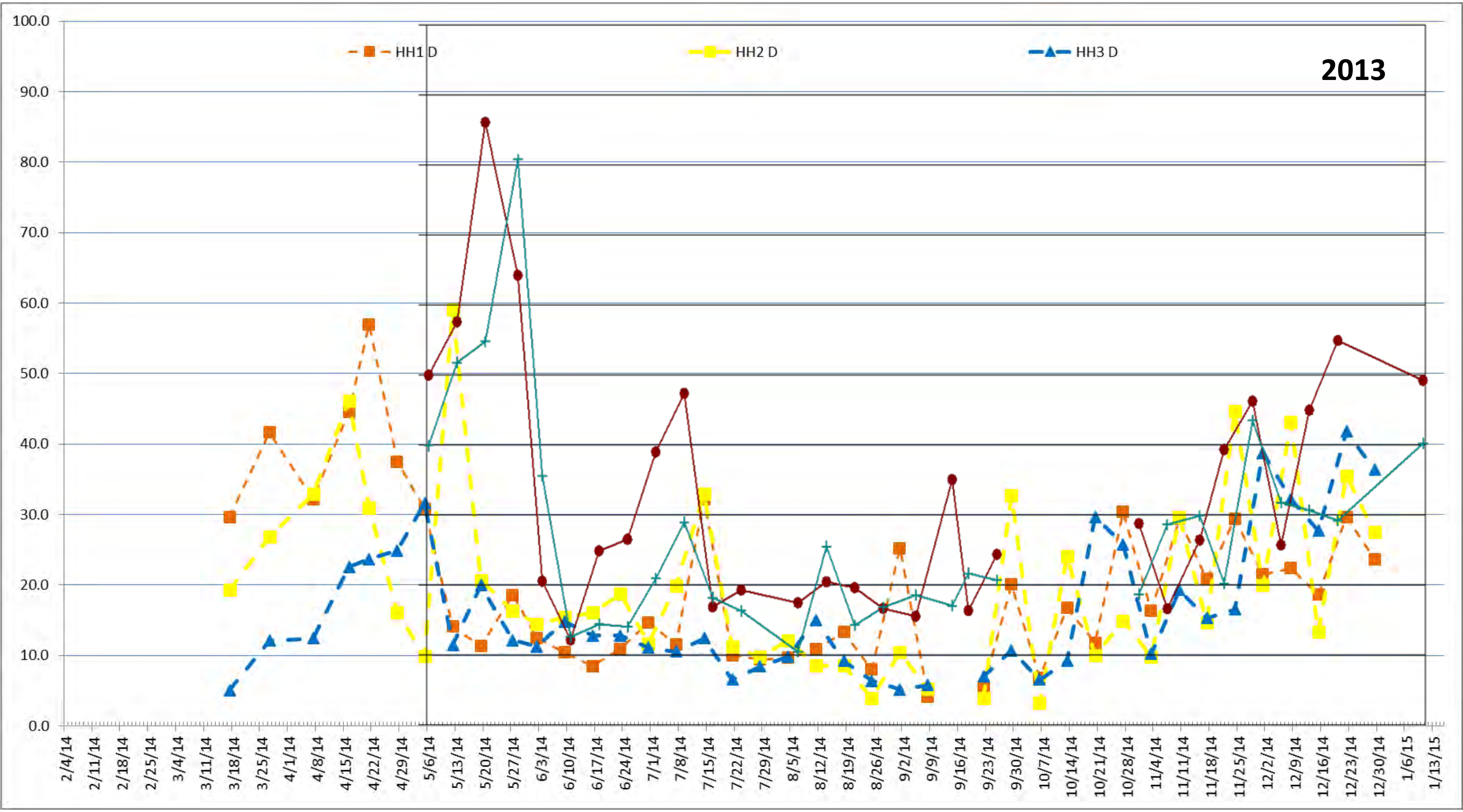
Efficacy: Destructive method, Honaunau High, 2014



% infested = % AB + % CD

Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

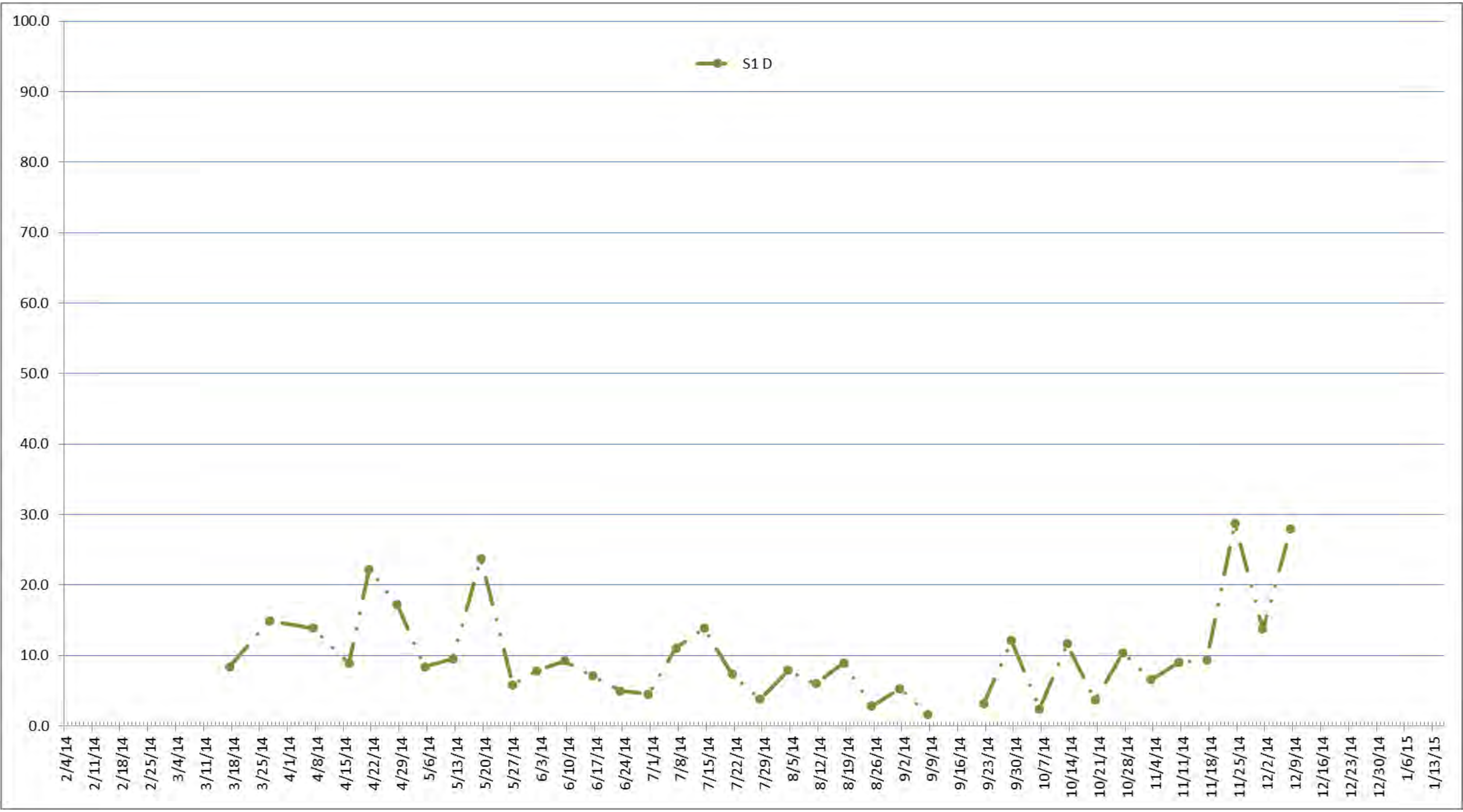
Efficacy: Destructive method, Honaunau High, 2014



% infested = % AB + % CD

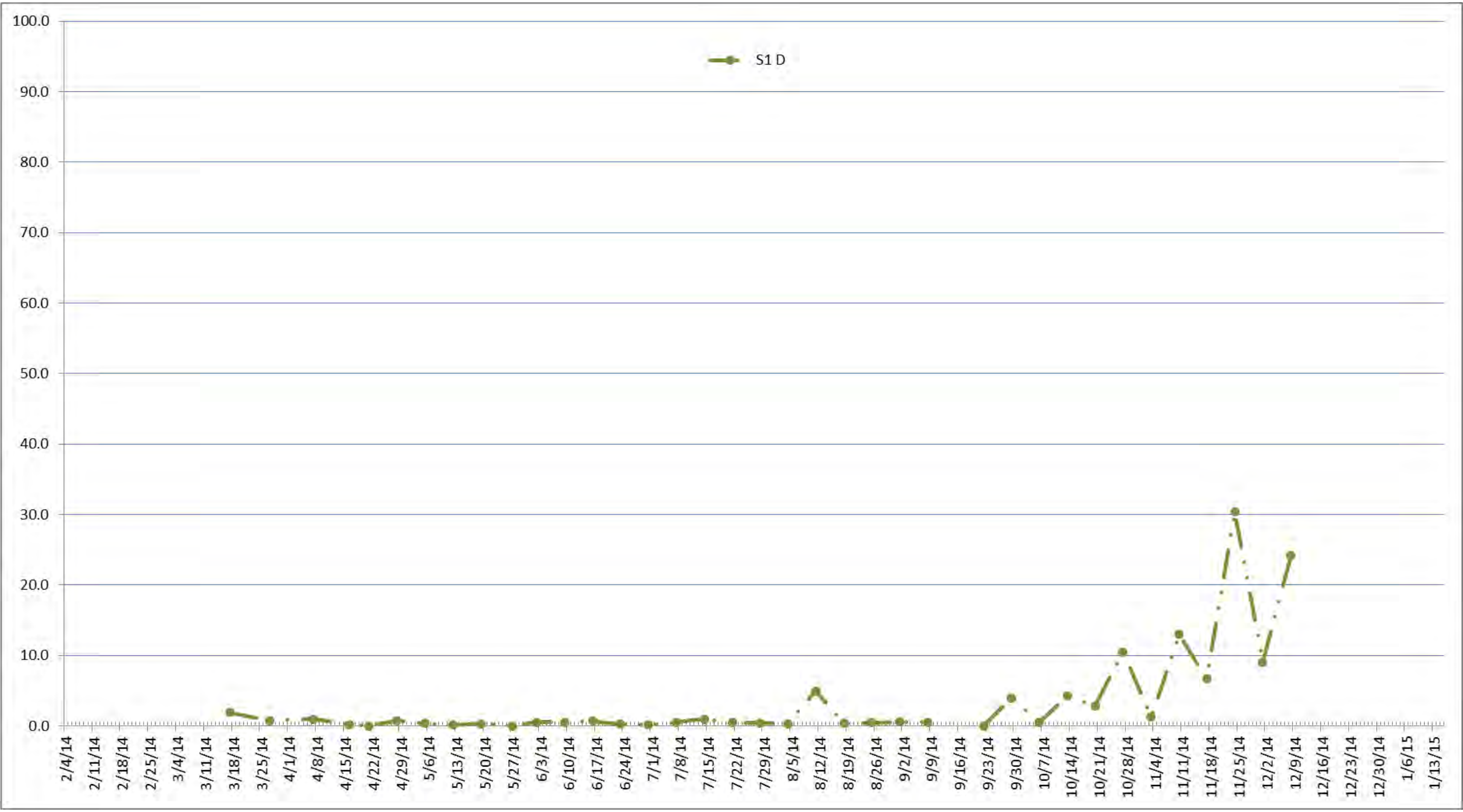
Once/month spray (HH1)
Twice/month spray (HH2)
Strip-pick + once/month spray (HH3)

Efficacy: Destructive method, Plot S, 2014



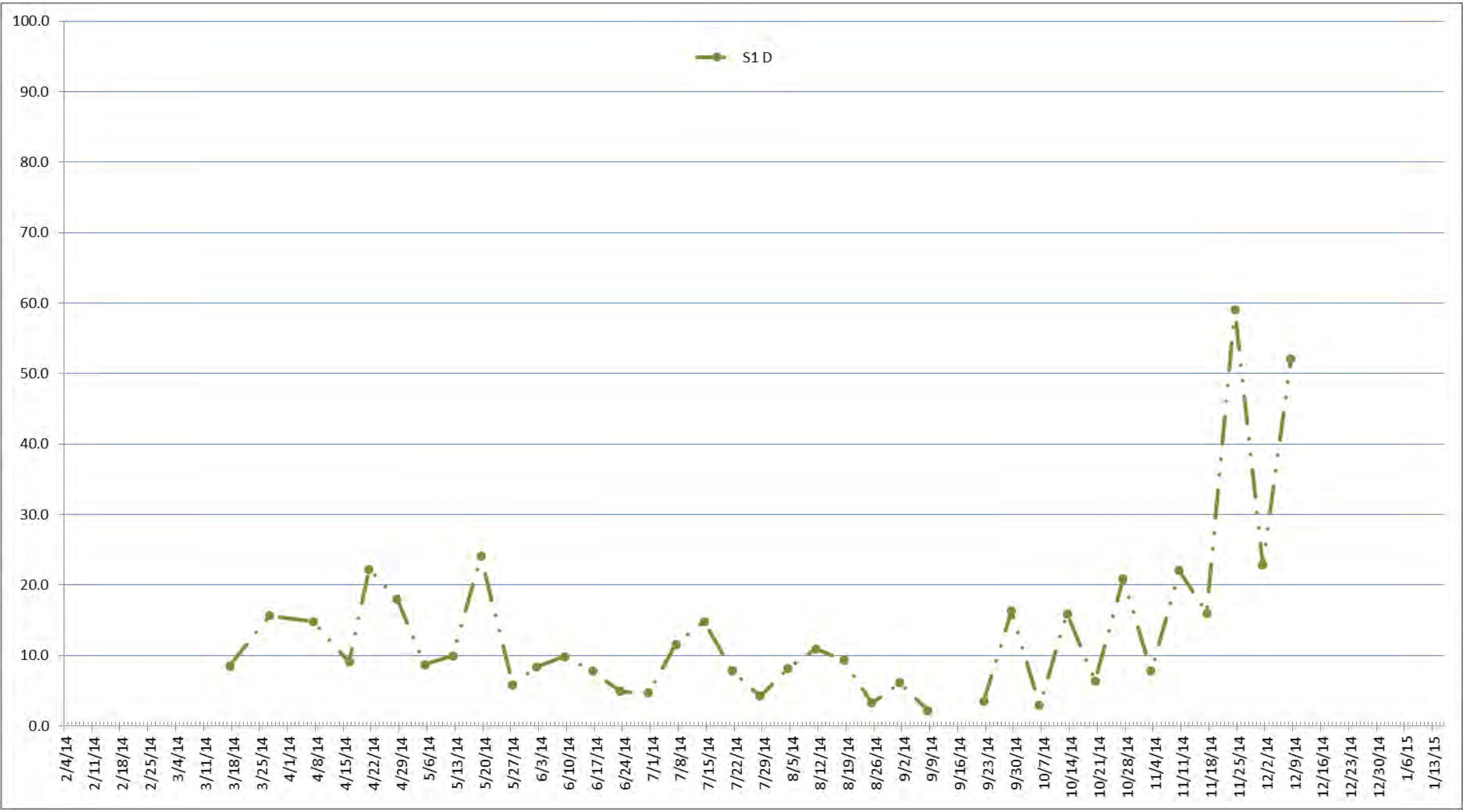
% AB = Alive + Dead + Absent (hole only)

Efficacy: Destructive method, Plot S, 2014



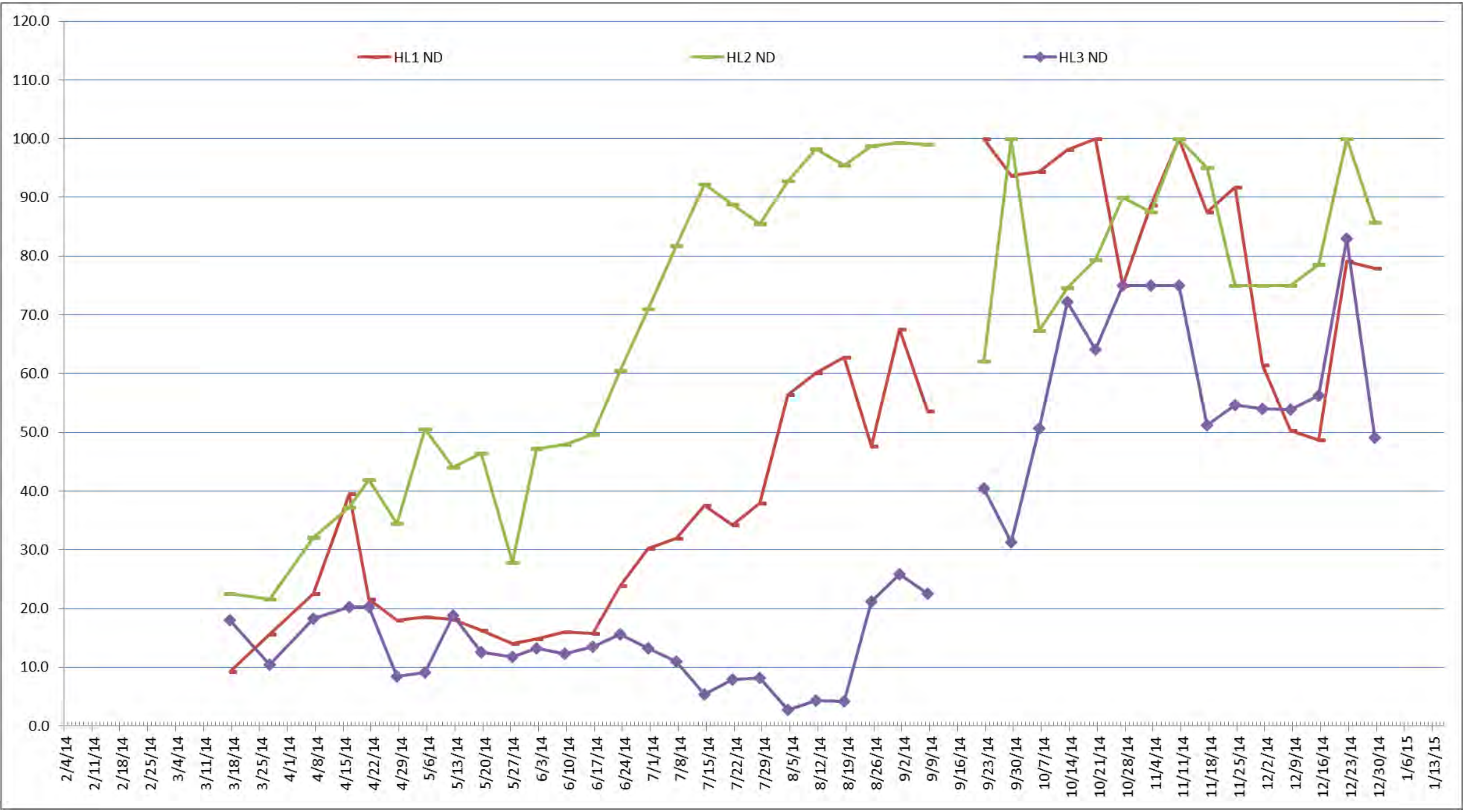
% CD

Efficacy: Destructive method, Plot S, 2014



% infested = % AB + % CD

Efficacy: Non-destructive method, Honaunau Low, 2014



% infested = a hole

Strip-pick (HL3)

Efficacy: Non-destructive method, Honaunau High, 2014

% infested = a hole

Strip-pick (HL3)

Environmental Data Conclusions/Observations

- Temp/%RH/Rainfall
- UV, leaf wetness
- Locations are unique
- Seasons can vary
- Data necessary for CBB Model

Conclusions/Observations

- Difficult to give a precise recipe for success
- Only *Beauveria*: Not the silver bullet
- Only stripping: Not the silver bullet
- Timing versus number of applications
- Location specific

What Does the Data Tell Us?

- Knock back the existing CBB population early (strip; *Beauveria*)
- Spray in the late afternoon
- *Beauveria* doesn't persist as much during the harvest months
- *Beauveria* sprays: monitor visually; spray when necessary
- "% infested" doesn't necessarily mean you have a high % of damaged beans

Goals for 2015

- Can strip-pick sanitation eliminate the need for early, intensive *Beauveria* sprays?
- Once/month spray versus spray when necessary
- Compare 2015 to 2013/2014

Elevation:
A. 1869 ft
B. 1547 ft
C. 624 ft (shade)

Thank You, Field Cooperators!

(Thanks to Nicholle, Lionel, Jim, Glenn, and John for excellent technical help)

Questions?

Abstract: Efficacy of Spray Applications of *Beauveria bassiana* strain GHA (BotaniGard®/Mycotrol®) Against the Coffee Berry Borer (CBB)

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[1] Emerging Pests and Pathogens Research Unit
Robert W. Holley Center for Agriculture and Health, Ithaca, NY 15853
[2] Tropical Plant Genetic Resources and Disease Research Unit
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CBB infestations were sampled on high- vs. low-elevation farms in South Kona on Hawai'i Island during April and May 2014 and March–May 2015 to determine levels of control achieved by applications of the *Beauveria bassiana* strain GHA-based biopesticide BotaniGard® ES. Applications were made at the approximate rate of 32 oz. BotaniGard® ES + 8 oz. surfactant in 30 gal water per acre. In most cases, each *Beauveria* application resulted in 25–45% infection of CBB adults present in the berries at time of spray. Lower levels of infection (10–15%) were observed at the beginning of the spray season when fields were under heavy attack from CBB emerging from their dry-season reservoirs (our knowledge of these "over-wintering" sites is incomplete, but old, desiccated berries remaining on the trees after harvest are known to be a major CBB reservoir).

New infections were detectable in the populations within 2–3 days post-spray, and mycosis was rapidly lethal (with most infected beetles succumbing within 7 days). During 2014, numbers of new infections detectable in live beetles (a rough measure of weekly disease incidence) generally dropped to < 10% within 10 days and remained low until the next application. However, under abnormally wet conditions at high elevation in 2015, levels of incidence between sprays remained as high as 20%. Whether these infections derived from greater persistence of spray residues or greater epizootic spread (horizontal transmission) of the fungus is not yet known. Also as yet undetermined is the proportion of infections attributable to wild (naturally occurring) *Beauveria* strains. Background levels of infection remained <10% in drier fields at low elevation. Our findings strongly suggest that the observed levels of infection were the result of direct spray contact, with contributions from spray residues or epizootic spread being significant only under weather conditions highly favorable to the fungus. As expected, *Beauveria* efficacy increased with field elevation (cooler, wetter conditions); however, we have not yet completed compilation of the environmental data for correlation to disease incidence.

The mode of CBB attack in developing coffee berries is slow, with the adults establishing shallow galleries in the ends of green berries and waiting in this exposed position until the berries have matured to a point that the galleries can be extended. Thus, in an intensive spray program, many beetles will be directly exposed to more than a single spray. In high-elevation fields in 2014, applications at 2-week intervals achieved a more or less constant 50% control of the pest populations (in weekly samples, 49–58% of all adult CBB in coffee berries were found to have been killed by or infected with *Beauveria*).

In programs of monthly spray applications, mortality levels gradually declined to 20–30% within 2 weeks post-application (apparently due to influx of untreated CBB from surrounding areas and/or in-field reservoirs), but were restored to ~50% following each spray. Initial results suggest that well-timed, monthly applications of *Beauveria* (targeting flushes of new berries under CBB attack) could be nearly as effective as twice-monthly calendar sprays and strongly support the research of ARS scientists seeking ways to synchronize coffee flowering.

Abstract: Exploring Coffee Berry Borer, *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae) Microbial Endosymbionts With Emphasis on Potential Resistance to Entomopathogenic Fungi and Other Fitness Determinants

Sayaka Aoki and Mark G. Wright
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Bacterial symbionts are frequently associated with arthropods and may play essential roles in host survival, reproduction, and host metabolism. They may also affect hosts' biology and phenotypes by providing vital nutrients, breaking down food materials, influencing host plant usage, and mediating interactions with natural enemies. A previous study conducted by Vega et al. positively identified a maternally inherited intracellular proteobacterium, *Wolbachia,* from coffee berry borer (CBB) in Benin, Brazil, Colombia, Ecuador, El Salvador, Honduras, India, Kenya, Mexico, Nicaragua, and Uganda. Although CBB associations with 22 families of bacteria species were also detected in previous studies, their functions and roles in biology of CBB have been understudied. The goal of our study is to characterize bacterial endosymbionts associated with CBB and their interaction with the beetle.

We used 16S rRNA gene and sequenced to survey the bacterial populations in/on CBB collected from 5 farms in the Kona and Kāʻū areas of Hawaiʻi. BLAST sequencing analysis yielded homologies with 50 genera of bacteria associated with CBB. Bacterial species found frequently in our samples were *Burkholderia*, *Gluconobacter, Shingobacterium*, and *Proteobacterium*. *Burkholderia*, gram-negative Bata proteobacteria, were predominant in our samples, found in all five localities in 20% of 143 sequenced samples.

We will examine the interaction of *Burkholderia* with the beetle host and *Beauveria bassiana* to determine whether the bacterium provides any degree of resistance to the fungal pathogen.

Abstract: Manipulation of Coffee Flowering for Harvest Management and to Aid CBB Sanitation

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Tropical Plant Genetic Resources and Disease Research
United States Department of Agriculture Agricultural Research Service,
Daniel K. Inouye Pacific Basin Agricultural Research Center, Hilo, HI 96720

The three main methods of CBB control are 1) monitoring with traps or other tools, 2) chemical and biological pesticides, and 3) field sanitation. Field sanitation is essential to CBB control since the life cycle of the CBB can be completed within the protected confines of the coffee berry between coffee seasons. Removing coffee berries by stripping green coffee berries between seasons is recommended for coffee farmers to reduce the CBB population for the start of the coffee season. Stripping green coffee berries at the end of the season is lost income for the farmer.

Coffee flowering is divided into 4 stages: bud initiation, dormancy, breaking of dormancy, and anthesis (flower opening). Flower dormancy is associated with drought conditions in which ABA (abscisic acid) plant hormone levels are high in the buds. Breaking of dormancy is associated with rainfall, which resumes growth of the plant and is associated with increased levels of GA (gibberellic acid) plant hormone. Sporadic rainfall that occurs during the dormancy period is responsible for multiple flowering occurrences. Since Hawaiʻi does not have distinct wet and dry seasons, each rainfall results in multiple flowering events in one coffee season, resulting in the need for multiple small harvests and often extending the coffee harvest season. This increases labor costs in hand-harvested coffee and decreases yield of marketable coffee in both mechanically and hand-harvested coffee fields by increasing the amount of green coffee berries at the end of or during the coffee season.

Here we use plant growth regulators to concentrate coffee flowering, combining small multiple flowerings into one larger flowering, by utilizing a combination of commercial products with GA_3 and ABA. Over the last four years, we have optimized growth-regulator concentration and application in both hand-harvested fields in Kona and mechanically harvested fields in Oʻahu and Kauaʻi. Larger-scale field trials were conducted over the past two years under a Special Local Needs (SLN) permit, and we are working with manufacturers to add coffee to the label of the plant growth regulators. Both products are currently available as OMRI (Organic Materials Review Institute) certified and can be used for conventional and organic coffee farms. Results over multiple years have shown that the treatments successfully promoted flowering of coffee to increase the amount of coffee berries in earlier harvests and reduced the amount of green coffee berries at the end of the season.

Abstract: Insect-Parasitic Nematodes Against Coffee Berry Borer

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United States Department of Agriculture Agricultural Research Service,
Daniel K. Inouye Pacific Basin Agricultural Research Center, Hilo, HI 96720

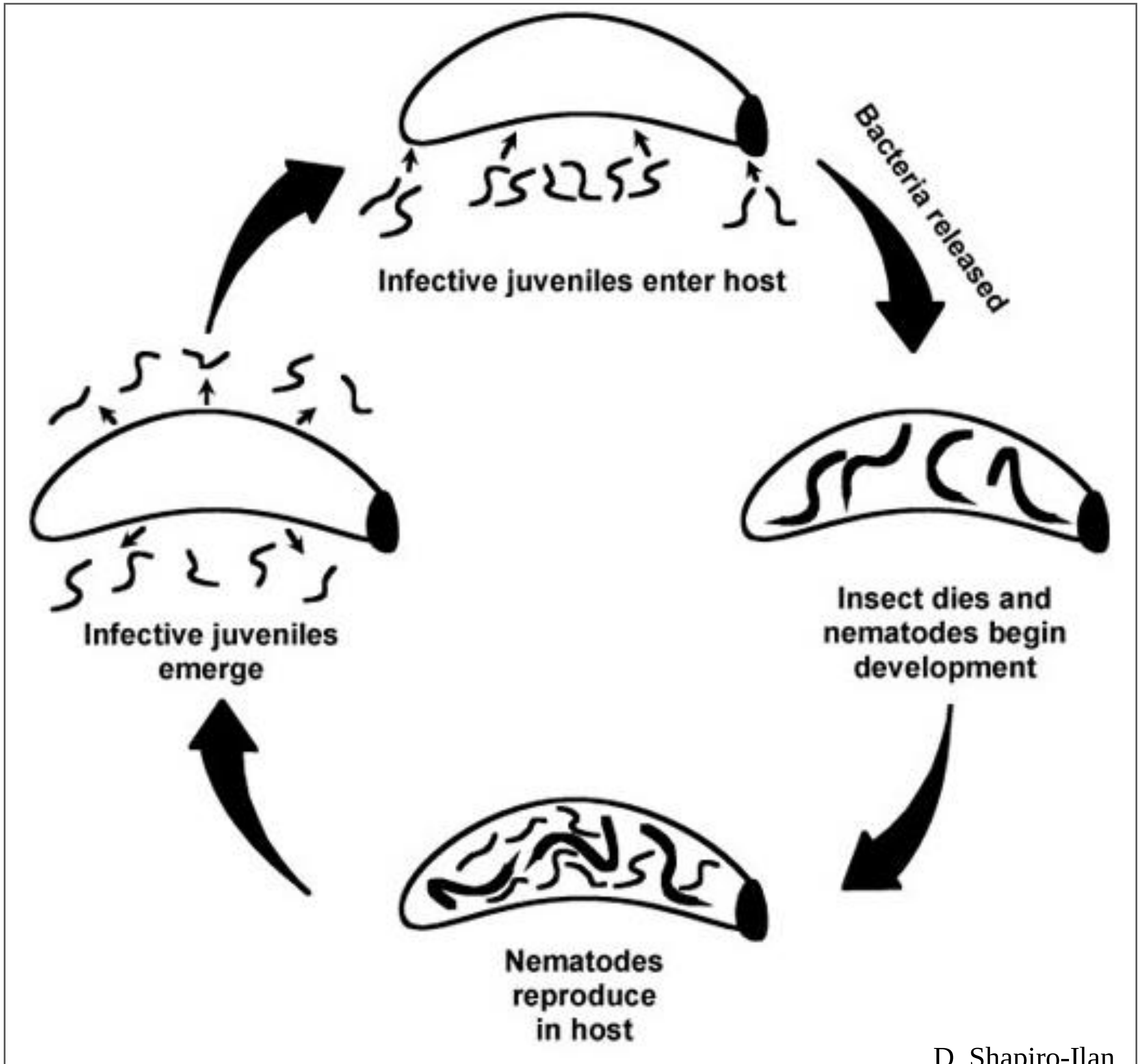
Entomopathogenic nematodes (EPNs) are insect-parasites that are utilized as biological control agents against some insect pests. EPNs have the potential to reduce CBB populations when sprayed on fallen coffee cherries in areas where sanitation is not feasible. Mortality was observed in CBB larvae and adults in previous laboratory trials conducted with a commercial EPN strain. A survey for native EPNs recovered 2 species of *Heterorhabditis* that were found to be widespread in the Hawaiian Islands. These species are assumed to be better adapted to our environmental conditions and have the potential to persist in the field after application. In laboratory bioassays, the native *H. indica* strain caused mortality of 67% and 80% of CBB adults within two days after inoculation with approximately 40 and 400 nematodes per adult, respectively. CBB-infested green cherries were placed on sand and inoculated with two dosages of *H. indica*, either 250 or 2500 nematodes per cherry. Although no mortality was observed with the smaller amount, 8% of adults were infected and killed when inoculated with the larger amount. Future research will examine the potential of other Hawaiian EPN strains and the ability of the nematodes to search out and infect CBB in ripe cherries.

INSECT-PARASITIC NEMATODES AGAINST COFFEE BERRY BORER

2015 Coffee Berry Borer Summit

Roxana Myers
USDA ARS
Daniel K. Inouye Pacific Basin
Agricultural Research Center

Insect-Parasitic Nematodes, aka EPNs



Background

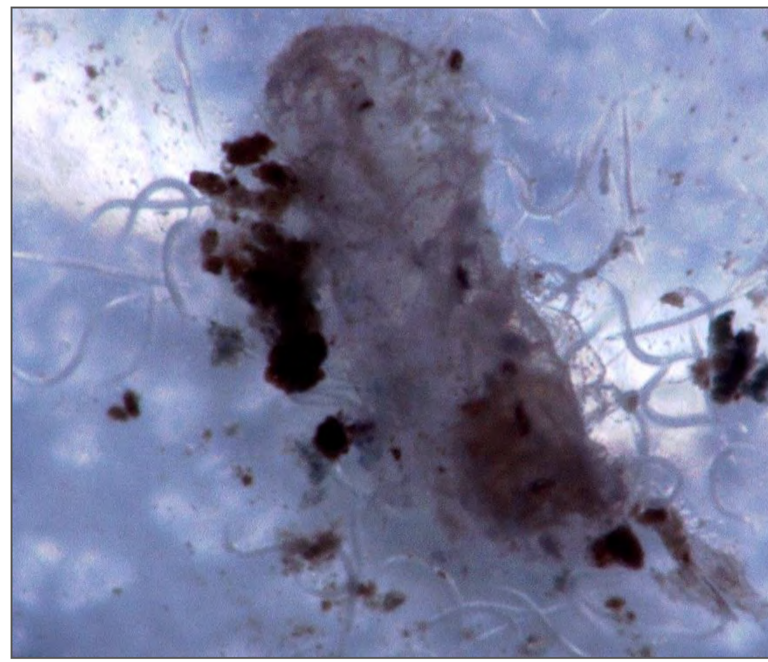
- Several publications on commercial EPNs causing CBB mortality in the lab
- No field research published
- Natural parasitism of CBB by other nematode species reported in Chiapas, Mexico, and India

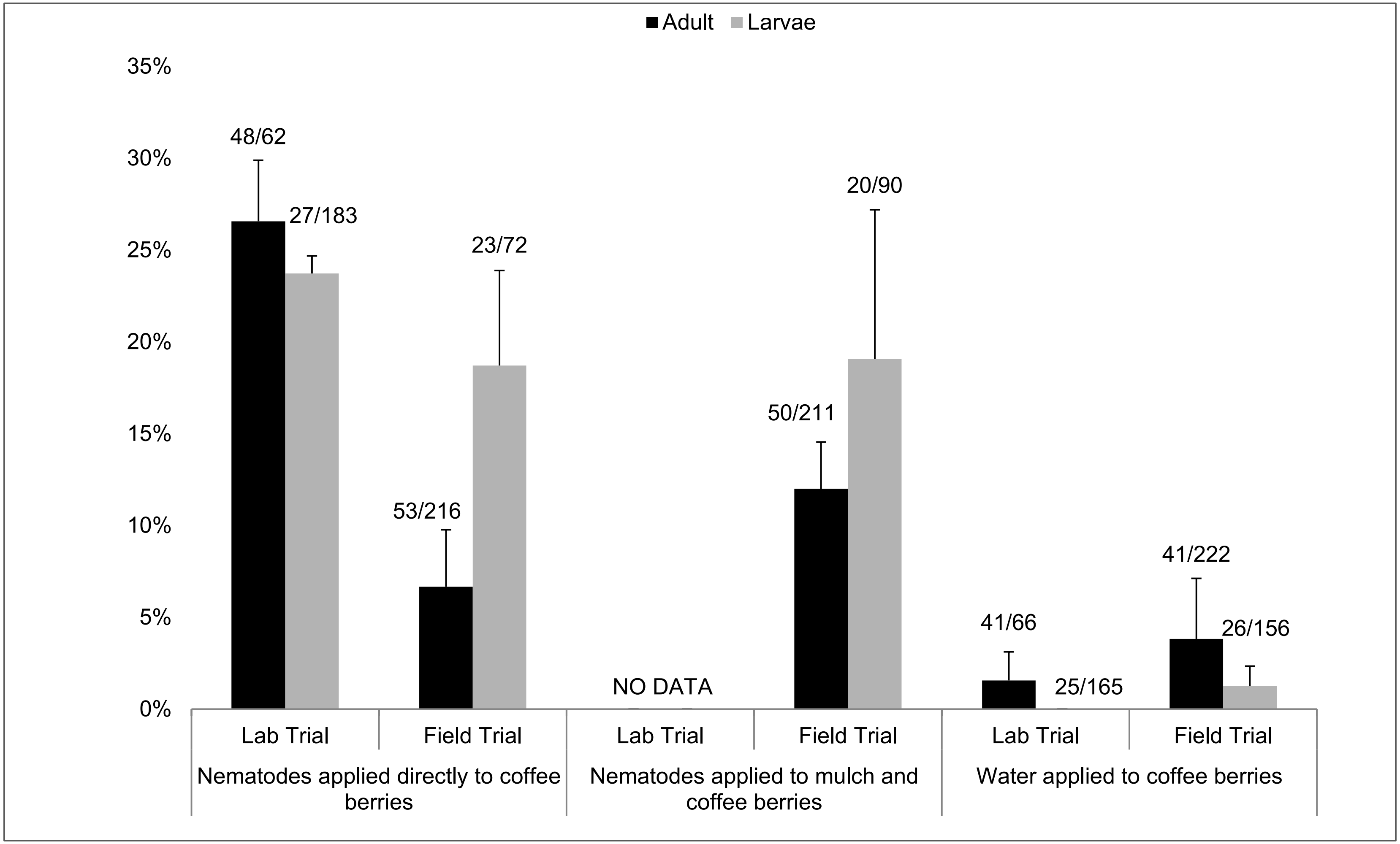
POTENTIAL OF *STEINERNEMA CARPOCAPSAE* (RHABDITIDA: STEINERNEMATIDAE) AGAINST *HYPOTHENEMUS HAMPEI* (COLEOPTERA: CURCULIONIDAE) IN HAWAI'I

JESSICA L. MANTON[1,*], ROBERT G. HOLLINGSWORTH[2] AND ROXANA Y. M. CABOS[2]

[1]Tropical Conservation Biology & Environmental Science Program, University of Hawai'i at Hilo, 200 West Kawili Street, Hilo, Hawai'i 96720, USA

[2]U.S. Pacific Basin Agricultural Research Center, USDA-ARS, 64 Nowelo Street, Hilo, Hawai'i, 96720, USA



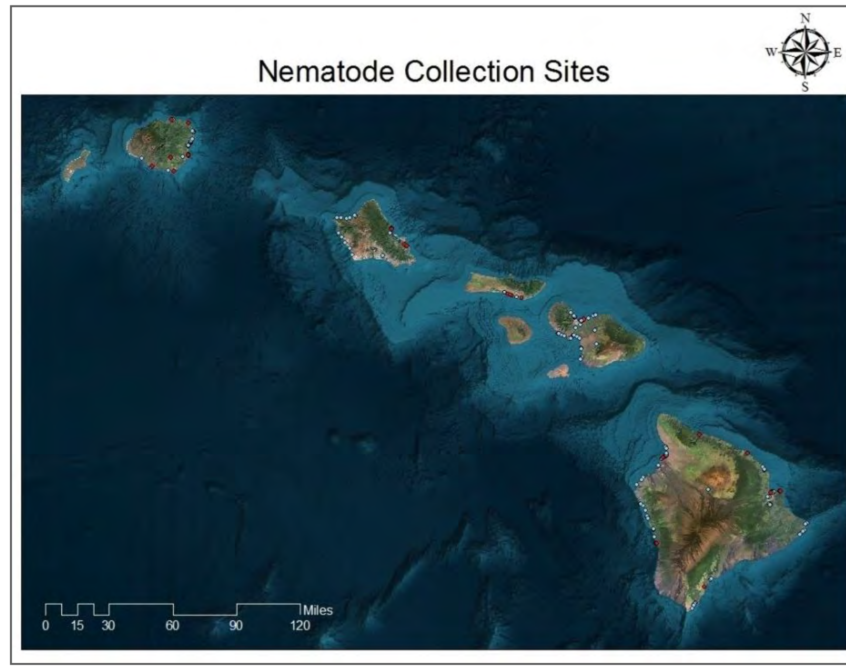


Percent nematode-caused mortality (no. berries/no. insects) of CBB in 2 experiments in which S*teinernema carpocapsae* IJs were applied to infested coffee cherries

Distribution and Occurrence of Heterorhabditid Populations in the Hawaiian Islands

R. Myers, B. Sipes, T. Matsumoto, C. Mello, J. Mello

- Surveyed natural habitats on 5 Hawaiian islands
- Recovered *Heterorhabditis indica* (aka *H. hawaiiensis*) and 2 undescribed *Heterorhabditis* species



Objectives

- Evaluate the efficacy of EPNs as an alternative to sanitation for control of CBB in fallen coffee cherries.

  - Test endemic Hwn strains in laboratory bioassays.
  - Evaluate EPNs on infected coffee cherries.

Manton *et al.*, 2012

Objectives

- Optimize efficacy of EPN applications in coffee fields.
  - Investigate adjuvants and cultural practices to prevent nematode dessication.
  - Evaluate effects of application rate and carrier volume.

Progress

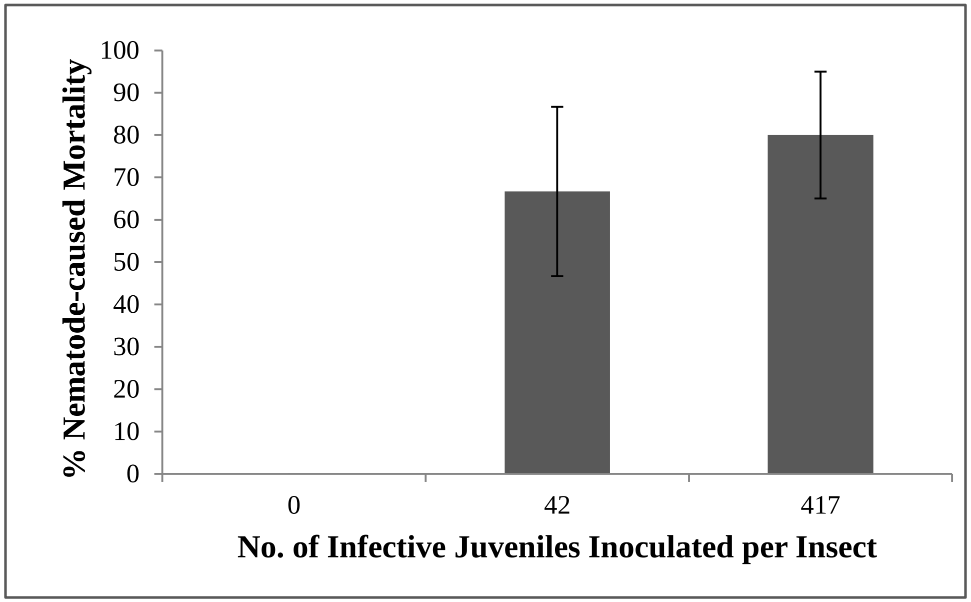
- Established in vitro CBB colony without antibiotics.
- Maintained and reared nematode strains on mealworm hosts.

- Conducted in vitro assays with CBB adults.
- Tested EPNs on infected green cherries.

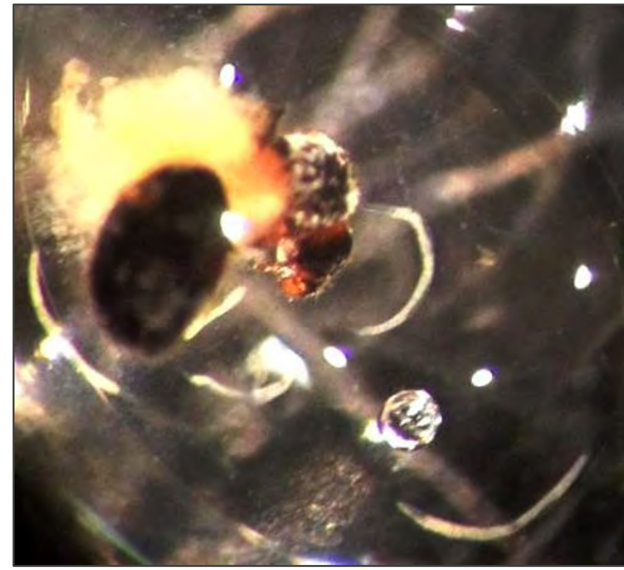
Petri Dish Assay

- 3 CBB adults/petri dish
- *Heterorhabditis indica* strain OM160
- Inoculate filter paper with 0, 125, or 1250 infective juveniles (IJs) per dish (0, 42, or 417 IJs/adult).
- Check CBB mortality and nematode infestation after 2 days.

Results



Percent nematode-caused mortality of CBB adults 2 days after inoculation in petri dish assays



Development of *H. indica* hermaphrodites 2 days after inoculation

Infested Green Cherry Trial

- 1 CBB-infested green cherry/50 mL centrifuge tube with 8g sterilized sand
- Inoculate 0, 250, or 2500 IJs/tube in 1 mL water (*H. indica* OM160)
- Dissect 5 days after inoculation

Results

- 8% of insects recovered from cherries inoculated with 2500 IJs were infested with nematodes.
- No nematode-caused mortality was observed in cherries inoculated with 0 and 250 IJs.
- Modification of methods is needed.

Future Plans

- Hired graduate research assistant, Justin Bisel, who starts this summer
- Ongoing survey for other endemic EPN species
- Ongoing laboratory bioassays
- Field trials to optimize EPN applications

Questions?

Abstract: Biological Engineering for Coffee Berry Borer Mitigation

Loren D. Gautz
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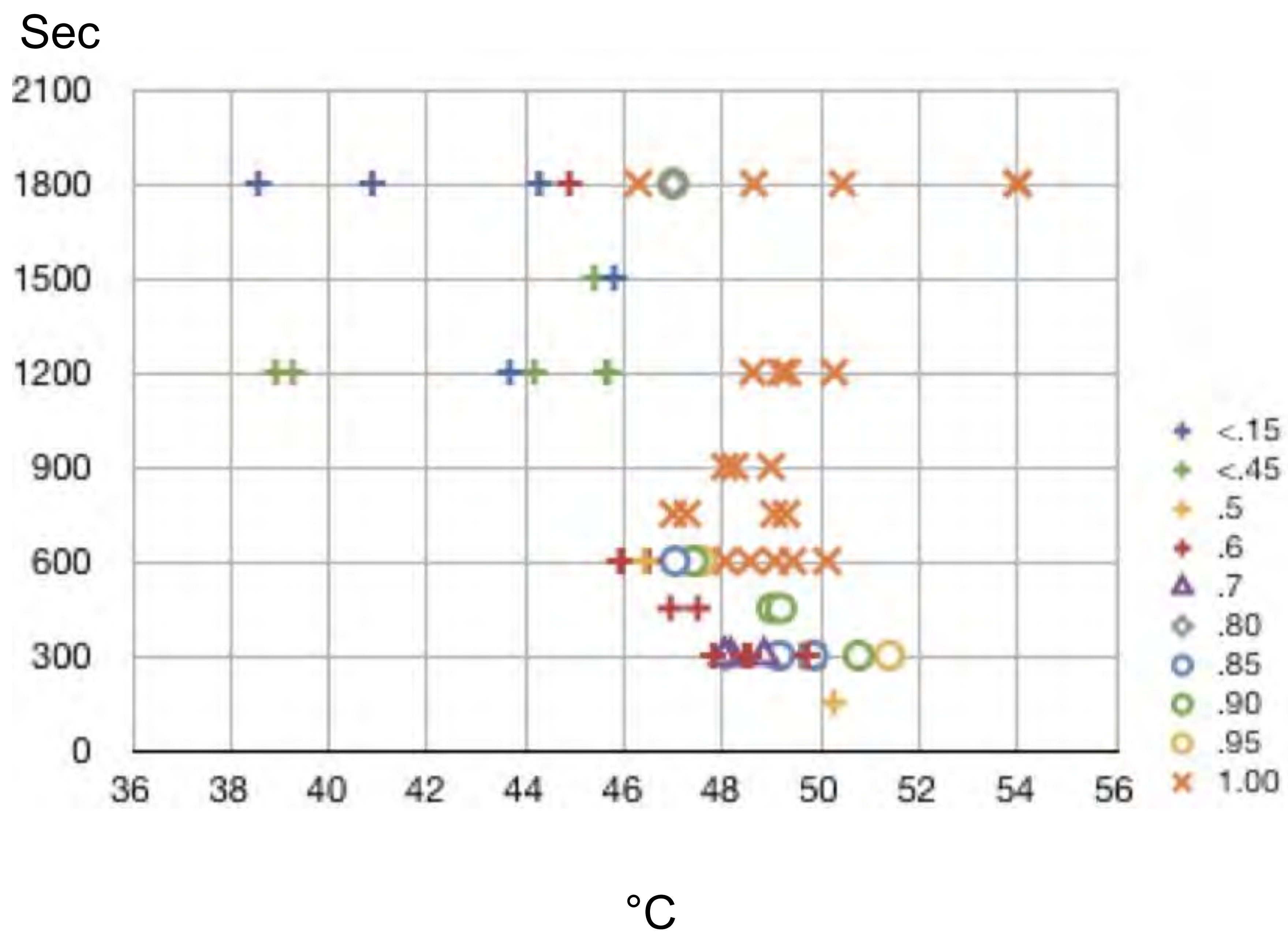
Heating green bean coffee to 50°C and holding that temperature for 15 minutes was shown in 2010 to kill all life forms of CBB (coffee berry borer) at Probit 9 level of confidence. This was reported at the 2010 ASIC Conference in Costa Rica. A device to thoroughly heat a 100lb burlap bag of green bean was installed at the Kona Research Station in Kainaliu. Taste tests with naive coffee drinkers and professional tasters detected no detrimental changes in their coffee beverage. There still remains a need for this treatment to be approved as satisfying HDOA quarantine requirements.

Another method of CBB mitigation in unsalable coffee cherries is burial. Experiments determined CBB-infested coffee cherries must be buried at depths greater than 100 mm (4 in.) in wet (friable) soil and 150 mm (6 in.) in dry soil to prevent escapes of CBB adults.

Heat treatment

Recirculating hot air gives Probit 9 mortality in 30 minutes



Burial

Summary

Treatment		Date ended	Days to 0 emergence	Live in cherry after 22 days		
mm depth	% FC soil moisture			Adults	Young	Larvae
50	1	10/30/13	18	8.5	5.8	11.5
50	75	12/4/13	10	9.8	6.5	11.5
100	75	12/4/13	10	3.3	2.0	6.8
150	75	1/21/14	0	0	0	0

Burial

Average count per cherry in sample

	Adults	*Pupae*	*Larvae*	*Eggs*	*Total*
	3.77	**2.62**	**4.04**	**1.35**	**11.77**
Likely number in 5 cherry	**19**	**13**	**20**	**7**	**59**

Depth mm	Moisture %	Fungus mg/pot	Cage	Escapes Total	Fraction of ... likely at start *Adults*	*Adults, pupae, & larvae*	*Adults & pupae*
125	50	0	Wood	17	0.895	0.531	0.327
175	50	0	PVC	9	0.474	0.281	0.173
125	70	0	PVC	1	0.053	0.031	0.019
175	70	0	Wood	6	0.316	0.188	0.115
125	50	5.715	PVC	3	0.158	0.094	0.058
175	50	5.715	Wood	3	0.158	0.094	0.058
125	70	5.715	Wood	2	0.105	0.063	0.038
175	70	5.715	PVC	8	0.421	0.250	0.154

Abstract: Pesticide Registration Update

Mike K. Kawate[1], Julia A. Coughlin[1], James K.F. Kam[1], and Andrea M. Kawabata[2]
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Since the last Coffee Berry Borer (CBB) Summit, laboratory bioassays were conducted with three additional insecticides, indoxacarb (Avaunt), zeta-cypermethrin (Mustang), and sulfoxaflor (Closer). Of these three, only indoxacarb showed good efficacy against CBB. A small field test was conducted with indoxacarb to determine crop safety and collect additional efficacy data. Crop safety was acceptable, and indoxacarb provided significant, but not complete, in-field control of CBB. Good efficacy will be partly dependent on thorough spray coverage of the berries and on whether CBB is exposed to the spray directly or indirectly. An IR-4 project was requested and prioritized at the 2014 Food Use Workshop. IR-4 field residue trials for indoxacarb will be implemented this year (2015).

Status of ongoing projects: IR-4's final report for cyantraniliprole is under review by QA and the manufacturer; pyrethrins+PBO, all field residue trials and laboratory analyses are complete and received at IR-4 HQ's; spinosad and spinotoram, tolerances proposed in Federal Register for both active ingredients, and EPA is supposed to make a decision by 06/2015. Bifenthrin is a potential IR-4 project for 2016, but a full risk cup may prevent it from going forward.

Possible additional insecticides we might test: *Bacillus thuringiensis galleriae* (beetleGONE!), lambda-cyhalothrin (Warrior), and beta-cyfluthrin (Baythroid).

Pesticide Registration Program

Update for CBB Summit

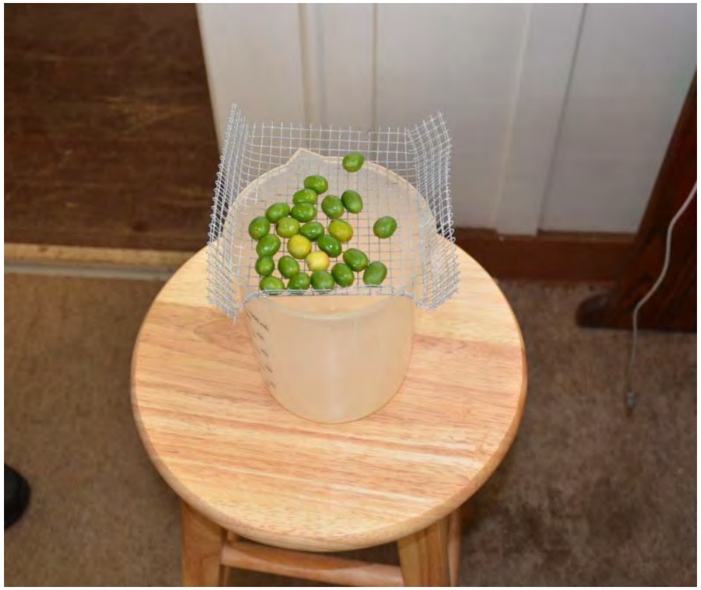
May 14, 2015

Mike Kawate
Plant & Environmental Protection Sciences
College of Tropical Agriculture and Human Resources
University of Hawaiʻi at Mānoa

LABORATORY BIOASSAYS

Direct:
Sprayed CBB directly

Indirect/Ingestion:
Dipped berries



- **Maximum field rate**
- **100 gal/acre**
- **8 fl oz/100 gal WideSpread Max**

LABORATORY BIOASSAYS

Direct: untreated berries + treated CBB
Indirect / Ingestion: treated berries + untreated CBB

Portion cups filled with plaster of Paris, 4 reps
Maintained moisture in cups
Evaluated after 2 weeks

LABORATORY BIOASSAYS – INSECTICIDES TESTED

		Effective?	
Common Name	Trade Name	Direct	Indir / Ingest
chlorpyrifos	Lorsban	yes	yes
cyantraniliprole (IR-4)	Exirel	some	yes
indoxacarb (IR-4)	**Avaunt**	**yes**	**yes**
bifenthrin (IR-4?)	Sniper	yes	yes
zeta-cypermethrin	**Mustang**	**yes**	**no**
fenpropathrin	Danitol	no	no
sulfoxaflor	**Closer**	**some**	**no**
tolefenpyrad	Torac	no	no
B. thuringiensis isral.	VectoBac	no	no

All the insecticides in this table are not labeled for use in coffee. The three insecticides that are unshaded were tested since the last CBB Summit.

LABORATORY BIOASSAYS – INSECTICIDES TESTED

		Effective?	
Common Name	Trade Name	Direct	Indir / Ingest
Na-tetrahydroborate	Prev-Am	no	no
K-salts of fatty acids	M-Pede	some	no
pyrethrin + PBO	Evergreen 60-6	yes	no
pyrethrin + PBO	Pyganic 5.0	yes	no
imidacloprid	Admire Pro	some	no
buprofezin	Applaud	no	no
neem oil	Trilogy	no	no
azadiractin	Neemix	no	no
spirotetramat	Movento	no	no

All these insecticides are labeled for use in coffee.

LABORATORY BIOASSAYS – INSECTICIDES TESTED

		Effective?	
Common Name	Trade Name	Direct	Indir / Ingest
spinosad (IR-4)	Entrust	no	some
spinosad (IR-4)	Success	some	some
spinetoram (IR-4)	Delegate	yes	yes

Pending tolerance establishment; will be decided upon by EPA in 06/2015. If tolerances are established, DowAgrosciences may then add coffee to the pesticide products' labels. The pest for this use will be coffee leafminer. However, we tested the proposed rates for coffee leafminer on CBB, and spinetoram looks promising. There may also be utility for these products against the banana moth to protect emerging shoots after pruning (but we did not test for this).

FIELD TEST – SLEEVED BRANCHES

cyanatraniliprole (Exirel)
indoxacarb (Avaunt)

Selected branches with berries, removed CBB-infested berries and yellow to ripe berries

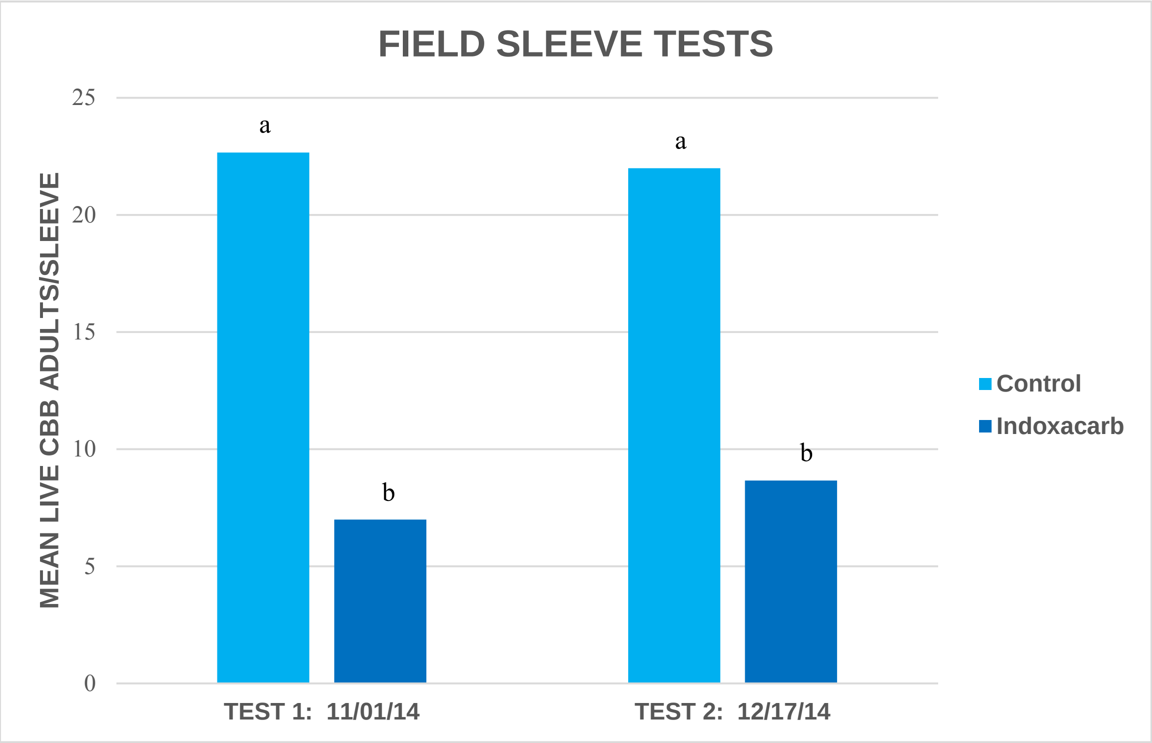
Treated with:

- Maximum field rates
- 100 gal/acre
- WideSpread Max at 8 fl oz/100 gal
- One application
- Mist blower

FIELD TEST – SLEEVED BRANCHES

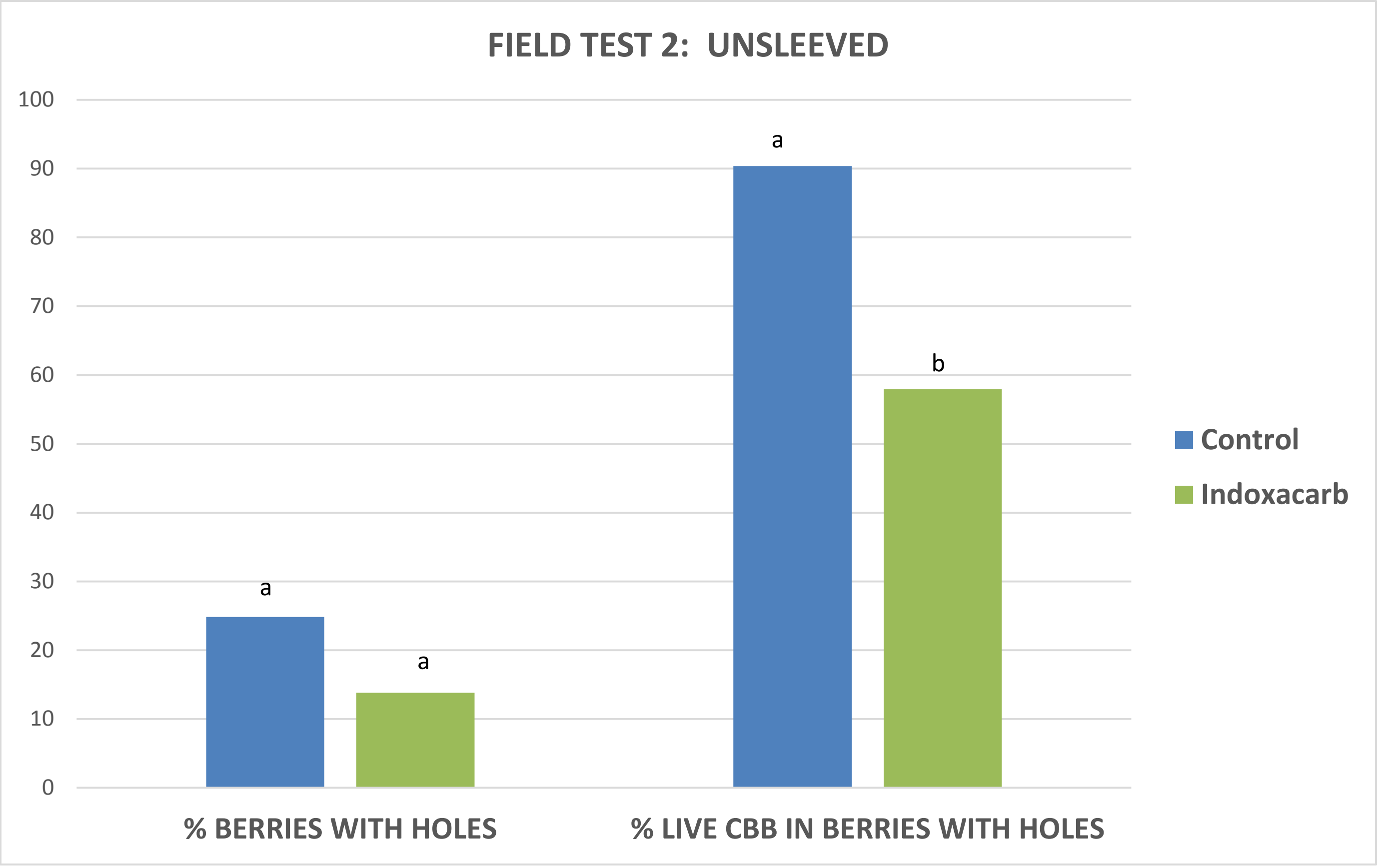
Attached sleeve to branch, introduced 25 mature female CBB collected from infested raisin berries

Evaluated 2 weeks after treatment



FIELD TEST – SLEEVED BRANCHES

FIELD TEST – UNSLEEVED BRANCHES



PROJECTS' STATUS

cyantraniliprole (Exirel) – IR-4

Final report (petition) is under review by QA and chemical manufacturer. Submission to EPA?

pyrethrins + PBO (Evergreen 60-6, Pyganic 5.0) – IR-4

All field and laboratory residue data complete and received at IR-4 HQ's; drafting tolerance petition.

indoxacarb (Avaunt) – IR-4

Field residue trials to be initiated in 2015.

bifenthrin (Sniper) – IR-4

Possible project for 2016; needs approval.

PROJECTS' STATUS

spinosad (Entrust/Success) – IR-4
spinetoram (Delegate) – IR-4

Proposed rules published in Federal Register for both these active ingredients.
EPA PRIA date ~06/2015.
Will be labeled for coffee leafminer, but proposed use pattern may have utility for CBB control, and for protection of new shoots from banana moth after pruning.

POSSIBLE PRODUCT(S) FOR TESTING

Bacillus thuringiensis galleriae (beetleGONE!)

Need to obtain a sample for testing, but needs HDoA import permit, and company (Phyllom) wants formal testing agreement.

Other suggestions for insecticides to test?

Recently met with Bayer CropScience; they suggested also testing lambda-cyhalothrin (Warrior, Syngenta) and beta-cyfluthrin (Baythroid, Bayer CropScience)

QUESTIONS?

Abstract: Volatiles From the Coffee Berry Blossom End and Their Potential Applications in Pest Management of Coffee Berry Borer *Hypothenemus hampei* (Coleoptera: Curculionidae)

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United States Department of Agriculture Agricultural Research Service,
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The coffee berry borer (CBB), *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae) is the most destructive pest of commercial coffee worldwide. We proposed two strategies to control CBB: push-pull and push-kill, by utilization of repellents and attractants. Push-pull works by pushing CBB from coffee berries using repellents and then attracting these CBB to the pull traps baited with attractants. Push-kill works by mixing repellents with pesticides so that CBB is pushed out from the bored tunnel of the coffee berry and exposed to pesticides, resulting in enhanced pesticide efficacy.

Considering the overlooked phenomenon that the majority of beetles bore through the blossom end, we proposed that the blossom end of green coffee berries contains more attractants and fewer repellents than the epicarp of the berry. Therefore, we carried out a comparison study of the volatile profiles between the blossom end and epicarp.

Using a headspace-GC-MS system we found that three compounds were significantly higher in the blossom end of non-infested green berries, and 3-ethyl-4-methylpentanol and an unknown peak were significantly higher in the blossom end of infested green berries. We further demonstrated in a field trial that some of the compounds showed repellent activity to CBB infesting Hawaiʻi coffee farms. Initial field tests demonstrated that strategies of both push-pull and push-kill can potentially be applied to control CBB in an integrated pest management system.

Abstract: Predation by Flat Bark Beetles (Coleoptera: Silvanidae and Laemophloeidae) on Coffee Berry Borer (Coleoptera: Curculionidae) in Hawaiʻi Coffee

Peter A. Follett[1], Andrea M. Kawabata[3], Robert R. Nelson[7], Curtis P. Ewing[6], Julie Gaertner[2,5], Glenn M. Asmus[2], Scott M. Geib[1], Jennifer Y. Burt[4], and Kally S. Goschke[4]

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The coffee berry borer (CBB), *Hypothenemus hampei*, is a serious pest of coffee worldwide and a new invasive pest in Hawaiʻi. Adult flat bark beetles, mainly *Leptophloeus* sp. (75%) and *Cathartus quadricollis* (21%) (Coleoptera: Silvanidae and Laemophloeidae, respectively), were found feeding on CBB in coffee trees. Research was conducted to better understand the ecology of these predators and explore ways to increase their role in suppressing CBB populations in coffee.

Feeding assays demonstrated the capacity for adult and larval flat bark beetles to feed on all CBB life stages in the laboratory. Molecular markers were developed to detect CBB in predator guts, and analysis of collections from coffee in the field showed that the majority of flat bark beetles were feeding on CBB. The predators are widely distributed in the coffee growing area of the Big Island, but feed mainly in dried coffee on the tree rather than in ripening cherry where crop damage occurs. Berlese funnel extraction of flat bark beetles from dried beans on the tree indicated that predator numbers can be extraordinarily high (e.g., 25 adult predators per 150-bean sample). *C. quadricollis* can be raised on a cracked corn–cornmeal diet, and a raise-and-release program was started by providing farmers with a starter kit. Over 200 predator starter kits were handed out to coffee farmers during four workshops on the Big Island. The predators do not appear to be susceptible to *Beauveria bassiana* which is used for field control of CBB in coffee.

Flat Bark Beetles Gorge on Coffee Berry Borer

Peter Follett, Bob Nelson, Andrea Kawabata
USDA –ARS Hilo, Hawai'i

Flat bark beetle predators

- Feed on small insects and mites or fungi under bark
- Adults well adapted to exploit scolytids

In Hawai'i:

- Primarily 2 species in Kona coffee berries
  - *Leptophloeus* sp. (Laemophloeidae) – ~70%
  - *Cathartus quadricollis* (Silvanidae) – ~30%
- Also found in macadamia "sticktight" nuts
- A few are stored-grain pests

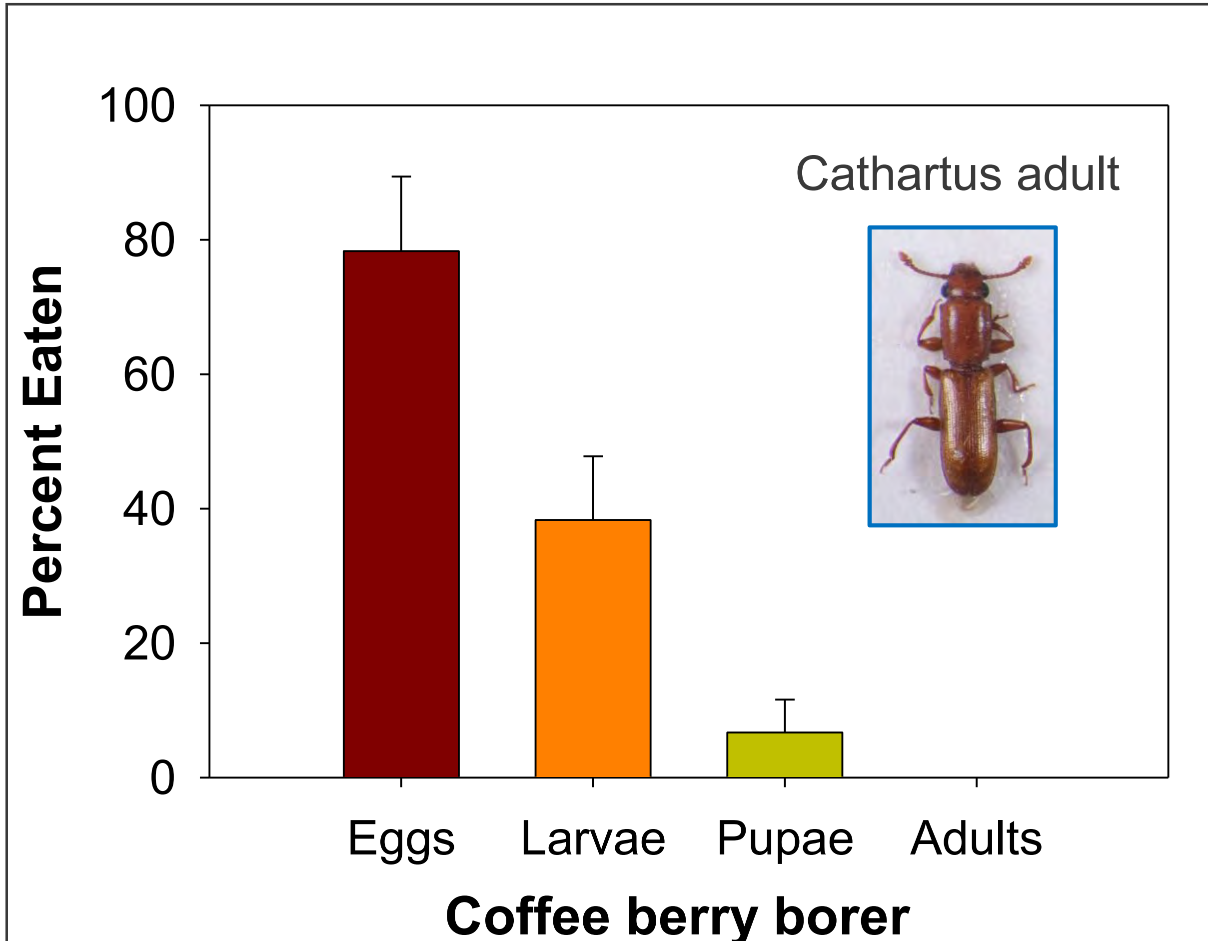
Objectives

- Proof of predation
  - Lab bioassays
  - Video
  - Genetic markers
- Geographical distribution
- Population tracking of CBB
- IPM - augmentation
  - Mass rearing and release
  - Aggregation pheromone
- Susceptibility to *Beauveria bassiana*

Cathartus quadricollis

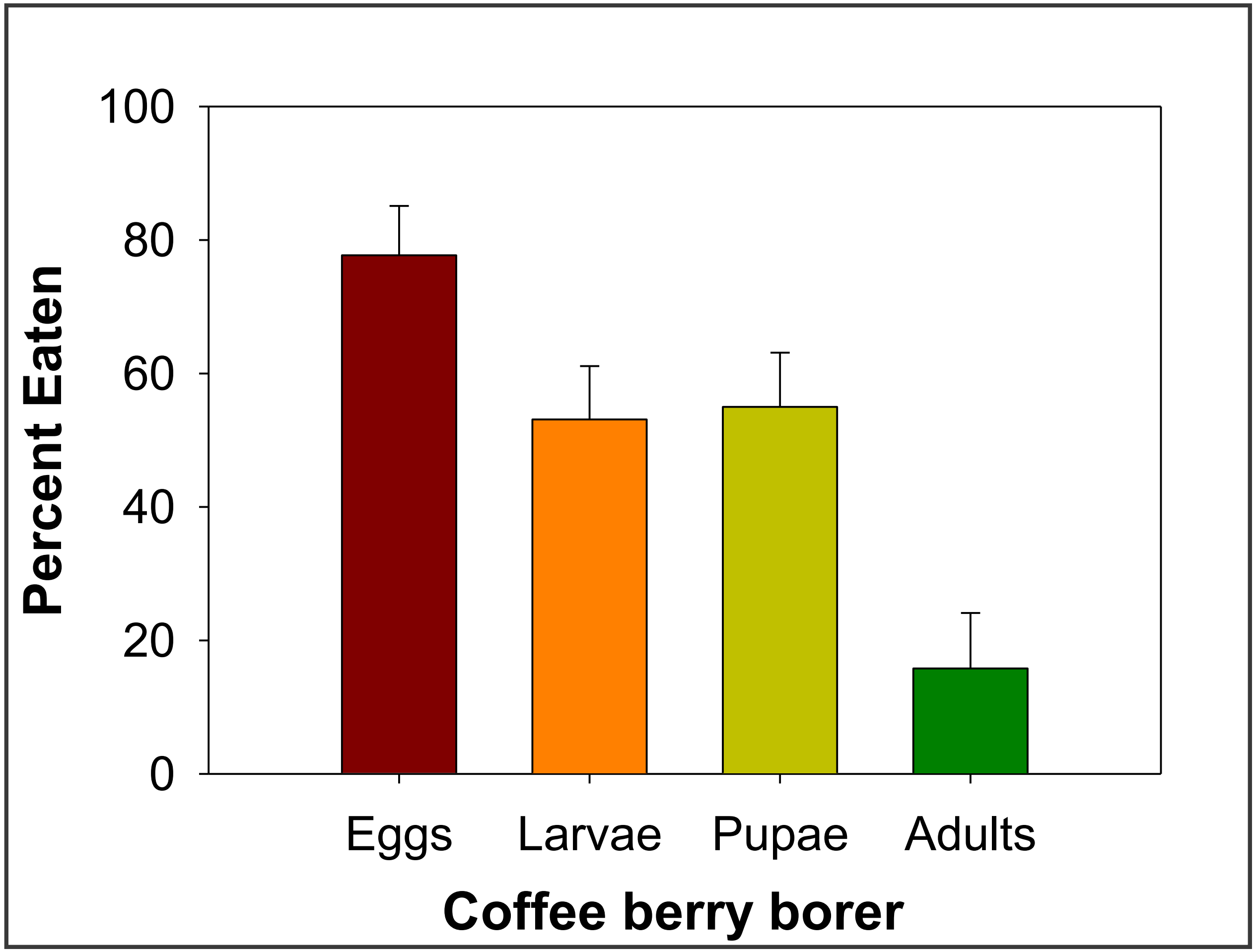
Lab bioassay:
Cathartus **choice** test

- 40 prey items, 10 each life stage
- Petri dish
- 3 *Cathartus* adults or larvae
- 24 h in dark



Lab bioassay: *Cathartus* **no-choice** test

- 20 prey items
- Petri dish
- 3 *Cathartus* adults or larvae
- 24 h in dark

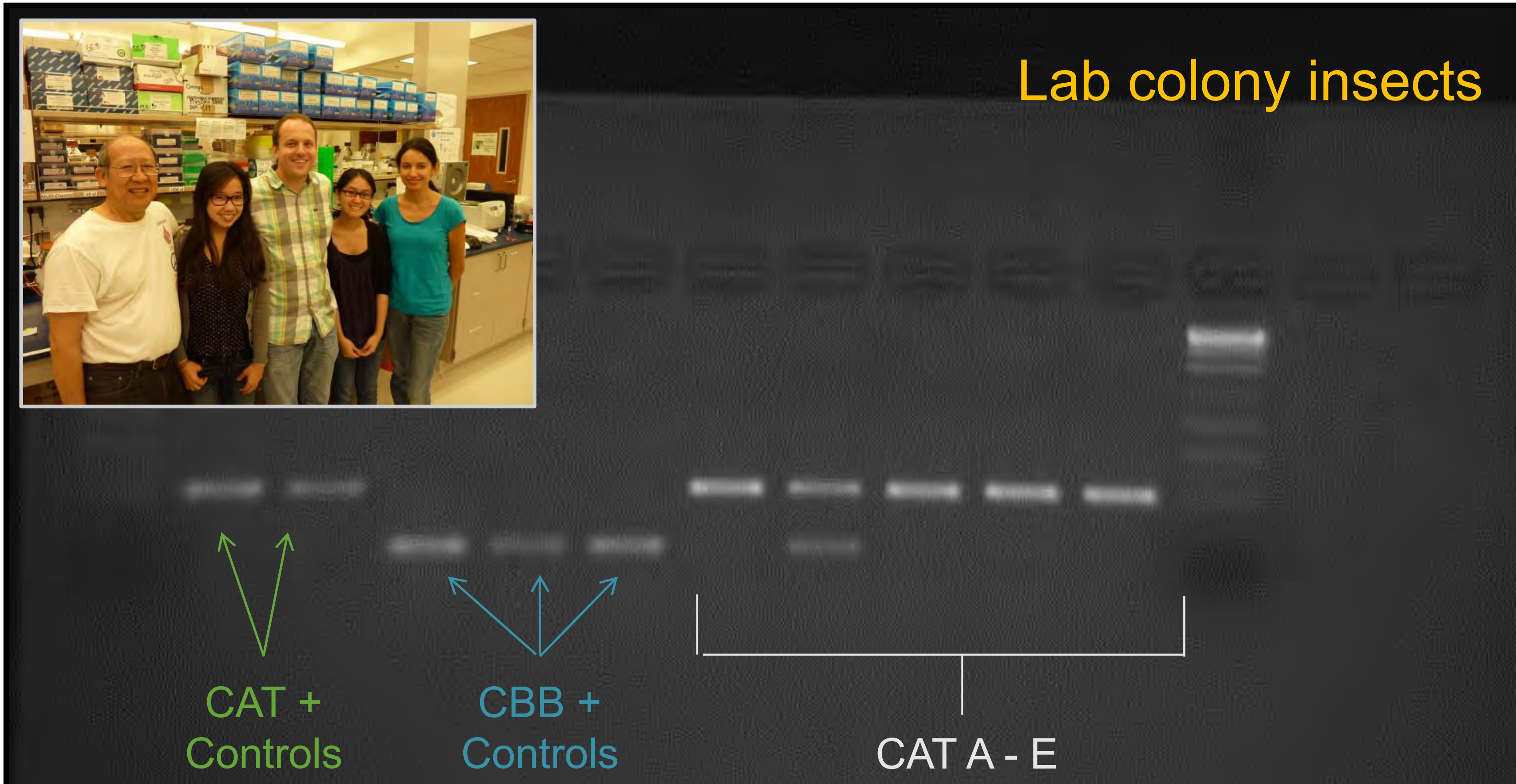


Video: Cathartus *adult chewing on CBB in bean*

CBB D

ntrol

Genetic markers: *Species-specific primers in CO1 region of mitochondria*



- CAT: ~200bp
- CBB: ~125 bp

Field predation

Can we find CBB DNA in *Cathartus*?

24 total:

11

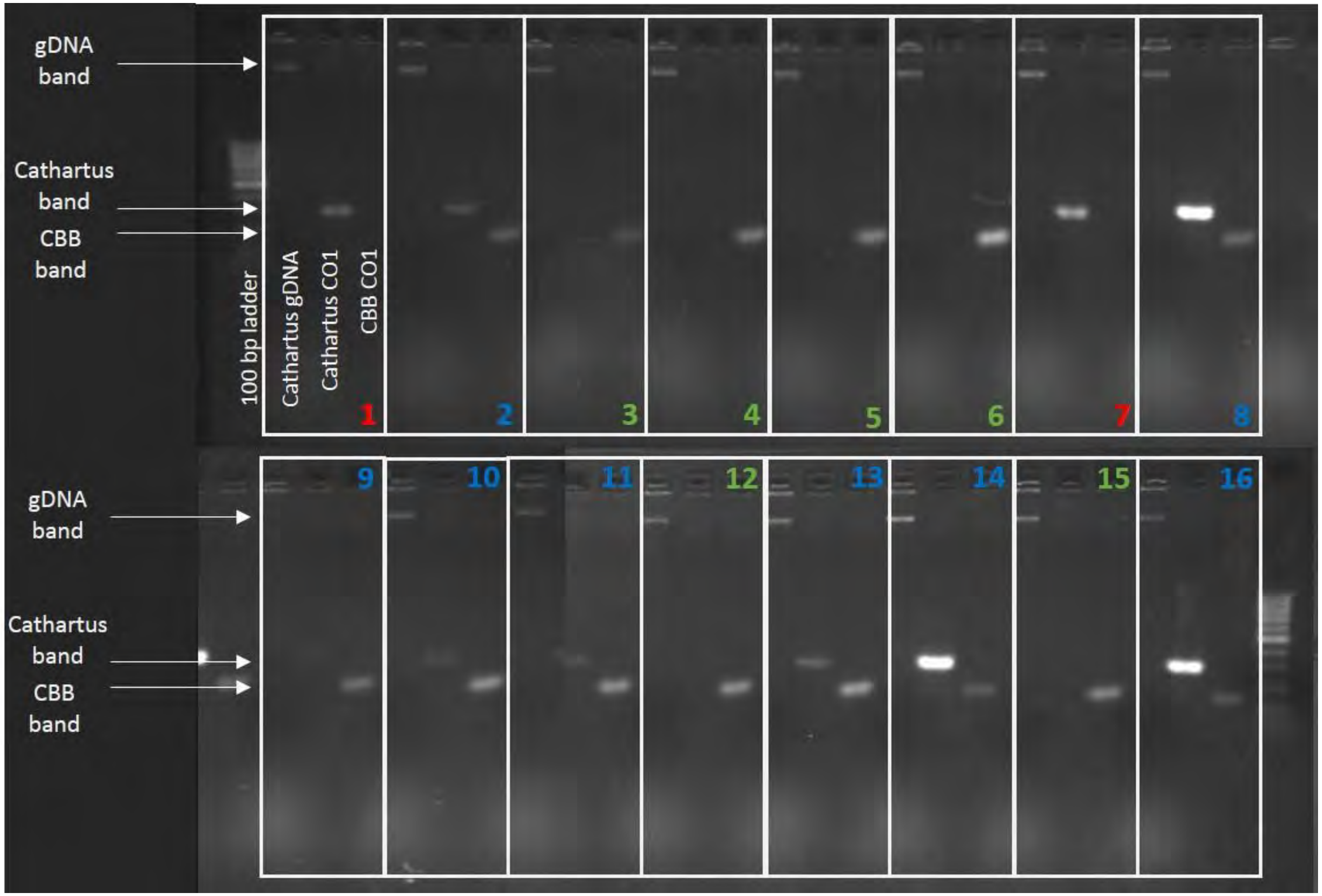
Cathartus + CBB

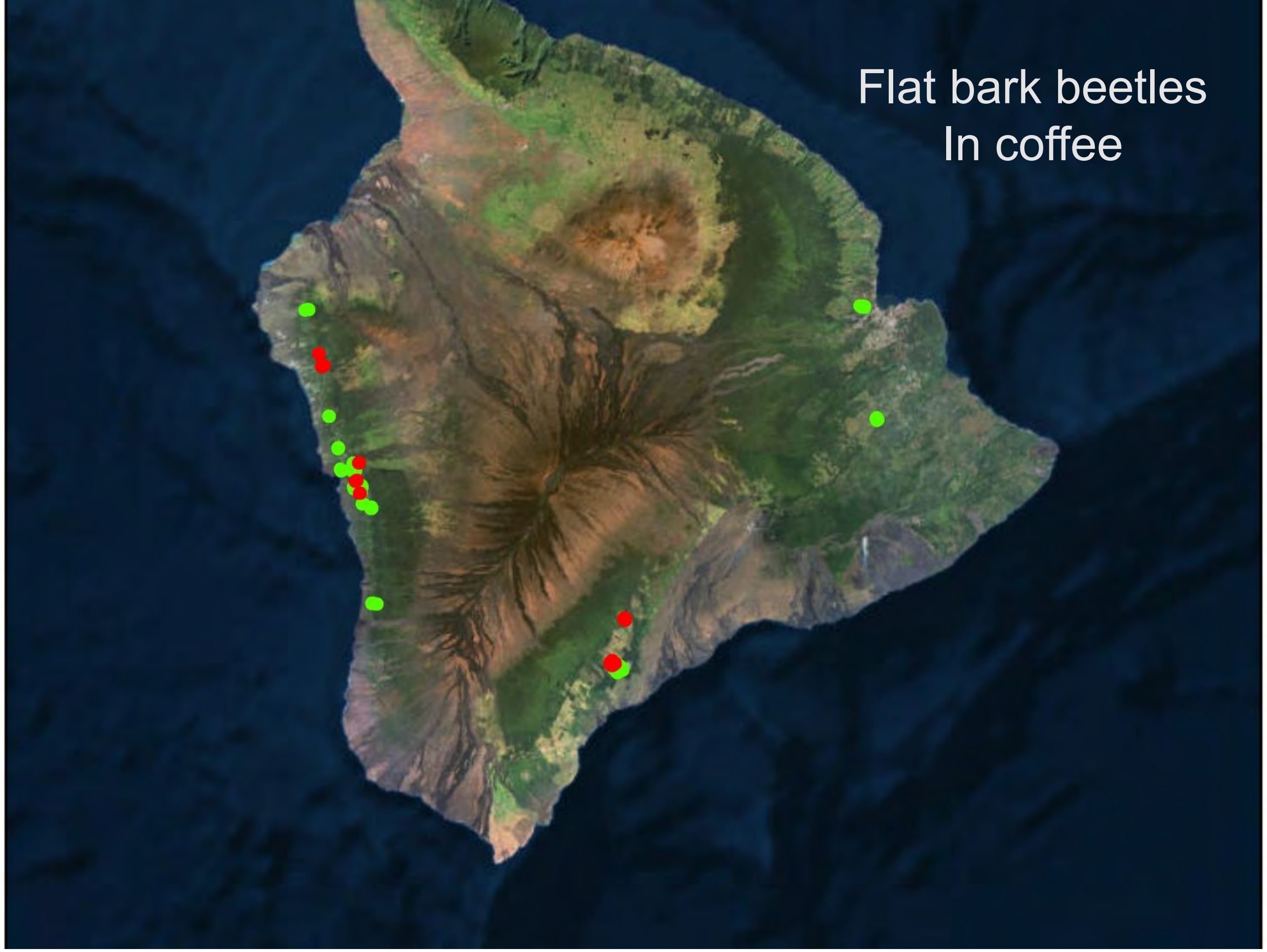
10

Leptophl.+ CBB

3

Cathartus, no CBB



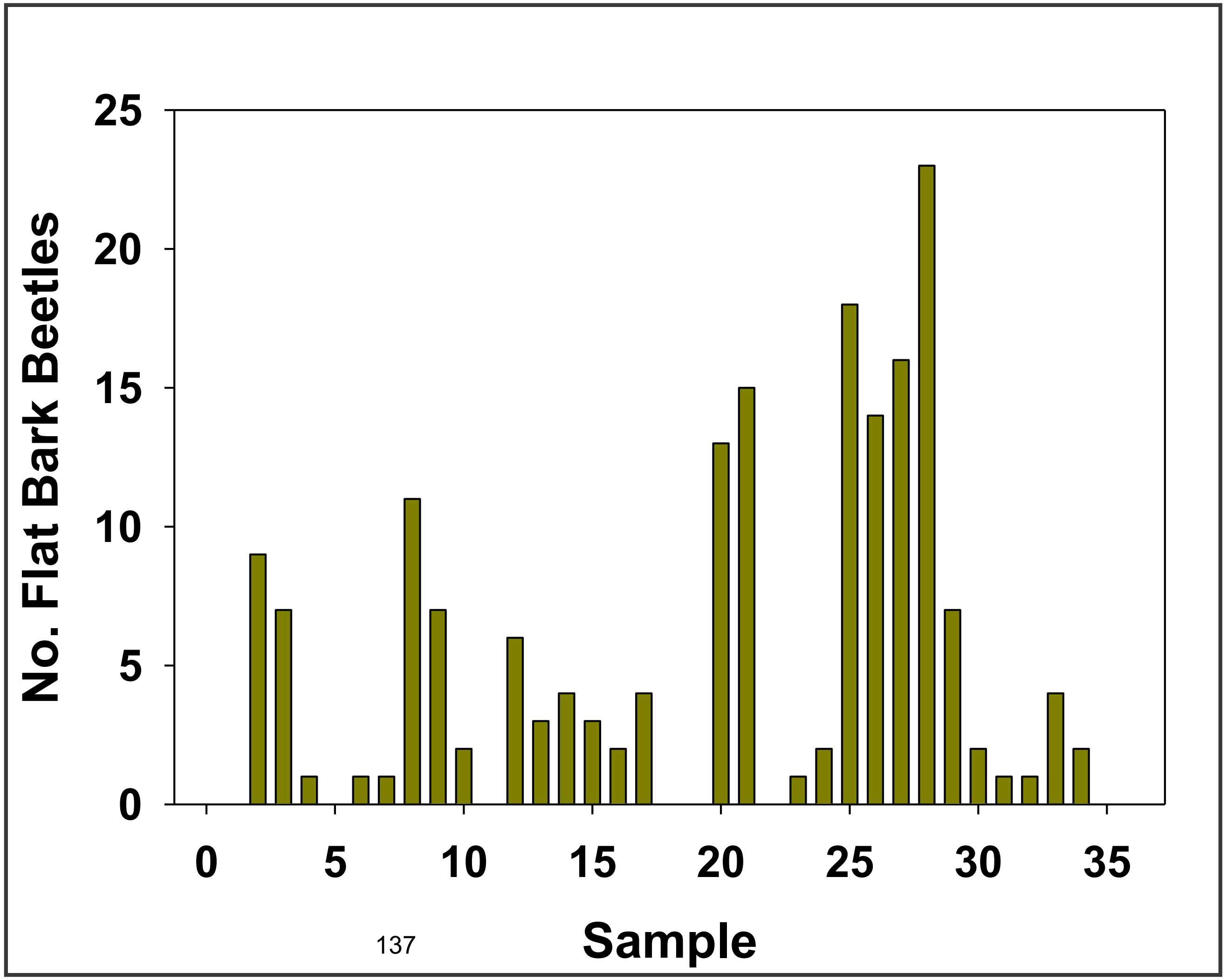


Geographical distribution

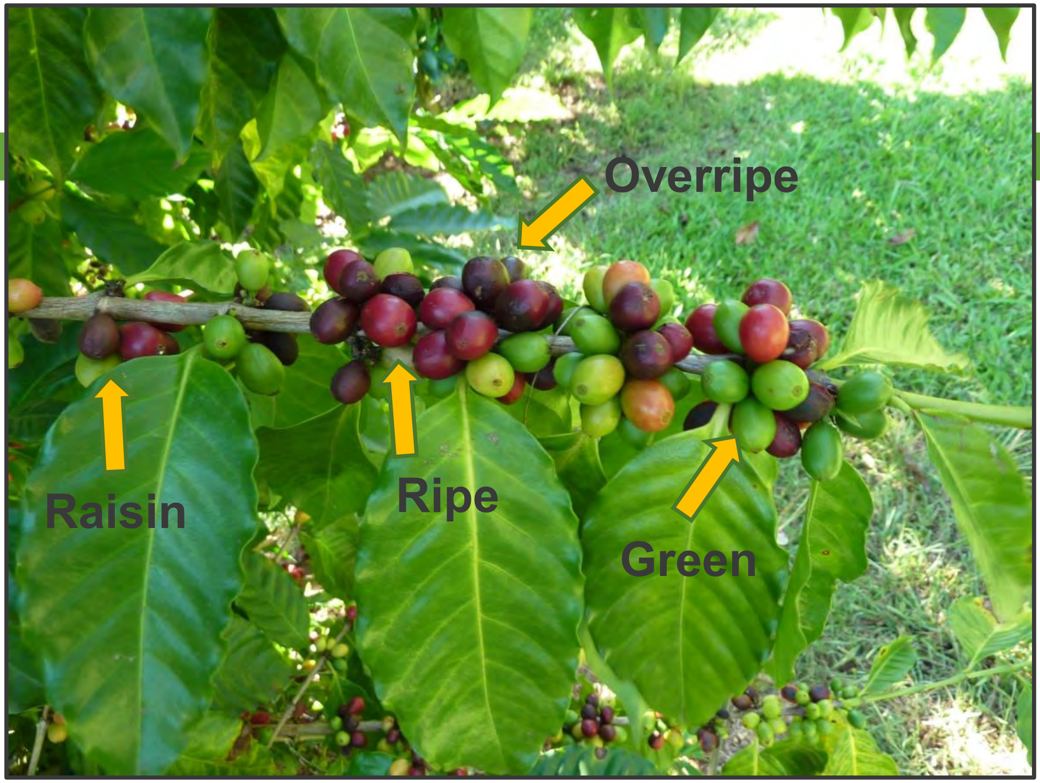
- "Raisin" samples from coffee farms**
- Cherry samples from processor deliveries

How common are flat bark beetles in coffee?

- Sample of 150 infested "raisins"
- 2-acre blocks
- Berlese funnel
- Count



Maturity stage

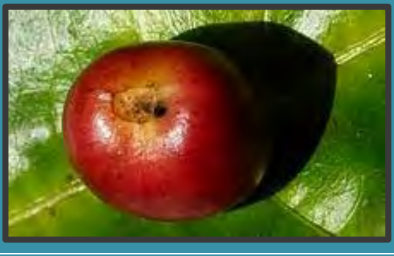


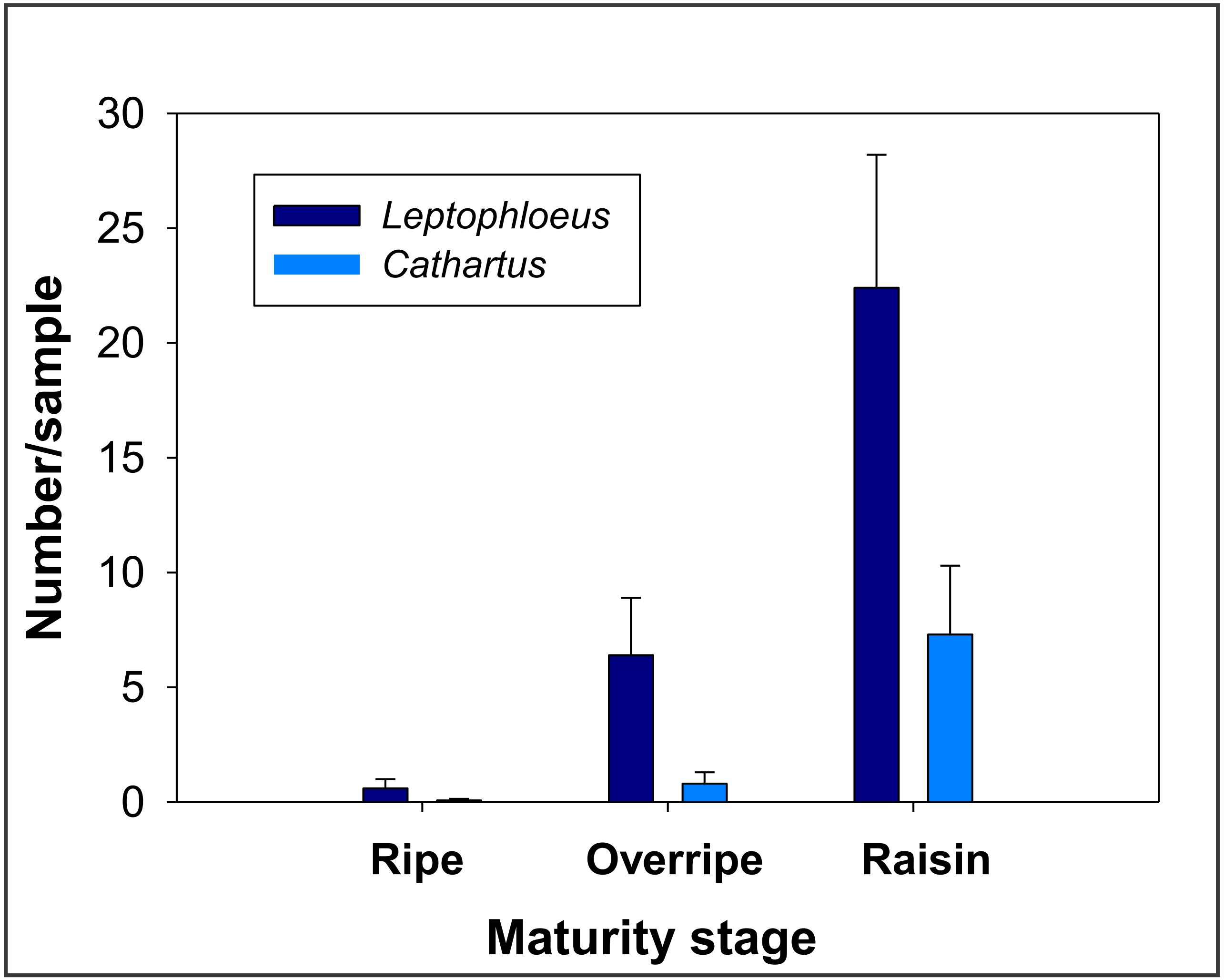
Can they track CBB populations?

- Flat bark beetles mainly found in "raisins" (dried beans) and overripe cherry
- Mainly found in trees, not on the ground

Maturity effect:
Flat bark beetles in infested beans

- 6 farms
- 3 maturity stages
- Berlese funnel
- Count





IPM – mass rearing

- Diet of cracked corn and cornmeal 4:1
- Potential for augmentative releases

Cathartus workshops

- Coffee grower education and outreach
- Provided 185 predator "starter" kits

Next steps

- Susceptibility to *Beauveria bassiana*
- What impact are flat bark beetles having?
  - Sleeve cage tests
- Larval ecology


Questions?