Balancing pest risk with cost of control when using *Beauveria bassiana* for Coffee Berry Borer Control

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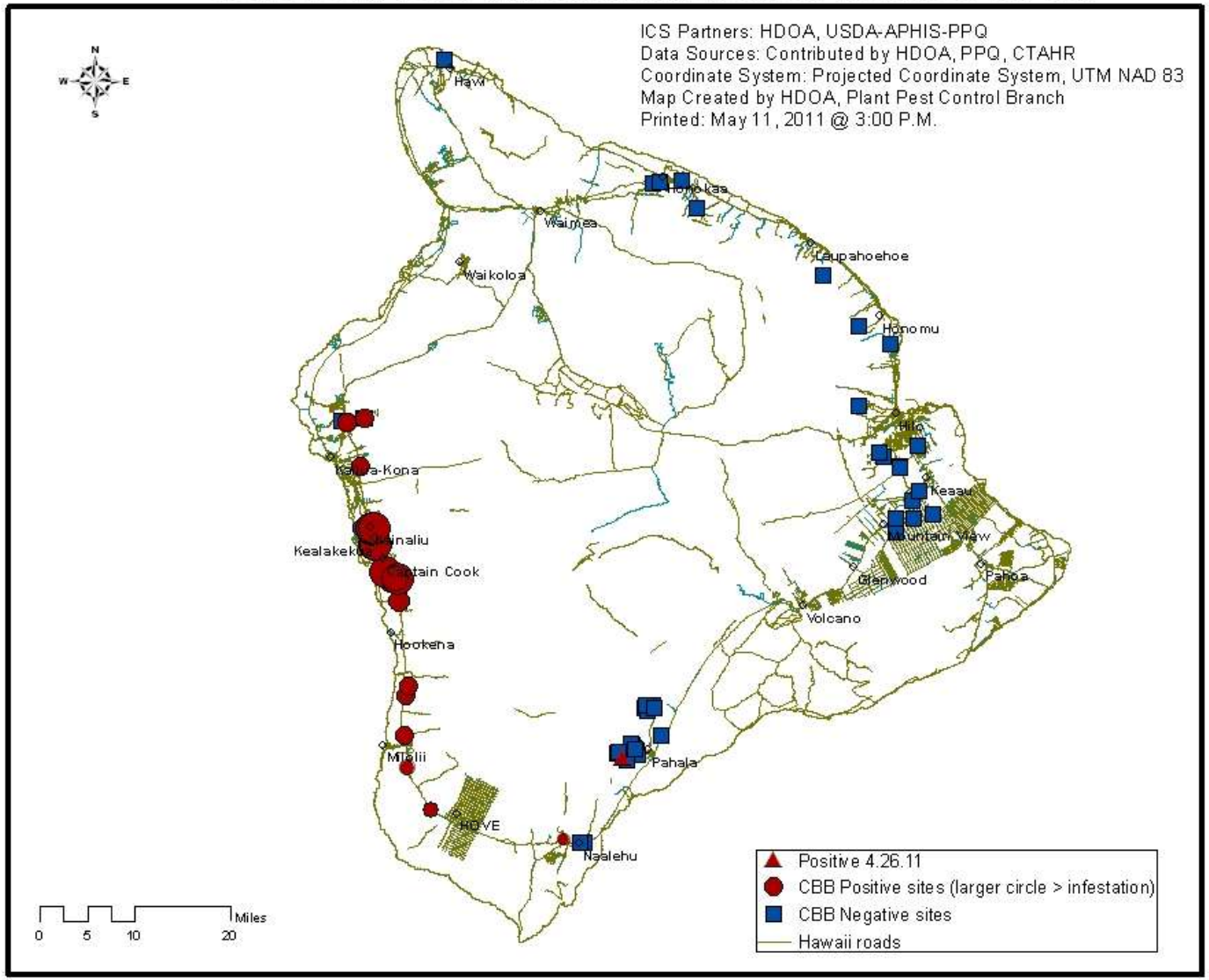
Coffee berry borer
Hypothenemus hampei (Ferrari, 1867)

- Native to Africa
- Most harmful pest of coffee worldwide
- Affects 70 countries, particularly those in Latin America
- Brazil: 1926
- Guatemala and Mexico: 1970's

Coffee Berry Borer (Hypothenemus hampei) Hawaii Survey Map






- The growth of the insect (from egg to adult) takes between 24 and 45 days. Female drills the berry through the central disc.
- Two days after the access, the beetle lays 35–50 eggs, which produce ~10 females for each male.
- The lifespan for females is 35–190 days and for males 40 days. The new insects mate inside the seed.



- Newly produced, emigrating females may infest cherries of the same coffee plant, others spread to new plants. Males never leave the fruit.
- There can be three to five generations per season. Up to a hundred beetles can be found in a single fruit.
- The insect is very sensitive to desiccation and waits for the rains to leave the fruit. The most affected areas in the crops are the shady and moist ones.

Coffee Berry Borer Trapping (Eric Jang, Lori Carvalho)

Trap Types:

Scentry 1= paper trap w/ sloped roof

Scentry 2 = paper trap w/ flat roof. Developed by Scentry Biologicals, Billings, Montana

Bucket 1 = one entry window (15cm tall, 15 cm in diameter, 7.5 X 7.5 cm window; red pepper Krylon Fusion spray paint)

Bucket 3 = three entry windows

Brocap ® = developed by CIRAD and PROCAFE

New area of research:

(1) Pher- emit dispenser

(2) Scentry Sticky traps

Evaluations are on-going

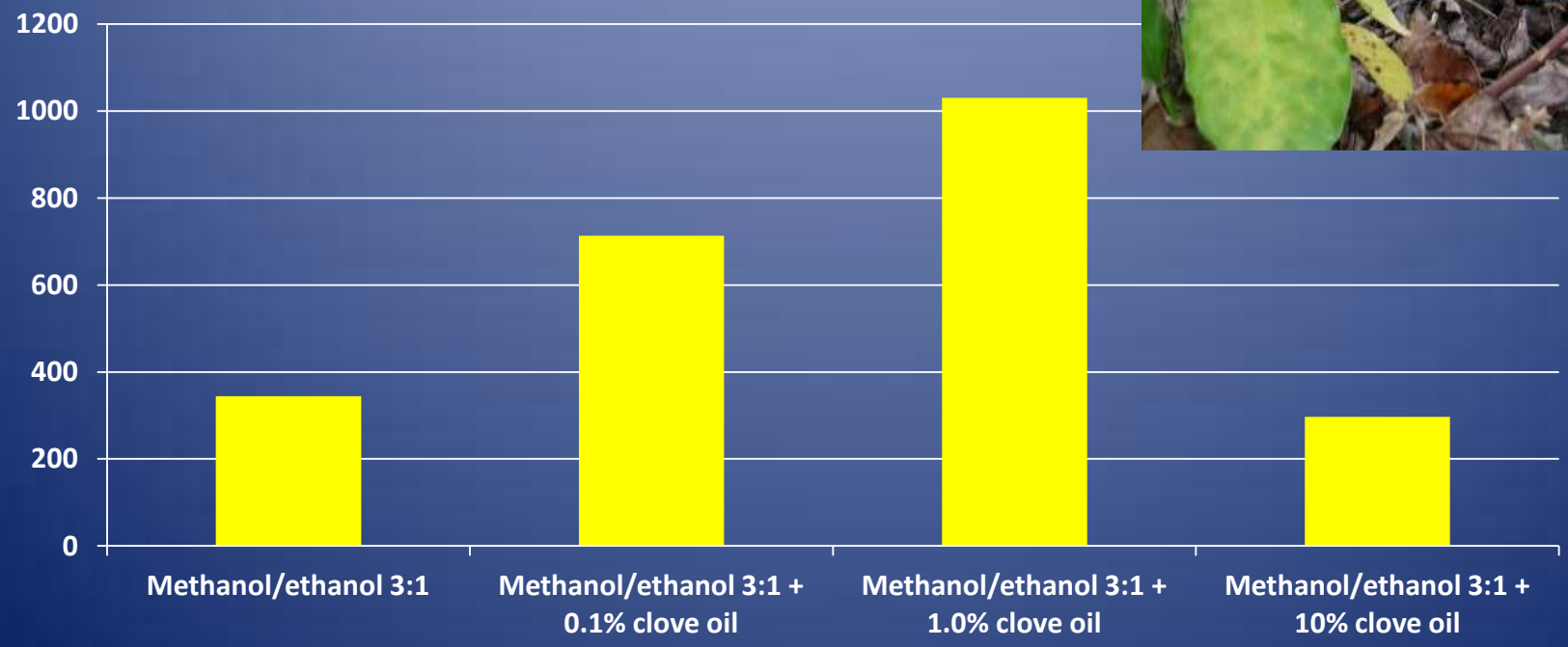
Scentry 1

Scentry 2

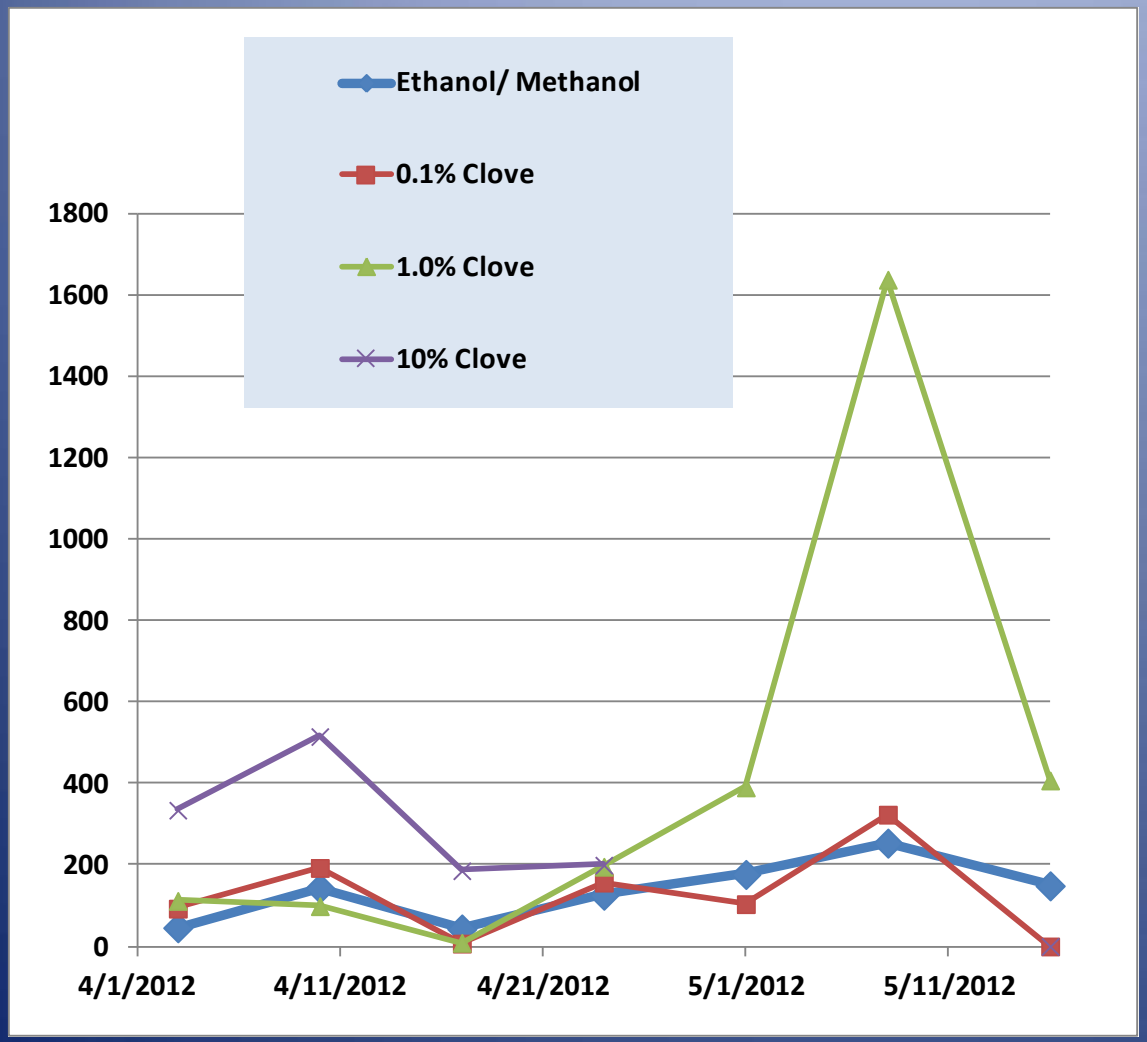
Bucket 1

Brocap

Number of CBB borers caught in 5 milk-jug traps over 7 days (Captain Cook)



Number of CBB caught in 5 milk jug traps per week



Control of Coffee Flowering to reduce CBB levels in field – Tracie Matsumoto

Without sanitation coffee berries will always be present in this field

Gibberellic Acid promotes uniform flowering

Untreated Control Trees

GA_3 Treated Trees

Research on Freezing as a Potential Quarantine Treatment for Green Coffee

1. Cherries frozen for 1-5 days at different temperatures
2. Cherries dissected to determine survival of beetles
3. >15,000 beetle life stages were counted (eggs, larvae, pupae, adults)
4. No survival after exposure to negative 15 degrees C for 48 hours
5. Hawaii Dept. of Agriculture may consider using our data to develop a treatment. As our samples were very small, it is recommended that freezing time for green coffee be longer than 48 hours to ensure all beetles are dead, and the timer should not be started until the warmest part of the coffee gets down to negative 15 degrees.

Biological Controls

- Birds reduce levels of coffee berry borer in Jamaica. Works best in shade.
- *The nematodes Metaparasitylenchus hypothenemi* (Nematoda: Allantonematidae) and *Panagrolaimus* sp. been reported in attacking CBB in the field in Mexico and in India, respectively.
- In laboratory experiments, Heterorhabditis sp. and *Steinernema* spp. (including *Steinernema carpocapsae*) have been shown to infect the insect.

Infective juveniles of *Metaparasitylenchus hypothenemi* emerging from an infected coffee berry borer (left), and detail of the infective juvenile (right). Credits: (A) A. Castillo, ECOSUR; (B) G. Nieto, ECOSUR.

Nematodes wiggling after spilling out of dead CBB larva

Entomopathogenic Nematode: *Steinernema carpocapsae*

- Roxana Cabos, Robert Hollingsworth, Jessica Manton


http://nematode.unl.edu/epn/Scarp.htm

Mass-produced by Becker Underwood (product name: Millenium)

Nematodes are mixed with water, sprayed on crops. Commonly used to control caterpillar pests, but also infect CBB (especially larvae) when sprayed onto coffee cherries held at high humidity

Nematodes go through life cycle in 8 days at 20 degrees C.

Juveniles burst from dead insect and seek out new hosts.

0.25 Billion Nematodes (in 3x5" bento container)

First nematode field test was a bust

A second field experiment was more successful

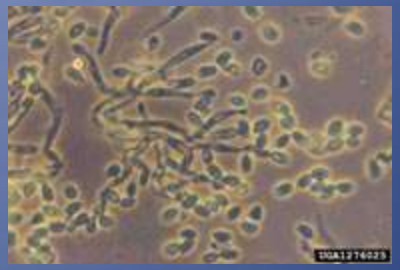
	Nematodes applied directly to coffee berries (SE)	Nematodes applied to mulch and coffee berries (SE)	Water applied to coffee berries (SE)
Test 1 - Laboratory			
Adults	26.57% (3.33%)	N/A	1.56% (1.56%)
Larvae	23.73% (0.96%)	N/A	0.00% (0.00%)
Test 2 - Field			
Adults	6.66% (3.10%)	12.01% (2.54%)	3.82% (3.29%)
Larvae	18.72% (5.17%)	19.07% (8.13%)	1.25% (1.09%)

Table 1. Percent mortality (SE) in two experiments applying *Steinernema carpoca* to *Hypothenemus hampei* in coffee berries

Beauveria bassiana is by far the most important entomopathogen for CBB, and considered the most important natural enemy generally.

Beetles killed by *Beauveria bassiana*

Beauveria bassiana –what is it?



- A generalist fungal pathogen of insects
- A good soil saprophyte; a weak insect pathogen
- Thousands of strains from around the world represented in entomopathogen collections.
- Commercial products are available
- For most insect pests affected: works well in the lab or greenhouse; frequently does not work in the field. Needs high humidity; broken down by UV light.
- Until February 2011, was not permitted for general use in Hawaii due to quarantine concerns

Does spraying Beauveria (GHA strain) on cherries actually work?

- Lifetable studies suggest that *B. bassiana* is the major biotic mortality factor affecting CBB in Columbia. It's effect is especially heavy (up to 80% mortality) when CBB are attacking young berries (Duque-O and Baker 2003). There was no previous quantitative field data on effect of GHA strain on CBB, just field observations in Puerto Rico.
- Effects of sprays not easily measured (dissection of cherries is slow and meticulous work)
- There is a lot of naturally occurring *Beauveria* already out there
- May depend on timing of sprays or weather conditions: beetles more exposed in early stages of cherry development
- Spraying *Beauveria* to protect cherries is different from spraying after the cherries have already become infested

Beauveria efficacy trial in heavily infested coffee in Honomalino

Beauveria efficacy trial in heavily infested coffee in Honomalino

Sprayed:

(1) Mycotrol *(at 1 qt/acre)*
+ EcoSpreader *(silicone spreader), ~350 ml spray solution (15 seconds) per tree*

- Versus -

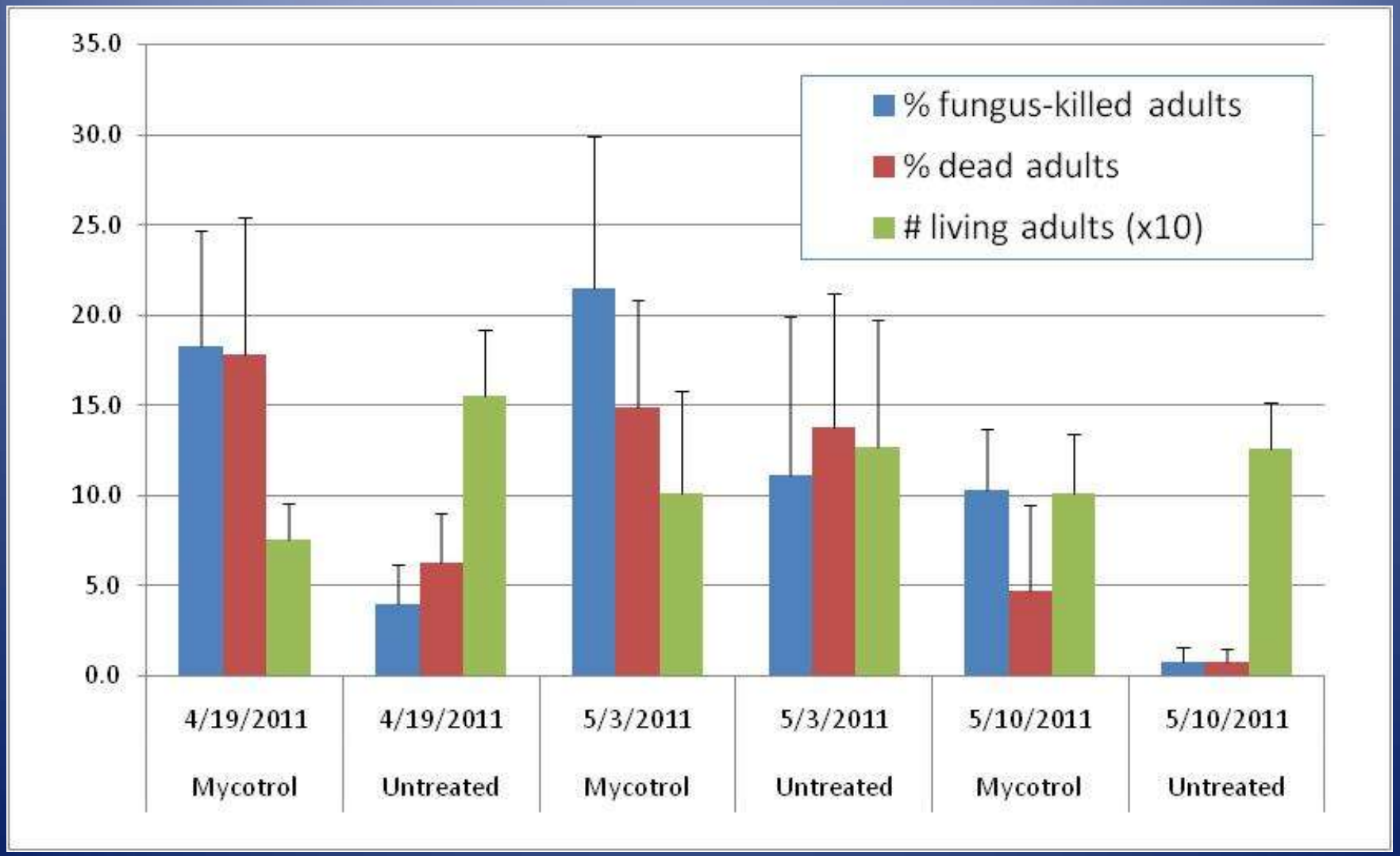
(2) Unsprayed

Harvested cherries the next day.
•Held the cherries in the lab for 7 days, then started dissections

Second and third collections of cherries from same trees made 2 and 3 weeks later; started dissecting the day after collection

Spraying water to calibrate sprayer

Beauveria efficacy trial in heavily infested coffee in Honomalino



Field Plot: farm in Captain Cook

Beauveria persistence (Lisa Keith), Strain Identification (Tracie Matsumoto) and Efficacy (Robert Hollingsworth)

Treatment field being sprayed April 25, 2012

Persistence studies

10 trees

3 trees

Spray rate = 1.5 qt/acre

Control; “no spray”

Field Sample (Tree 6)

- Lisa Keith

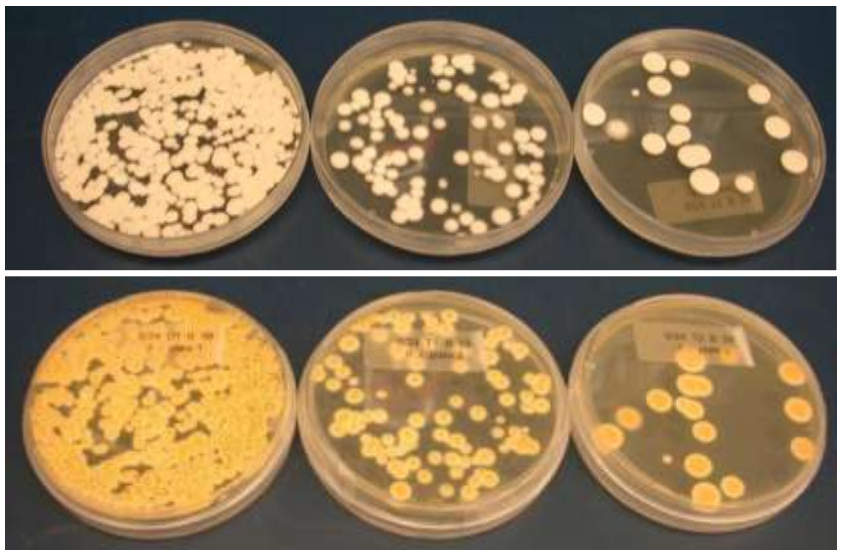
high

middle

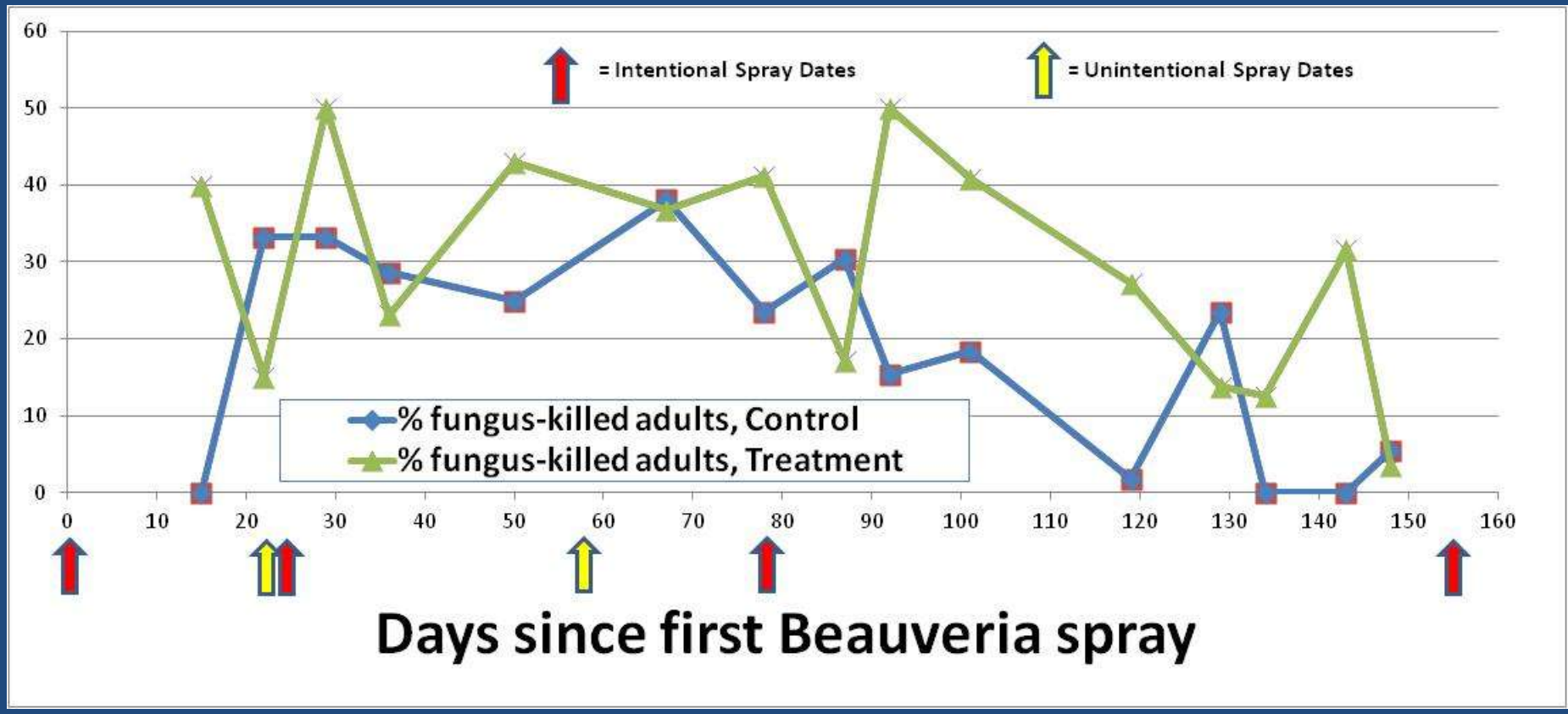
low

1 sample = 15 berries
5 berries/branch

Laboratory Results - Lisa Keith



Intentional sprays: Treatment side only
Unintentional sprays: Both Treatment and Control portions of field



Goals for Year 2

- Repeat Year 1 field trial
- Test frequency of application (2 sprays versus 4 sprays) and environment (500 ft versus 1500 ft elevation) on efficacy

What does it cost to spray *Beauveria* over one acre of coffee? (estimates)

- 7.0 ounces Beauveria product at $16.50
- 3.5 ounces Silicone Spreader (Widespread, Silwet or Ecospreader) at $4.00
- Labor at $20/hr x 2 hours using backpack: $40.00
- Total minimum cost, one spray: $60.50
- Need at least 4 sprays over the season
- Total cost per acre per year: Minimum of $242

Is 7 ounces of Botanigard per acre enough?

1. Picked off all infested berries from selected trees
2. Sprayed individual trees with mist blower
3. Went back at two weeks, collected the infested berries, and determined the percentage of adult beetles with obvious signs of *Beauveria* infection

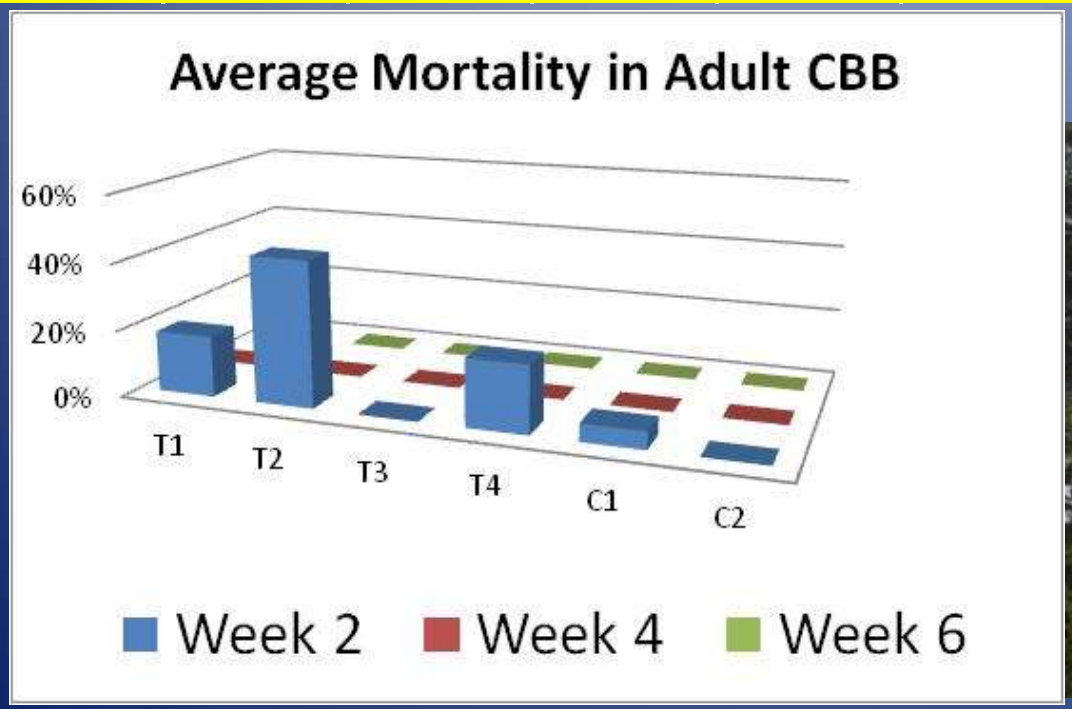
Using mist blower to apply water to experimental control trees

Warning: Very preliminary results. Just started collecting data.

Treatments

T1 - 10 ml Botanigard + 0.1% EcoSpreader
T2 - 30 ml Botanigard + 0.1% EcoSpreader
T3 - 10 ml Botanigard + 0.1% EcoSpreader + 0.1% EcoSpreader + 0.1% Eugenol
T4 - 10 ml Botanigard + 0.1% EcoSpreader + 0.1% EcoSpreader + 0.5% Caryophyllene
C1 - H_2O Only
C2 - 0.1% EcoSpreader Only

Treatment	*Week 2*
T1	18%
T2	43%
T3	0%
T4	20%
C1	5%
C2	0%



Using mist blower to apply water to experimental control trees

Main control measures for CBB

- Trapping using ethanol/methanol traps
- Spraying *Beauveria bassiana*
- Practicing good sanitation (thorough and frequent picking, not allowing cherries to fall to ground)
- If you had to select just one control measure, which would it be?

MONITORING CULTURAL PRACTICES FOR COFFEE BERRY BORER *HYPOTHENEMUS HAMPEI* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) MANAGEMENT IN A SMALL COFFEE FARM IN COLOMBIA

Florida Entomologist: September 2011
http://journals.fcla.edu/flaent/article/view/76568/74184

LUIS F. ARISTIZÁBAL, MAURICIO JIMÉNEZ, ALEX E. BUSTILLO AND STEVEN P. ARTHURS Mid Florida Research and Education Center, IFAS/University of Florida, Apopka, Florida, 32703, USA

To manage existing CBB populations, all mature and dry berries were collected every 2 or 3 weeks over a 2 year period. One additional sanitation pick ('re-pase') was made at the end of each major harvest period in each year. No additional control methods were employed. All harvesting was conducted by contract workers, following participatory training exercises in CBB management (Aris-tizábal et al. 2004).

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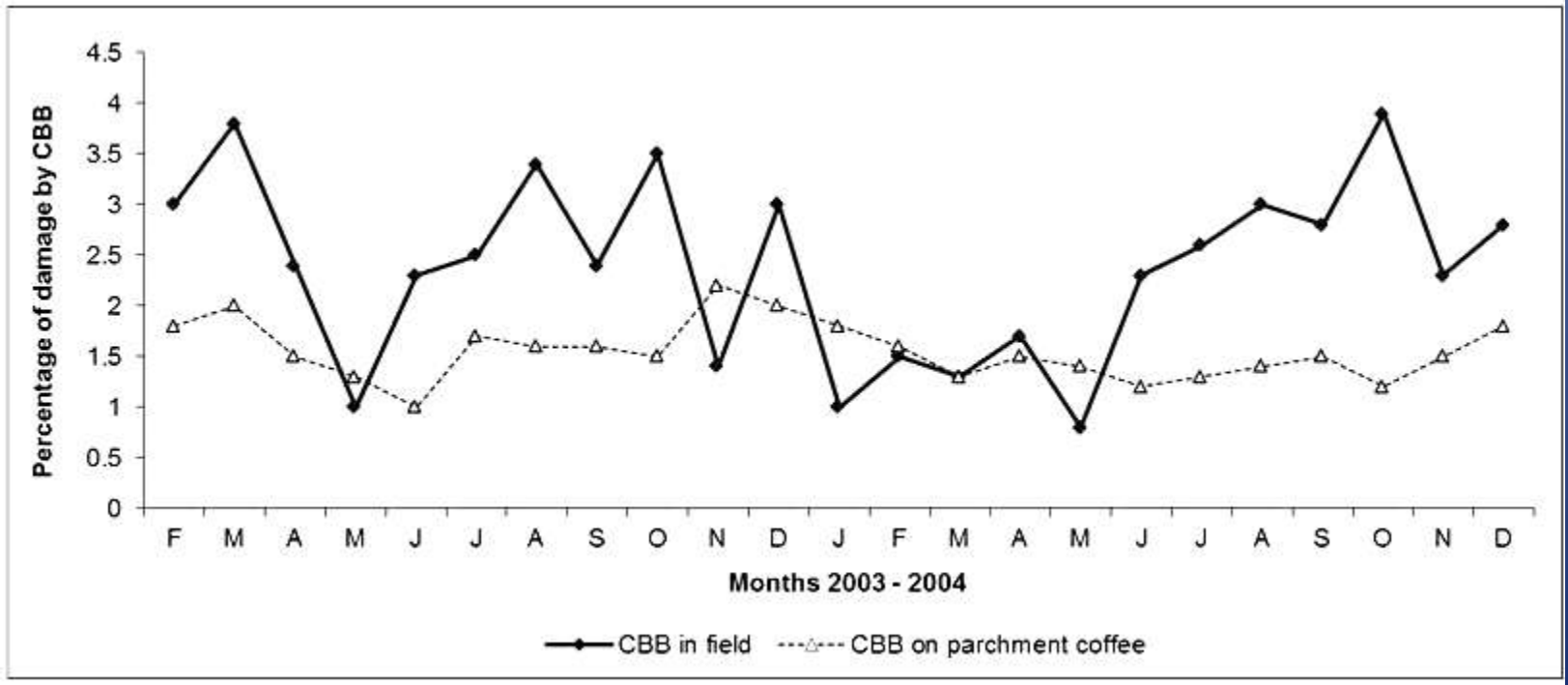
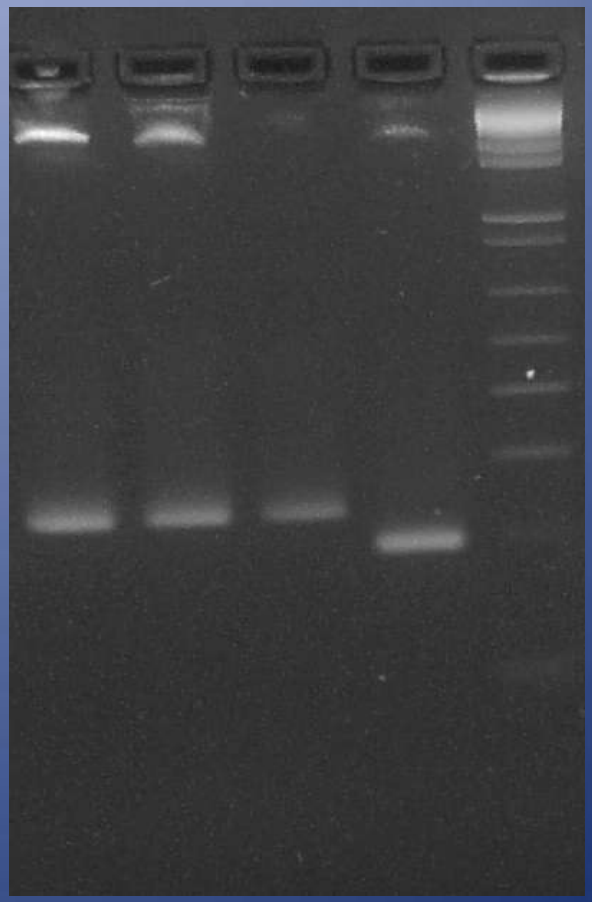


GHA Strain Molecular Identification

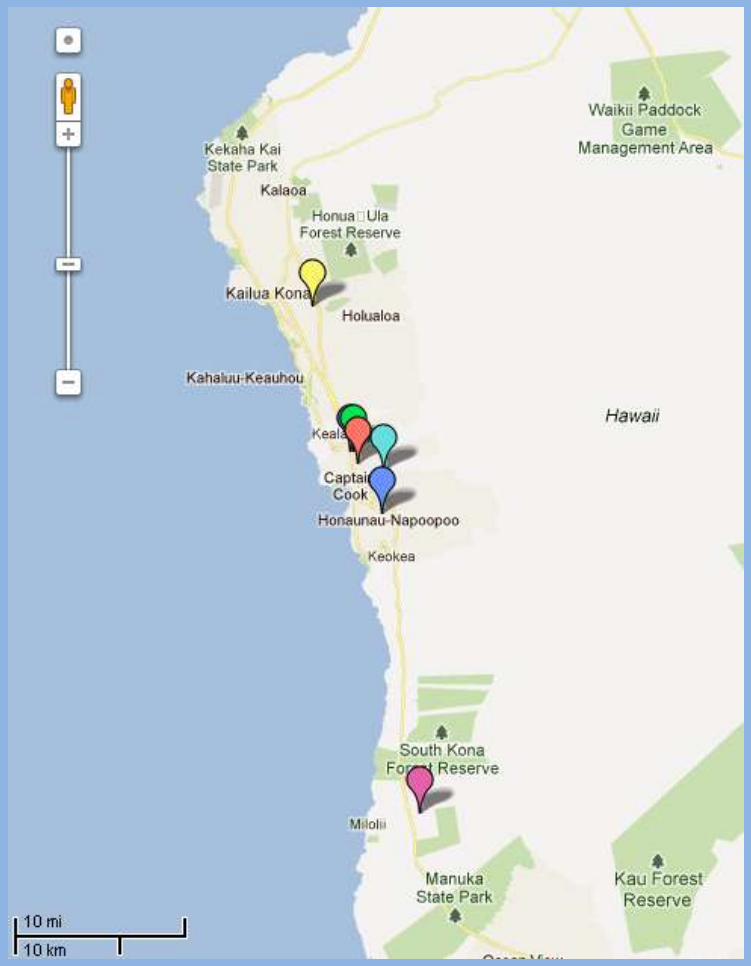
- Tracie Matsumoto

- In progress:
  - Look at the relative representation of GHA vs "native" *Beauveria* isolates on coffee berries
  - Determine the relative numbers of beetles killed by GHA vs "native" *Beauveria* isolates



Primer set Ba12

Collection and Characterization of "Native" Beauveria prior to release of GHA



Location	Elevation (ft)	Similar to Beauveria Isolated from Host/Country
1	2157	CBB/Nicaragua
2	1775	CBB/Nicaragua
3	1239	CBB/Nicaragua
4	2361	NA/Korea
5	1775	CBB/Nicaragua
6	1598	CBB/Nicaragua
7	701	Banana Stemborer/Brazil

What we've learned about *B. bassiana*

- Natural *Beauveria* infection is playing an important role in causing mortality of CBB.
- *Beauveria* sprays appear to be helpful but are not a substitute for sanitation.
- Dominant local strains exist – at least at this point in time – and deserve more research

Jessica Manton

Glenn Asmus

Fran Calvert and
Izabella Zobova

Shannon Costa

John Ross