Use of Chemical Ecology for Detection and Management of Insect Pests

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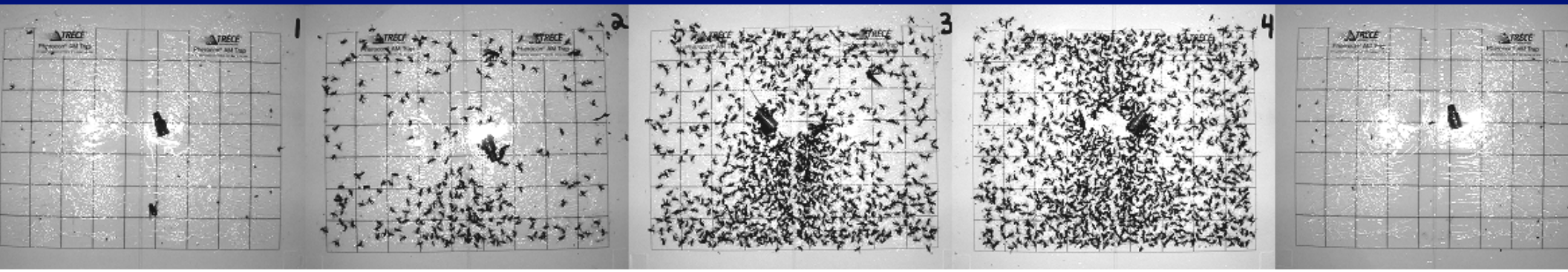
Asian citrus psyllid

Vine mealybug

Applications for Insect Pheromones:

- **Sampling and Monitoring**
  - **Presence**
  - **Flight phenology, timing**
  - **Damage thresholds**
  - **Quarantine**
- **Control strategies**
  - **Mating disruption**
  - **Attract and kill**
  - **Mass trapping**

Pheromone-baited traps



Bottom line: we appear to have tremendous power to manipulate insect populations

Need for new and "better" pheromones:

- **Increasing rate of introduction of new pests**
  - **Red palm weevil**
  - **Light brown apple moth**
  - **European grapevine moth**

- **Increasing importance of "old" pests**
  - **Stink bugs, other bugs**
  - **Navel orangeworm**
  - **Mealybugs**

Increasing importance of old pests:

- Fundamental changes in crop protection
  - Transgenic plants
  - Pheromone-based mating disruption
- Loss of insecticide registrations
- New diseases transmitted by insects
- Now, more than ever, need for Integration of pest management practices.
  - Systems approach

Other types of attractants:

- **Plant-derived compounds**
  - **Plant odors alone (pear ester, codling moth)**
  - **Plant odors enhance pheromones**
- **Food-based odors**
  - **Medfly and other fruit flies**
  - **Noctuid moths (Peter Landolt)**

- **The $64 question:**

Which types of insects can we detect and manage most effectively with chemical ecology?

Some good characteristics:

- Short adult lifetime; nonfeeding adults
- Limited, defined host range
- Limited time window/number of generations
- Crop characteristics
  - High value/limited acreage
  - Canopy/foliage height, shape, characteristics
- Well defined pheromone chemistry
  - Stability of the pheromone
- Strong activity of the pheromone
- Economics

California examples of effective chemical ecology tools:

- Pink bollworm
- Oriental fruit moth
- European grapevine moth
- Citrus leafminer
- Vine mealybug
- Some fruit flies (Mexfly, melon fly)

Citrus leafminer

Recent example of successful use of pheromones for a native insect

Mating disruption of western poplar clearwing moth

- Long generation time (2 years)
- Short activity window
- Well defined acreage (plantations)
- Well-defined chemistry
  - Long-lasting pheromone

- **The other $64 question:**

Which types of insects are we less likely to be able to detect and manage effectively with chemical ecology?

Insects that are NOT good candidates for development of chemical ecology tools:

- No evidence for use of powerful pheromones
- Long adult lifetime with feeding adults
- Broad host range
- Multiple generations
- Crop characteristics
  - Low value/large acreage
  - Canopy/foliage height, shape, characteristics
- "Bad" pheromone chemistry
  - Unstable
  - Expensive

Possible examples of insects with less likely prospects for effective pheromones:

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- Glassy-winged sharpshooter
- Asian citrus psyllid
- Tea shot-hole borer
- Gold spotted oak borer
- Diaprepes root weevil

Example of a difficult species:

Carob moth in dates

- **Pheromones very unstable**
  - **Use a mimic**
- **Multiple generations, almost year-round**
- **Crop characteristics**
  - **Little foliage to hold pheromone in the canopy**
- **Environmental characteristics**
  - **Wind, heat, strong sunlight**

How can we be most effective in the 21st century?

Development of pheromones for detection of invasive pests, worldwide.

- **Detection**
- **Demarcate distribution as early as possible**
- **Eradication**

Successful models:

- Japanese beetle

- Pink bollworm

- Mediterranean fruit fly

Recent examples of pheromone projects from UCR:

Mealybugs infesting grapes and other crops:

Vine mealybug

Obscure mealybug

Longtailed mealybug

Grape mealybug

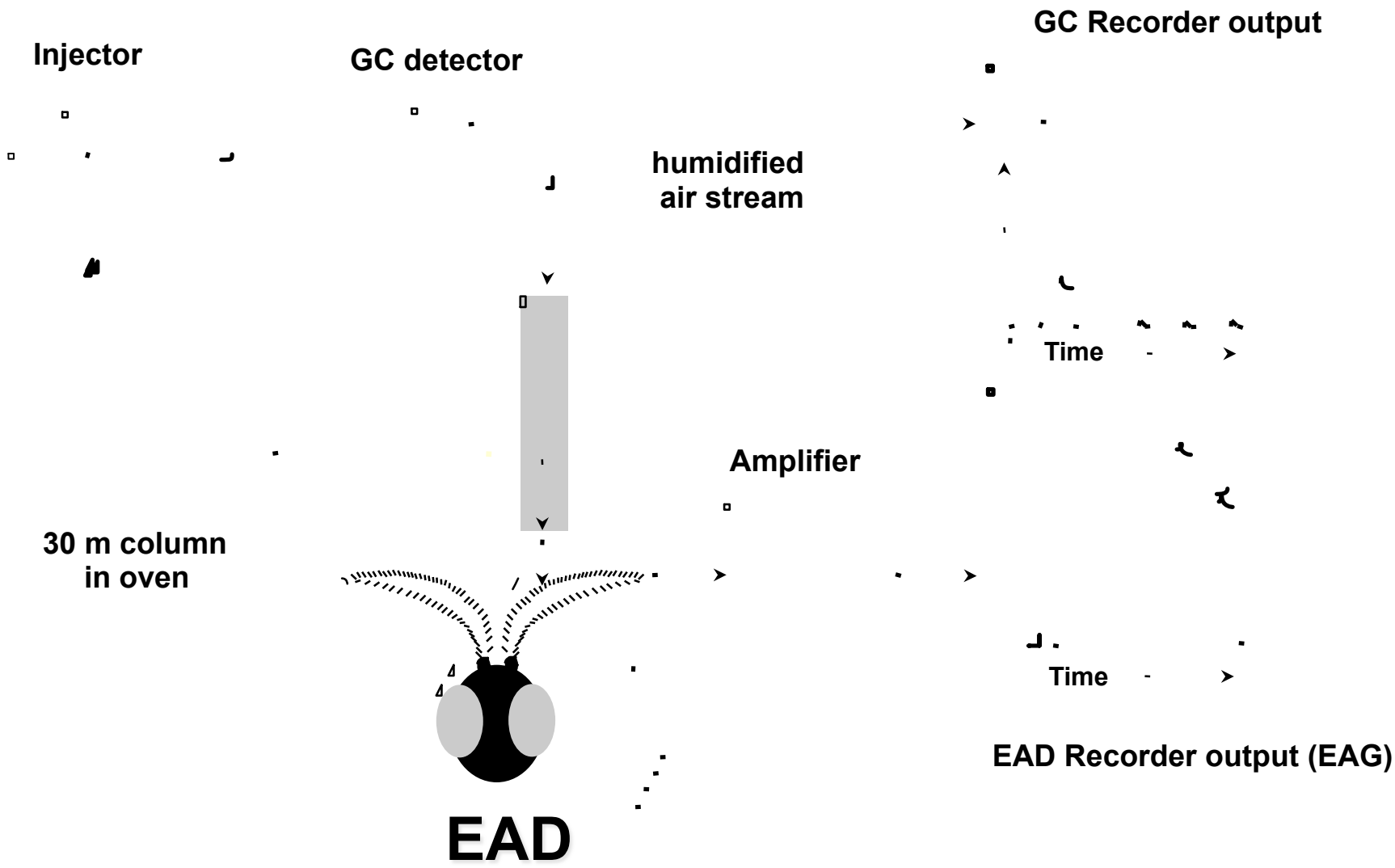
Mealybug honeydew, wax, and associated sooty mold on grapes.

Leafroll viruses transmitted by mealybugs

Photo: Roderick Bonfiglioli

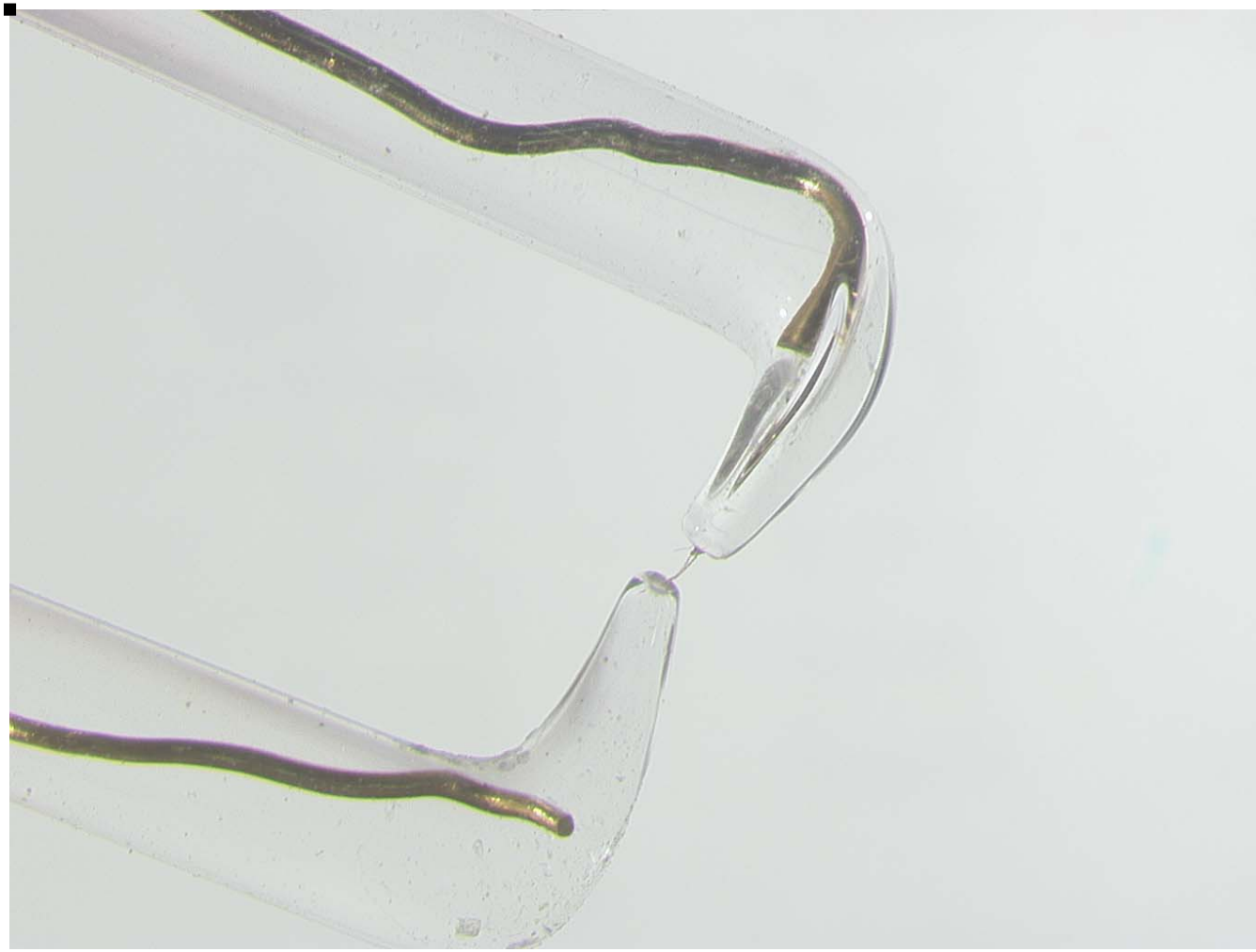
Male mealybug, ~ 1 mm long

Gas chromatograph

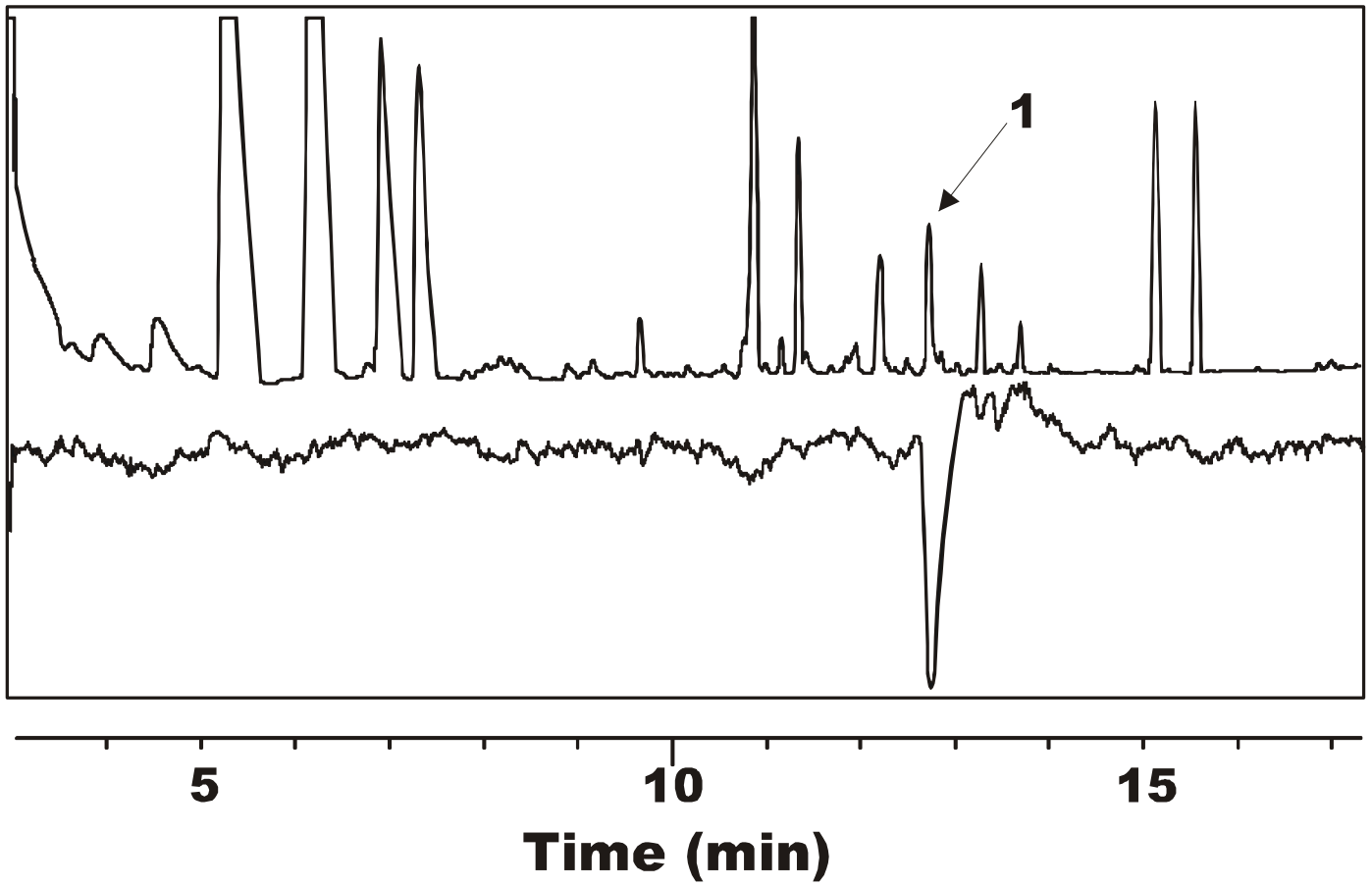


Coupled gas chromatography-electroantennogram analysis of pheromone extracts

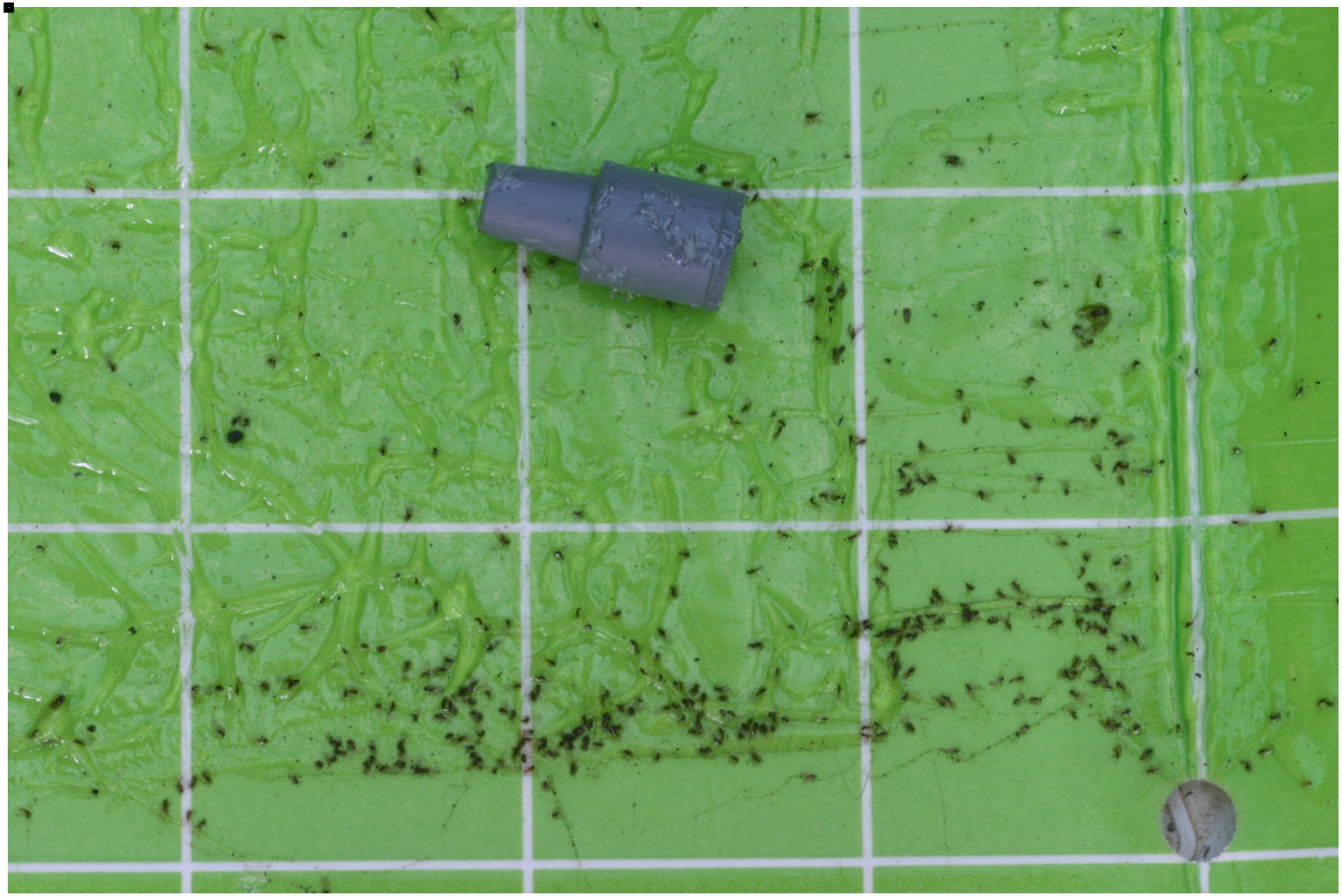
Gold wire in electrodes is 0.2 mm diameter!



Top trace: GC analysis
Bottom, inverted trace, antennal response



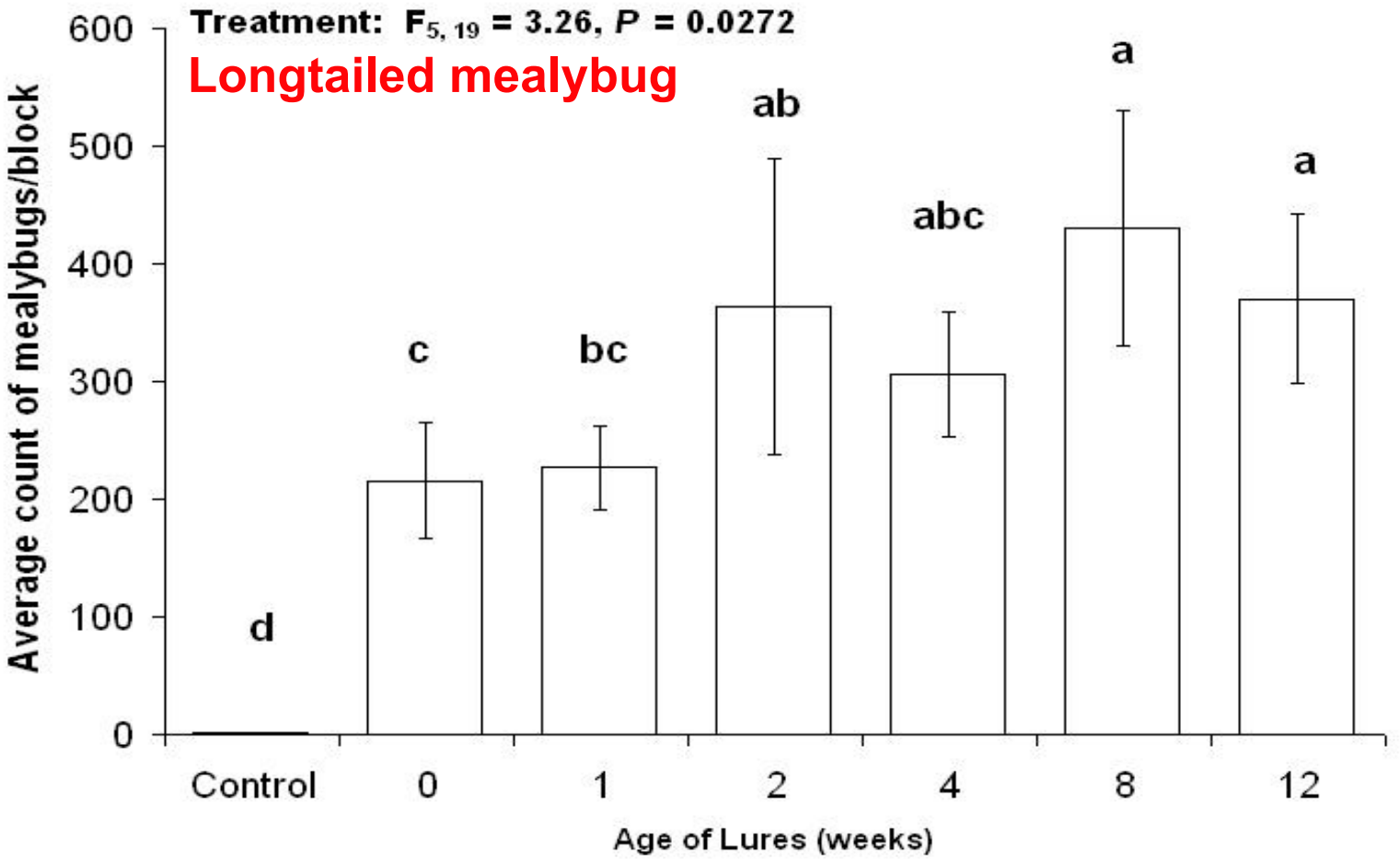
Trapping male mealybugs



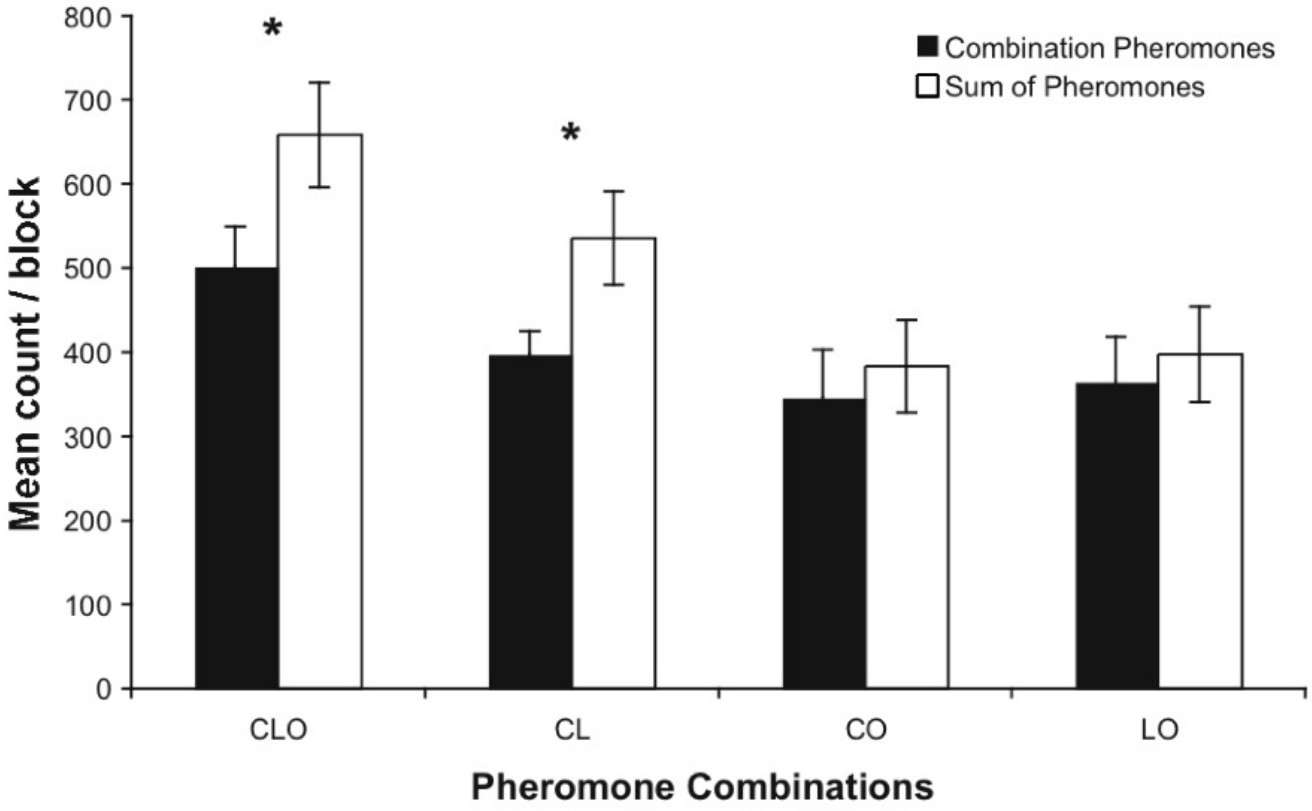
2. Mealybug control with pheromones: Mating disruption of vine mealybug

- **Commercialized in 2008**
  - **35,000 acres treated in California in 2011**
- **Works best at low initial population densities**
- **Formulated as discrete retrievable dispensers.**

Lure longevity in the field

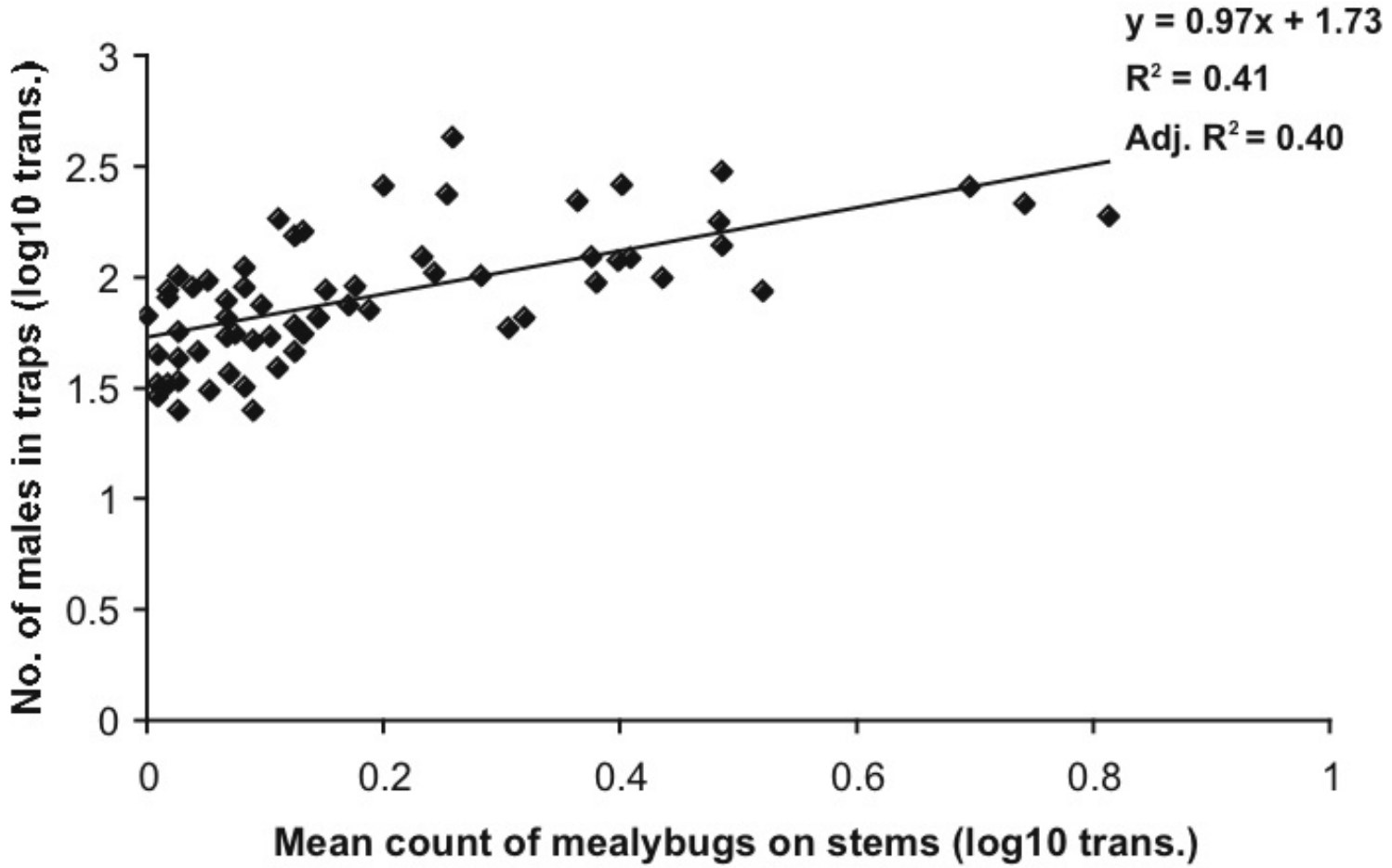


Using mixtures of pheromones to monitor several species in one trap



Result: No species are strongly inhibited by the pheromones of other species

Correlation between pheromone traps and manual sampling



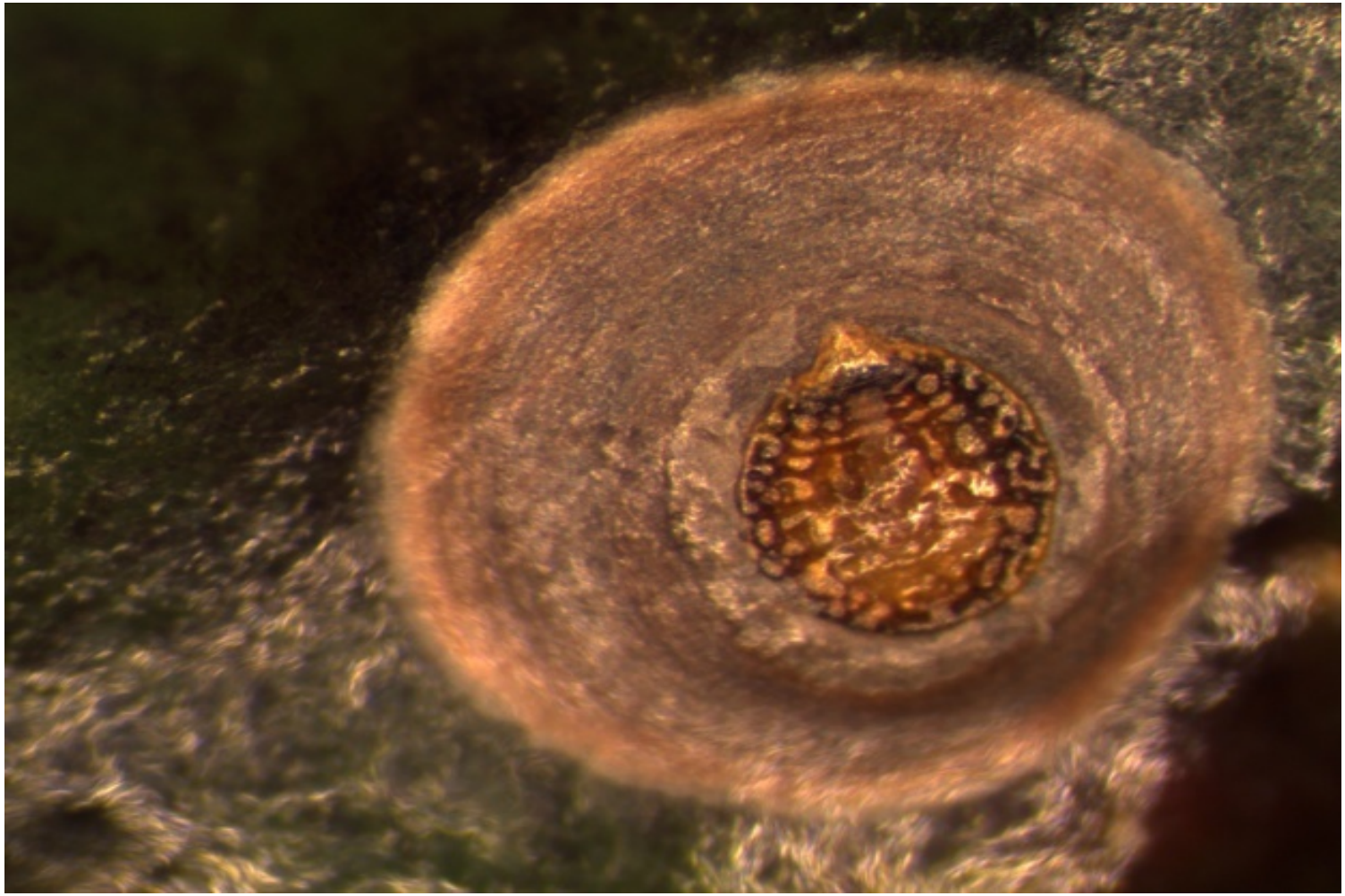
Result: Good correlation in nursery crops, for longtailed mealybug

Scale insects on Mexican avocados entering California

- **From February 2007, fresh Mexican avocados shipped into California year-round**
- **7 exotic scale spp. found, 2 new to science**
- **92% of boxes had live scales; ~50 million live scales entered CA 9/07-4/08**

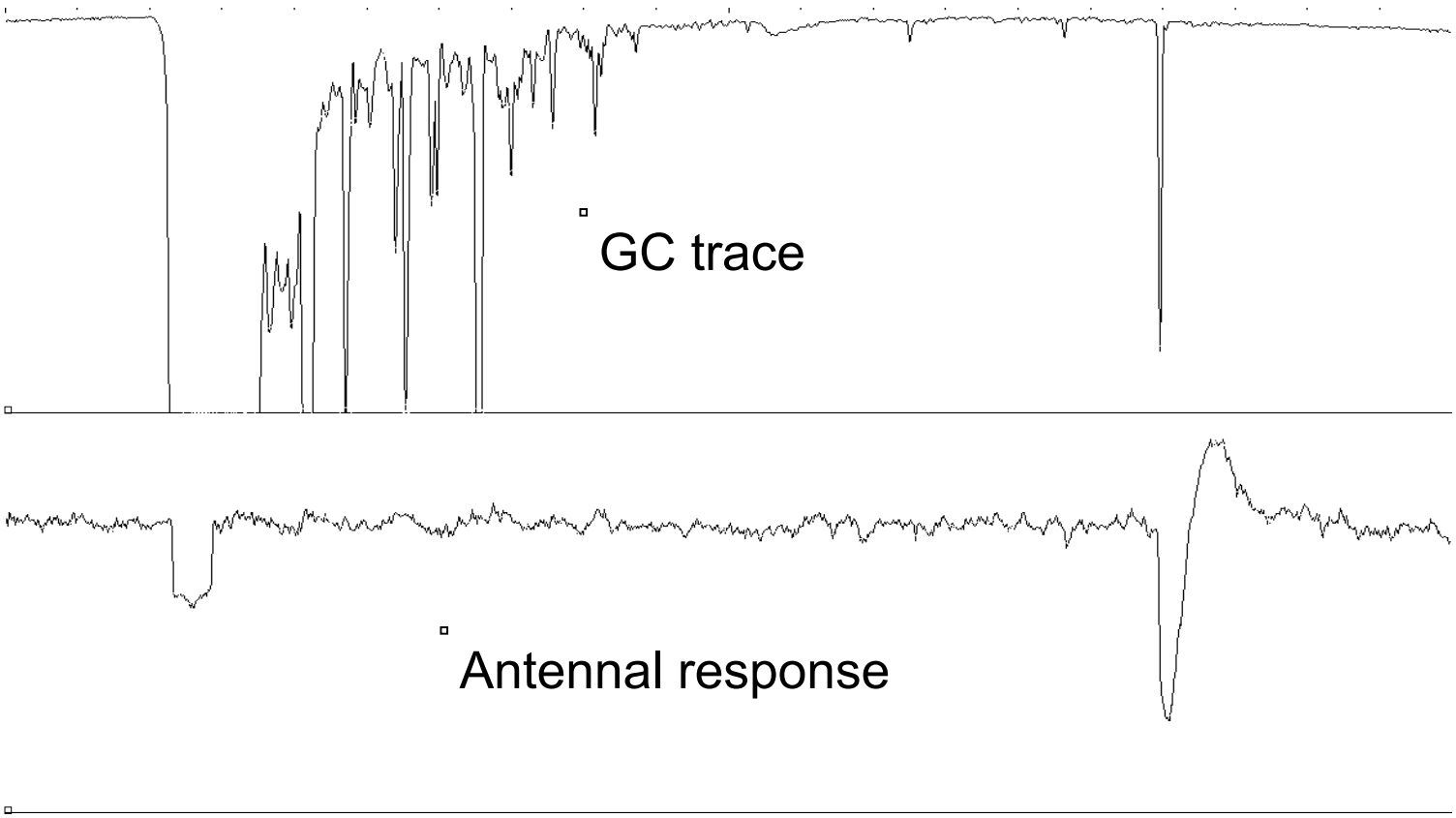
Morse, J. G., P. F. Rugman-Jones, G. W. Watson, L. J. Robinson, J. L. Bi & R. Stouthamer. 2009. High Levels of Exotic Armored Scales on Imported Avocados Raise Concerns Regarding USDA-APHIS' Phytosanitary Risk Assessment. Journal of Economic Entomology 102(3): 855-867

First target of pheromone identification: *Acutaspis albopicta*



Male *Acutaspis*

Analysis of pheromone extracts by GC-EAD



Preliminary bioassay results

Males highly attracted to synthetic pheromone

Pheromone traps for detection of *Acutaspis*

- **Detection of invasions, new infestations at earliest possible moment.**

- **Determine range, rate of spread, key tool for monitoring success of eradication**

- **Provide a method of monitoring and certifying Mexican orchards as being free of this scale**

With Mark and Christina Hoddle:
Identify pheromone of Red Palm Weevil found in California

Photo CISR-UCR

Photo John Kabashima

Key questions:

1. Which species of Red Palm Weevil do we have in California?
   - → *R. ferrugineous*?
   - → *R. vulneratus*?
   - → Another, undescribed species?

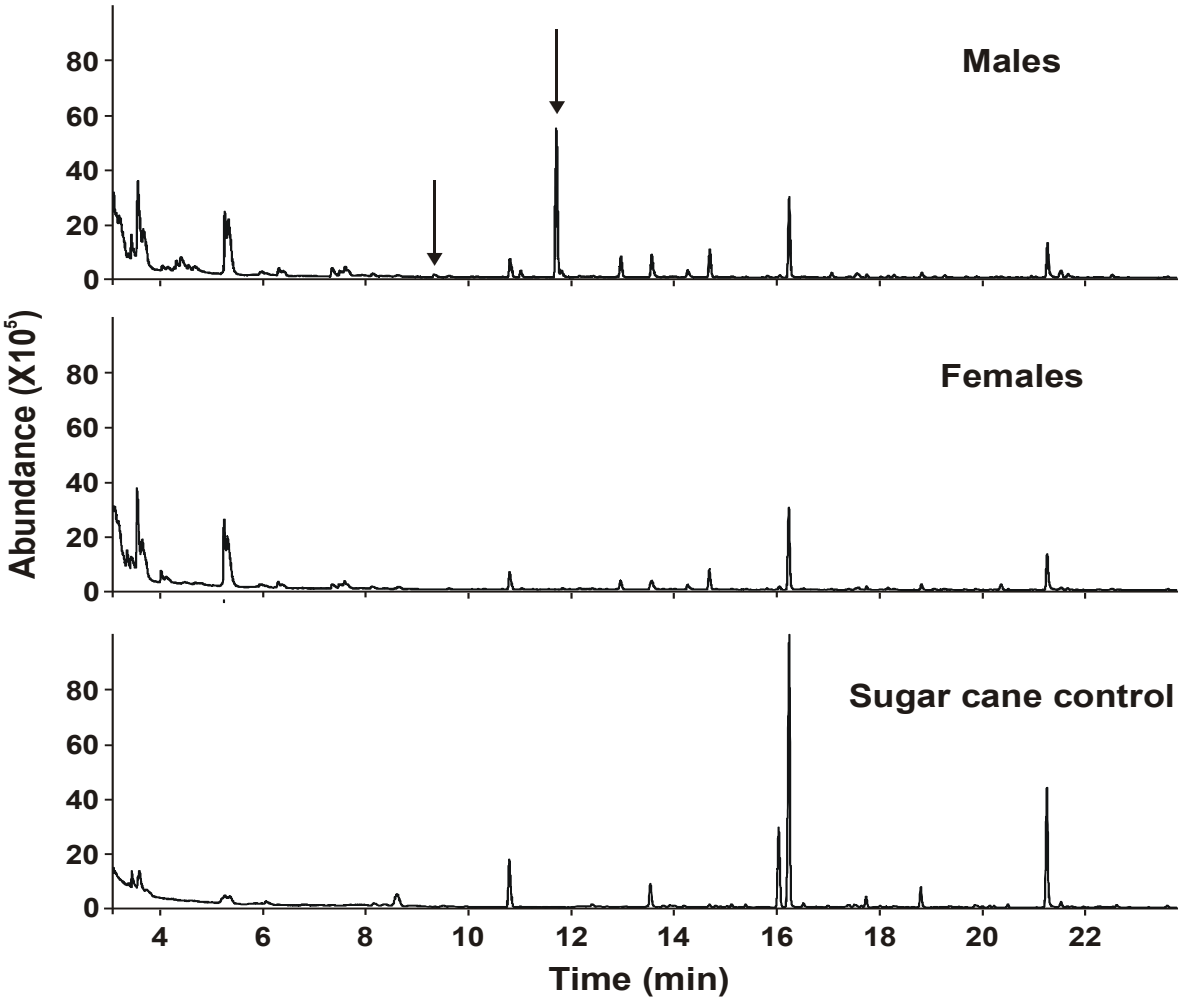
2. What is its pheromone?
   1. Are there other important components to the attractant in addition to the pheromone?

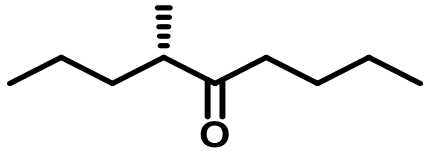
Portable system for collecting pheromone from multiple samples in Indonesia

Mark, inserting pheromone collection trap

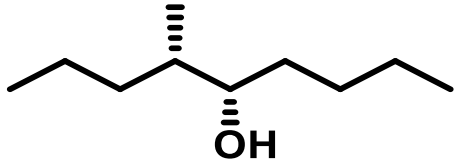
Christina, collecting pheromone in Sumatra

Gas chromatography analyses of extracts of males, females, and sugar cane control





1: 4-methylnonan-5-one



2: 4-methylnonan-5-ol

Bottom line:

- **Pheromone appears to consist of the same components as for *R. ferrugineous***
- **Host plant coattractants are critically important for good attraction**
  - **Fresh cut palm logs and fermenting palm hearts**

Pheromone of a native insect, *Prionus californicus*

Jim Barbour, Idaho

Why *Prionus californicus*???

→ A major insect pest of hops in US

From This

To This

STATS ON TAP

QUICK BEER FACTS:

- In the U.S., a barrel of beer contains 31 gallons.
- Americans drink more beer on July 4th than any other day of the year.
- Beer is the most popular alcoholic beverage in America and accounts for about 85% of the volume of alcoholic beverages sold in the United States each year.

Sources: Beer Institute: Shipment of Malt Beverages and Per Capita Consumption By State 2008 (Preliminary); Comedy Zone Beer Trivia; BeerFacts.net

P. californicus life history

- **Adults**
  - **Emerge in late June-July**
  - **Exhibit traits associated with pheromone production**

- Sexual dimorphism in antenna
- Sedentary females
- Active nocturnally
- Adults do not feed
  - Short lived (2-4 weeks)
  - Must locate mates quickly
- Female calling behavior

Testing traps:

BONUS: Pheromone structure is highly conserved:

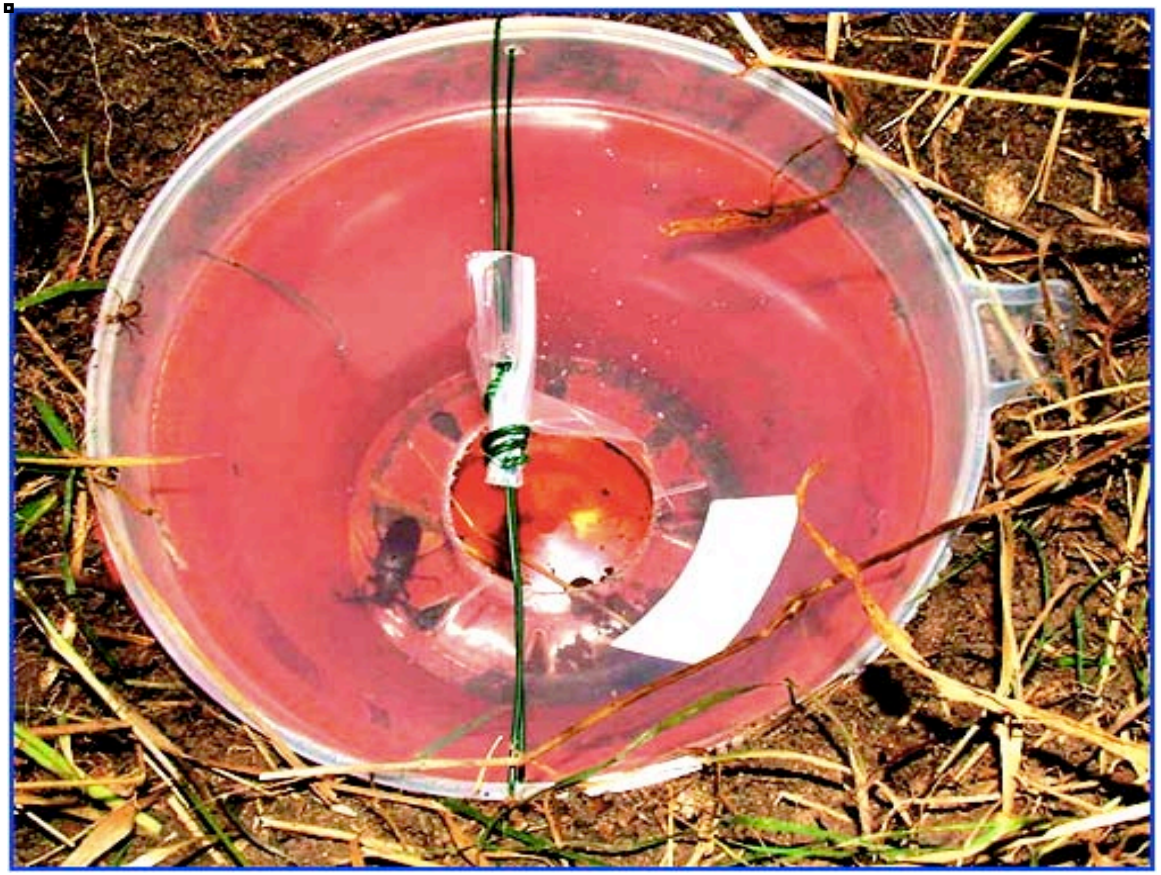
Georgia:
Prionus laticollis
Prionus imbricornis

Arizona:
Prionus aztecus
Prionus linsleyi

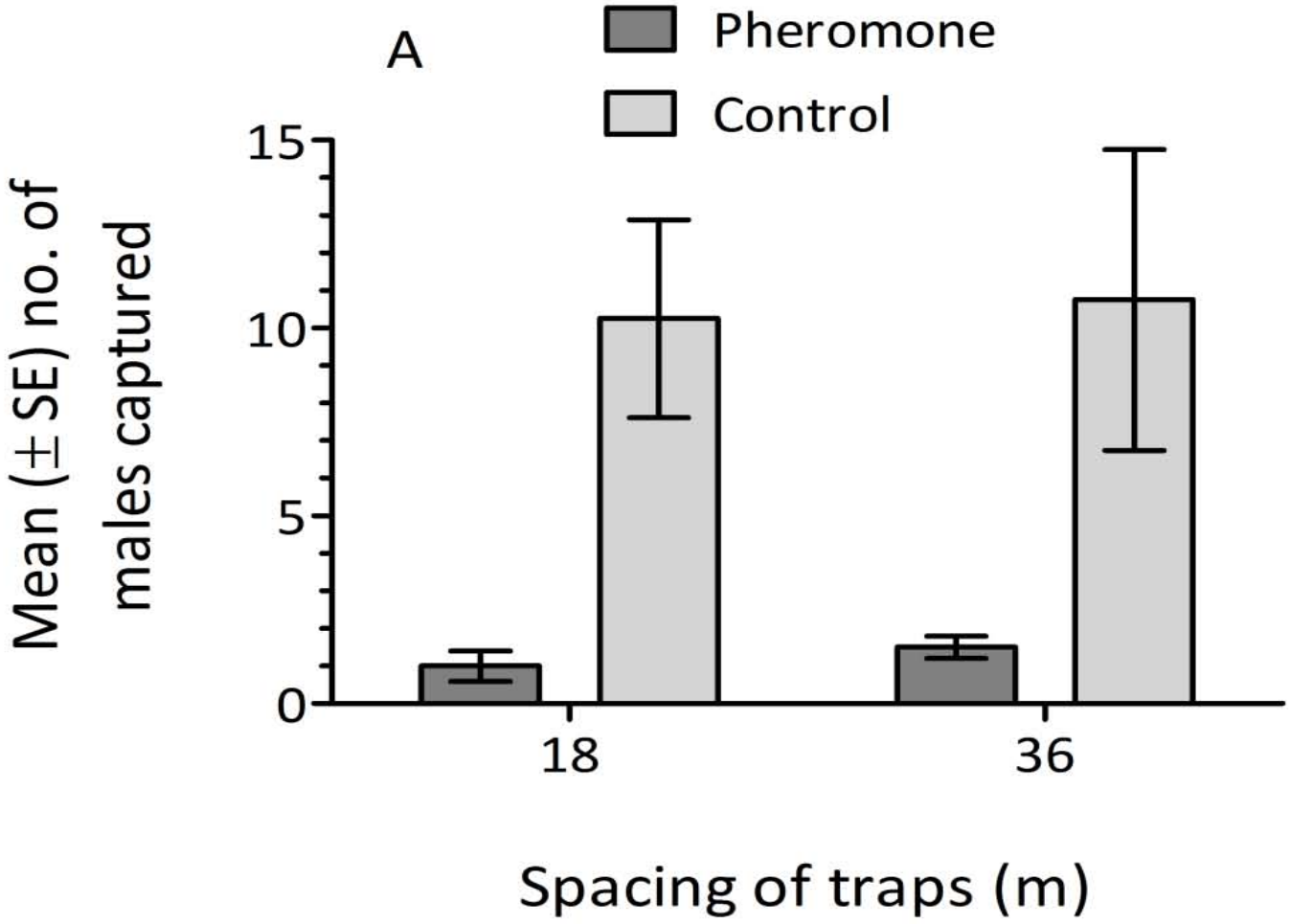
Western US:
Prionus lecontei
Prionus integer

Norwich, UK:
Prionus coriarus

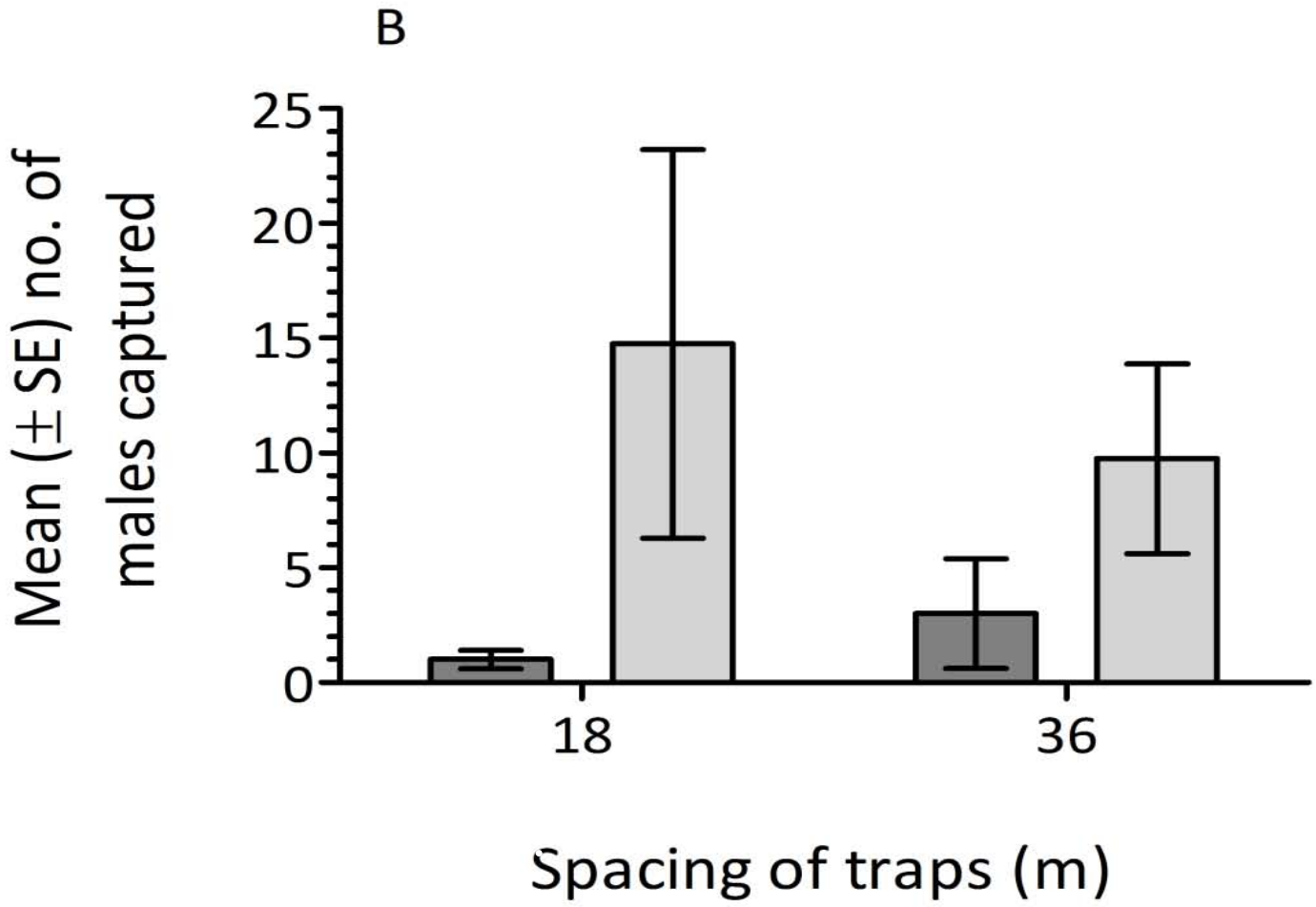
All males



Mass trapping results



Mating disruption results



Bottom line:

Prionus **pheromone is highly effective for:**

- **Monitoring**
- **Trapping**
- **Possibly mating disruption**

Control strategy chosen will depend on a combination of economics and efficacy

Summary

- **Chemical ecology tools can be crucial components of IPM**
- **Not all insects have chemical ecology that can be exploited for IPM**
- **Chemical ecology tools can be useful for both native and exotic pest detection and management**

Acknowledgements: $$$

Mealybugs:

- California Table Grape Commission
- The Viticulture Consortium
- California Raisin Marketing Board
- USDA Western Regional Grants Program
- Foothills Agricultural Research, Corona CA.
- Suterra LLC, Bend Oregon
- Kuraray Co., Tokyo

Red Palm Weevil:

- CDFA

Prionus californicus:

- Western regional IPM grant

Invasive scale species:

- California Avocado Commission

Acknowledgements