Development of Sterile Insect Technique for Navel Orangeworm in California Orchards

Houston Wilson | Assoc. Cooperative Extension Specialist
Dept. Entomology, Univ. of California - Riverside

Chuck Burks | Research Entomologist
Agricultural Research Service, US Dept. Agriculture

Reva Scheibner | Staff Research Associate
Dept. Entomology, Univ. of California - Riverside

Sarah Meierotto | Staff Research Associate
Dept. Entomology, Univ. of California - Riverside

Joshua Reger | Ph.D. Student
Dept. Entomology, Univ. of California - Riverside

Jessica Maccaro | Staff Research Associate
Dept. Entomology, Univ. of California - Riverside

Navel Orangeworm

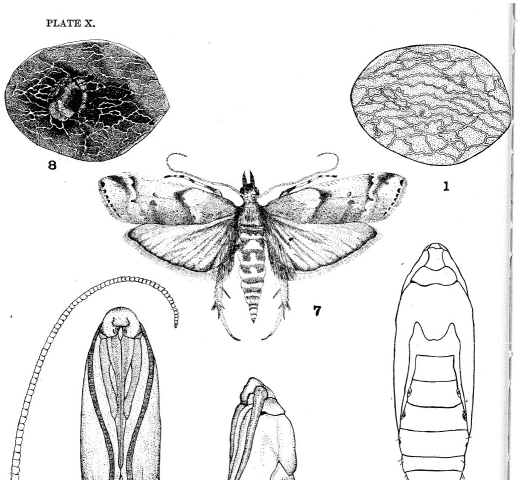
Origins + Arrival in CA

Species Name

Order: Lepidoptera

Family: Pyralidae

Species: *Amyelois transitella*



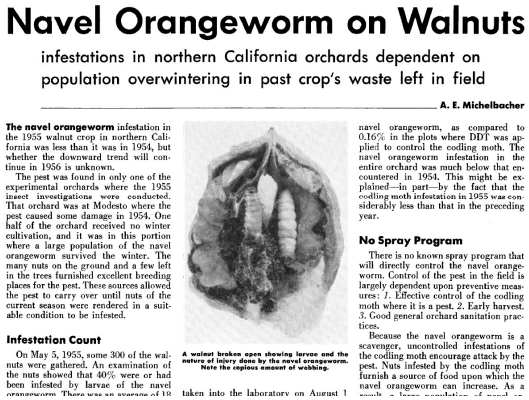
Arrival in California

1800s – Reported in Mexico, Caribbean, Central America, South America

1900s – Reported on citrus in AZ ("navel orange worm")

1940s – Reported on walnuts and almonds in CA

1970s – Reported on pistachio in CA



Navel Orangeworm on Walnuts

infestations in northern California orchards dependent on population overwintering in past crop's waste left in field

A. E. Michelbacher

The navel orangeworm infestation in the 1955 walnut crop in northern California was less than it was in 1954, but whether the downward trend will continue in 1956 is unknown.

The pest was found in only one of the experimental orchards where the 1955 insect investigations were conducted. That orchard was at Modesto where the pest caused some damage in 1954. One half of the orchard received no winter cultivation, and it was in this portion where a large population of the navel orangeworm survived the winter. The many nuts on the ground and a few left in the trees furnished excellent breeding places for the pest. These sources allowed the pest to carry over until nuts of the current season were rendered in a suitable condition to be infested.

Infestation Count

On May 5, 1955, some 300 of the walnuts were gathered. An examination of the nuts showed that 40% were or had been infested by larvae of the navel orangeworm. There was an average of 18

A walnut broken open showing larvae and the nature of injury done by the navel orangeworm. Note the copious amount of webbing.

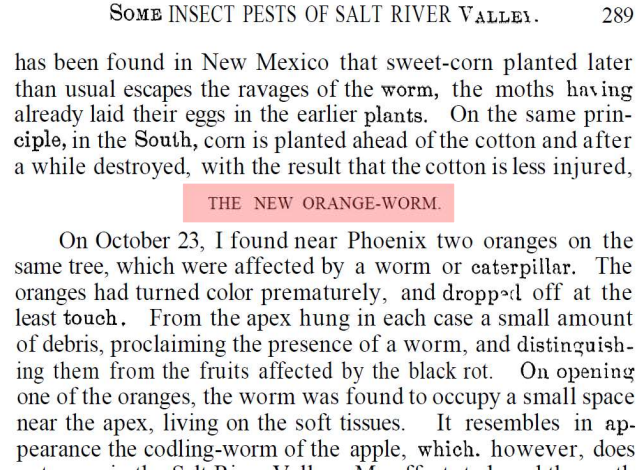
taken into the laboratory on August 1

navel orangeworm, as compared to 0.16% in the plots where DDT was applied to control the codling moth. The navel orangeworm infestation in the entire orchard was much below that encountered in 1954. This might be explained—in part—by the fact that the codling moth infestation in 1955 was considerably less than that in the preceding year.

No Spray Program

There is no known spray program that will directly control the navel orangeworm. Control of the pest in the field is largely dependent upon preventive measures: 1. Effective control of the codling moth where it is a pest. 2. Early harvest. 3. Good general orchard sanitation practices.

Because the navel orangeworm is a scavenger, uncontrolled infestations of the codling moth encourage attack by the pest. Nuts infested by the codling moth furnish a source of food upon which the navel orangeworm can increase. As a



SOME INSECT PESTS OF SALT RIVER VALLEY. 289

has been found in New Mexico that sweet-corn planted later than usual escapes the ravages of the worm, the moths having already laid their eggs in the earlier plants. On the same principle, in the South, corn is planted ahead of the cotton and after a while destroyed, with the result that the cotton is less injured,

THE NEW ORANGE-WORM.

On October 23, I found near Phoenix two oranges on the same tree, which were affected by a worm or caterpillar. The oranges had turned color prematurely, and dropped off at the least touch. From the apex hung in each case a small amount of debris, proclaiming the presence of a worm, and distinguishing them from the fruits affected by the black rot. On opening one of the oranges, the worm was found to occupy a small space near the apex, living on the soft tissues. It resembles in appearance the codling-worm of the apple, which, however, does

Navel Orangeworm

Current Pest Status

Extremely Low Tolerance for Damage (<2%)

High Crop Value

- **Yield/quality x price – of course…**
- **Infestation leads to increased processing time/costs**
- **Carryover of infested remnant/mummy nuts to following year**

Navel Orangeworm

Current Pest Status

Extremely Low Tolerance for Damage (<2%)

Aflatoxin

- **Known human carcinogen, regulated in domestic/foreign markets**
- ***Aspergillus flavus* fungi produce aflatoxin**
- **NOW adults move *Aspergillus* around**
- **Larval feeding create opportunities for fungal growth on nuts**

Spread of *Aspergillus flavus* by Navel Orangeworm (*Amyelois transitella*) on Almond

Jeffrey D. Palumbo, Noreen E. Mahoney, and **Douglas M. Light,** Plant Mycotoxin Research Unit, Western Regional Research Center, United States Department of Agriculture–Agricultural Research Service (USDA-ARS) Albany, CA 94710; **Joel Siegel,** USDA-ARS, San Joaquin Valley Agricultural Sciences Center, Parlier CA 93648-9757; and **Ryan D. Puckett** and **Themis J. Michailides,** University of California–Davis, Kearney Agricultural Research and Extension Center, Parlier 93648

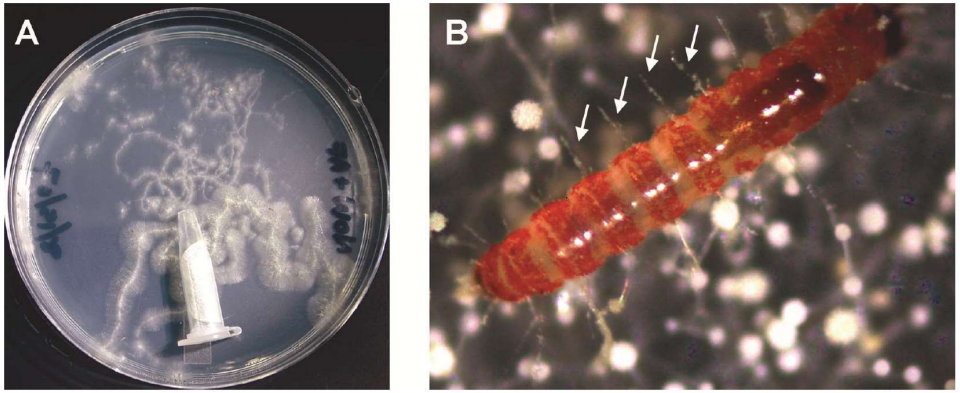


Fig. 1. A, Trails of *Aspergillus flavus* colonies, resulting from navel orangeworm (NOW) transport of conidia from microcentrifuge tube to potato dextrose agar medium. **B,** Accumulation of *A. flavus* conidia on setae (arrows) of NOW larva after crawling across plates containing sporulating *A. flavus* colonies.

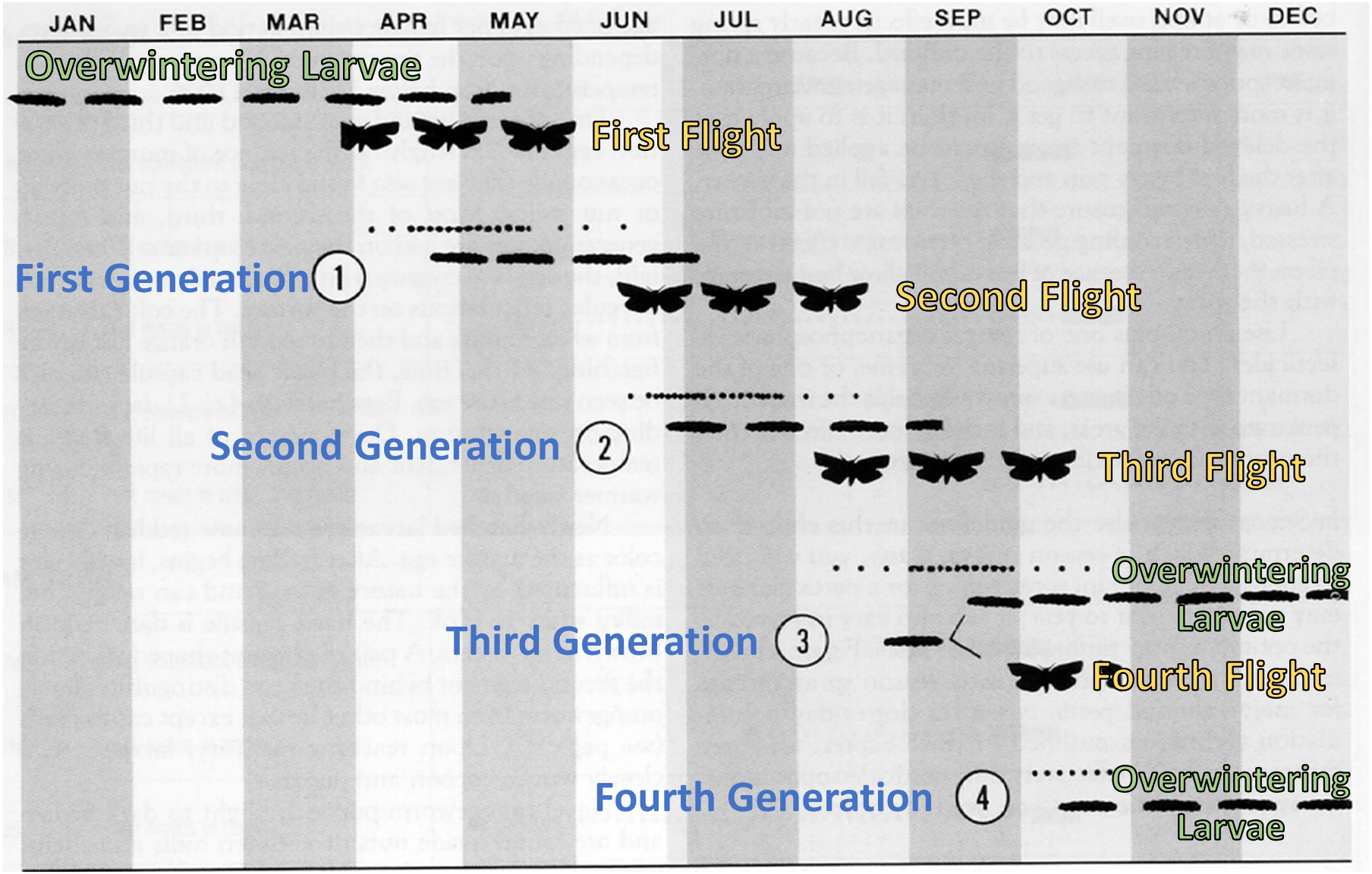
Seasonal Phenology

- **Overview**
  - **Overwinter as larvae/pupae in remnant “mummy” nuts**
  - **Adults emerge in the spring**
  - **3-4 generations per year, depending on weather and host quality**
- **Populations develop more rapidly as the season progresses**
  - **Warmer weather**
  - **Develop more rapidly on new crop vs. mummy nuts**
  - **Increased host availability (hull split / hull slip)**

Mummy vs. New Crop Nuts

Increasing host availability as hull integrity declines

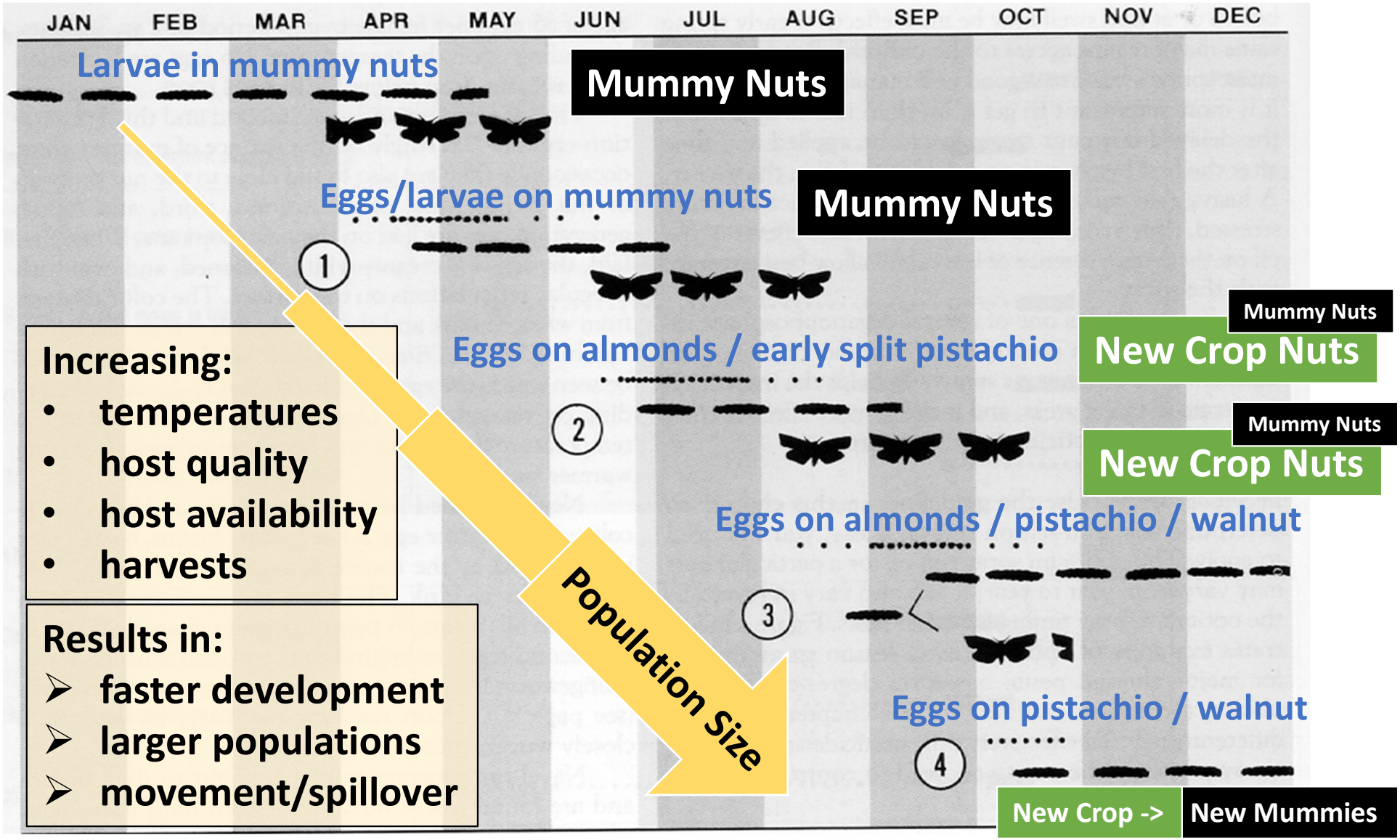
Seasonal Phenology Overview



IPM for Almonds, UC ANR Publication #3308

Seasonal Phenology

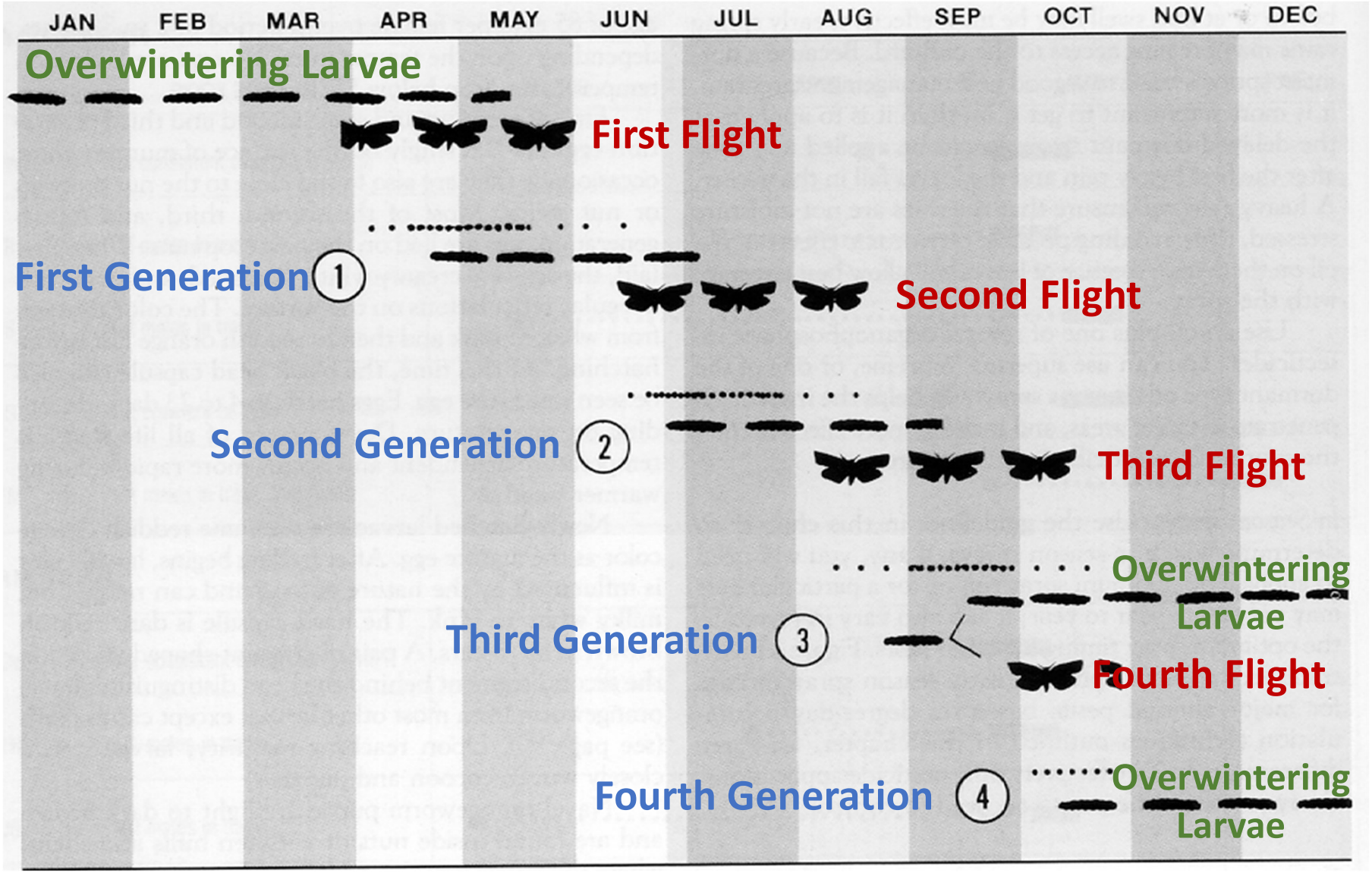
Increasing Populations Over Time



IPM for Almonds, UC ANR Publication #3308

Bringing It All Together

KEEP THEM ON THE RUN!



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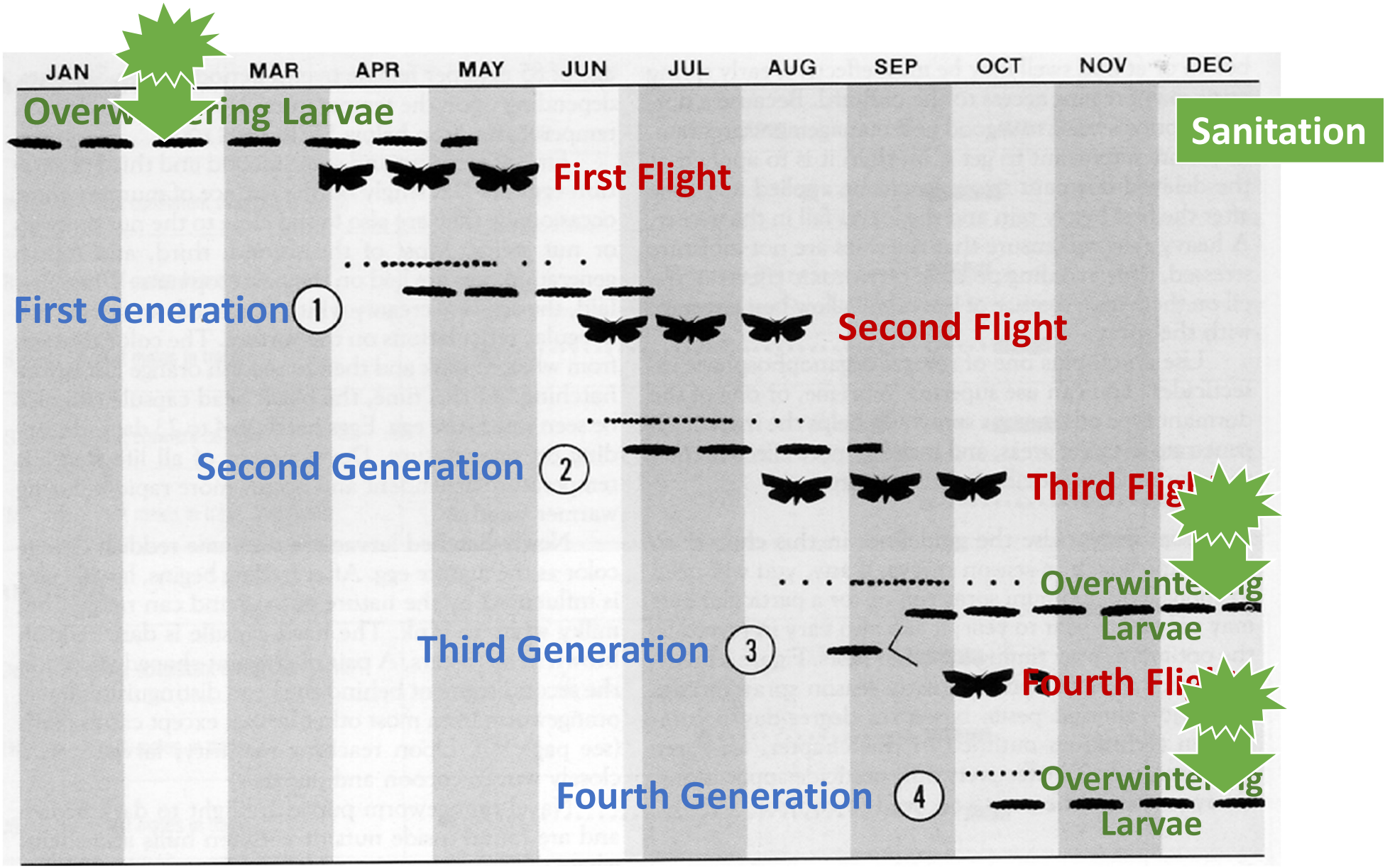

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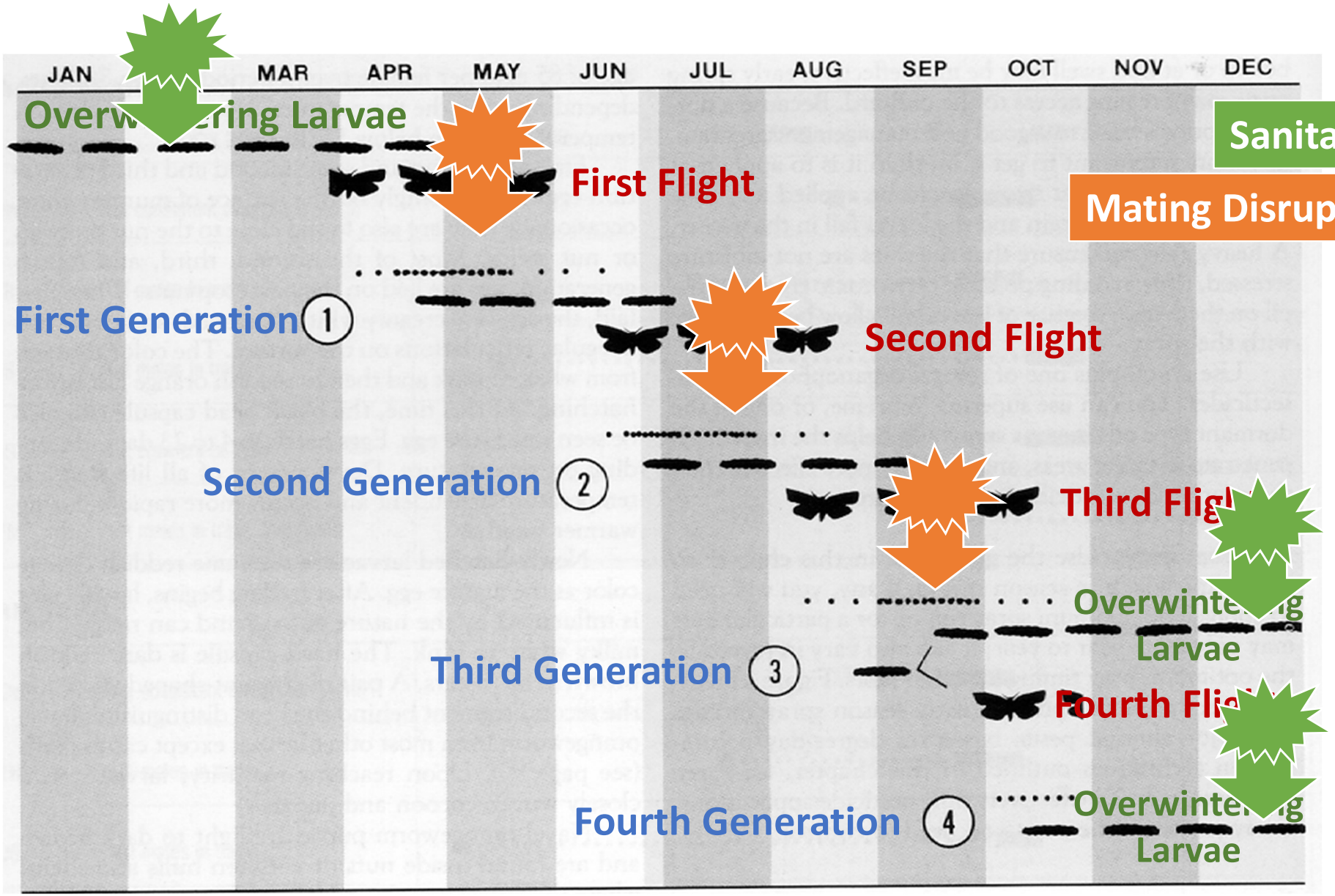

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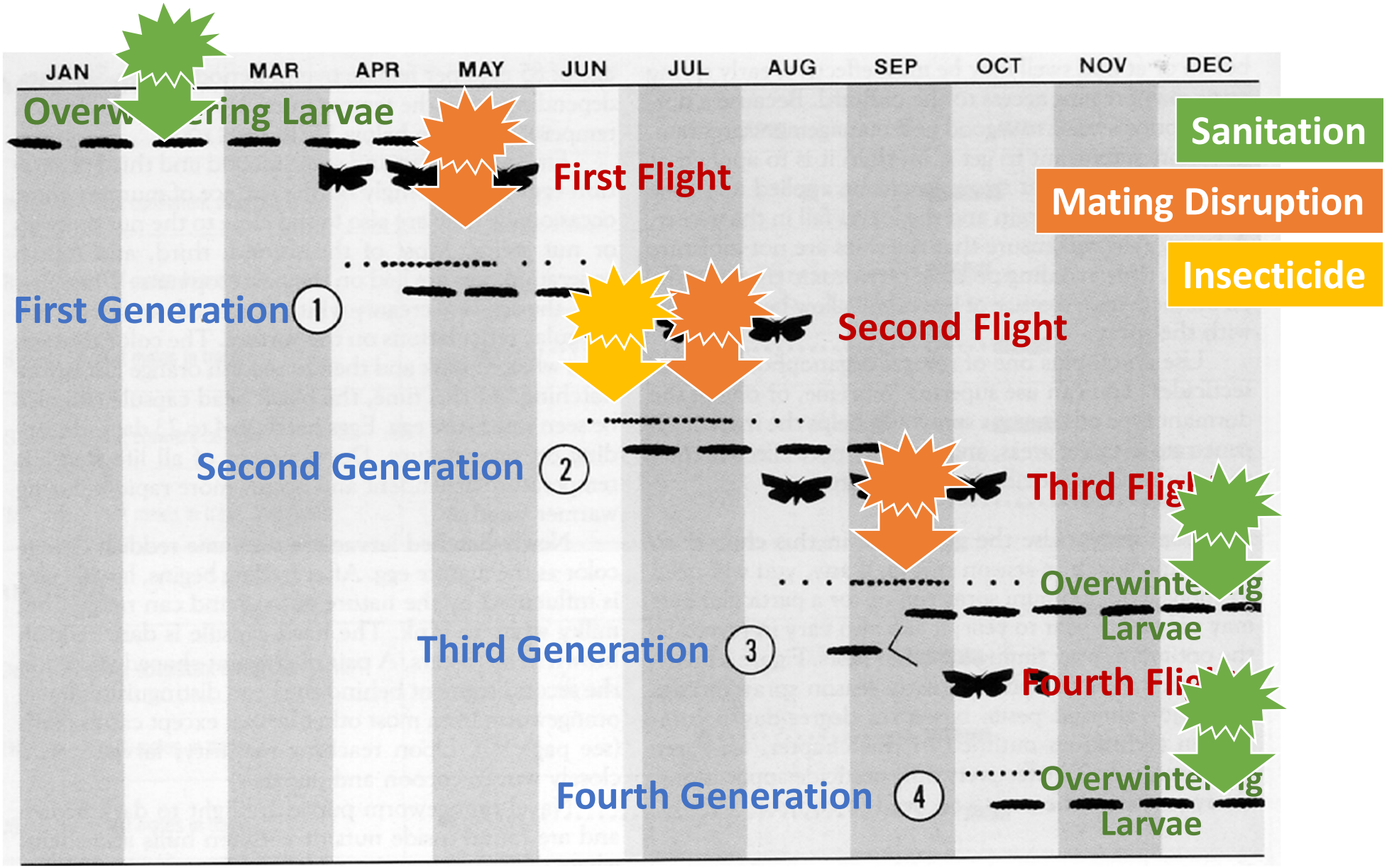

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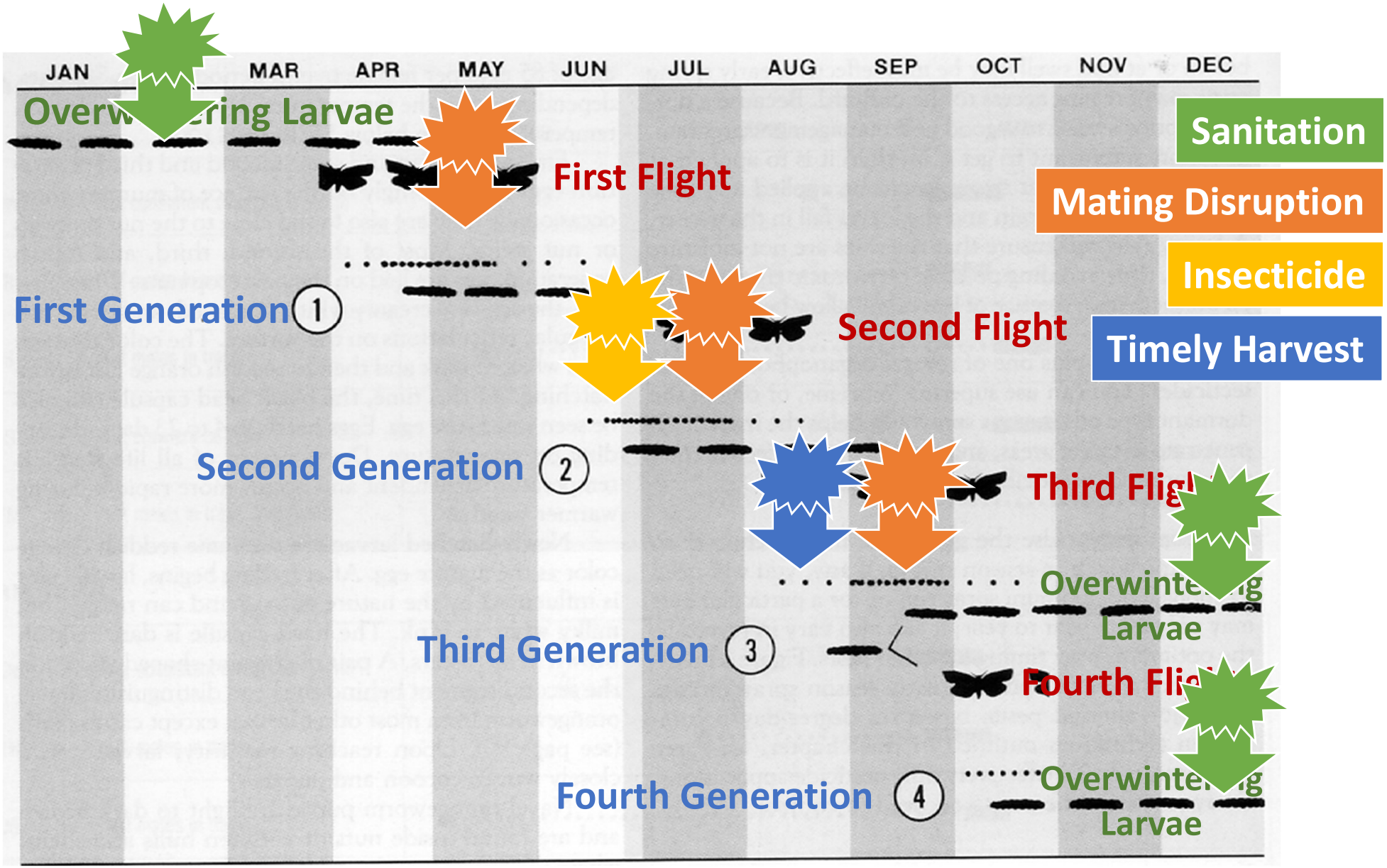
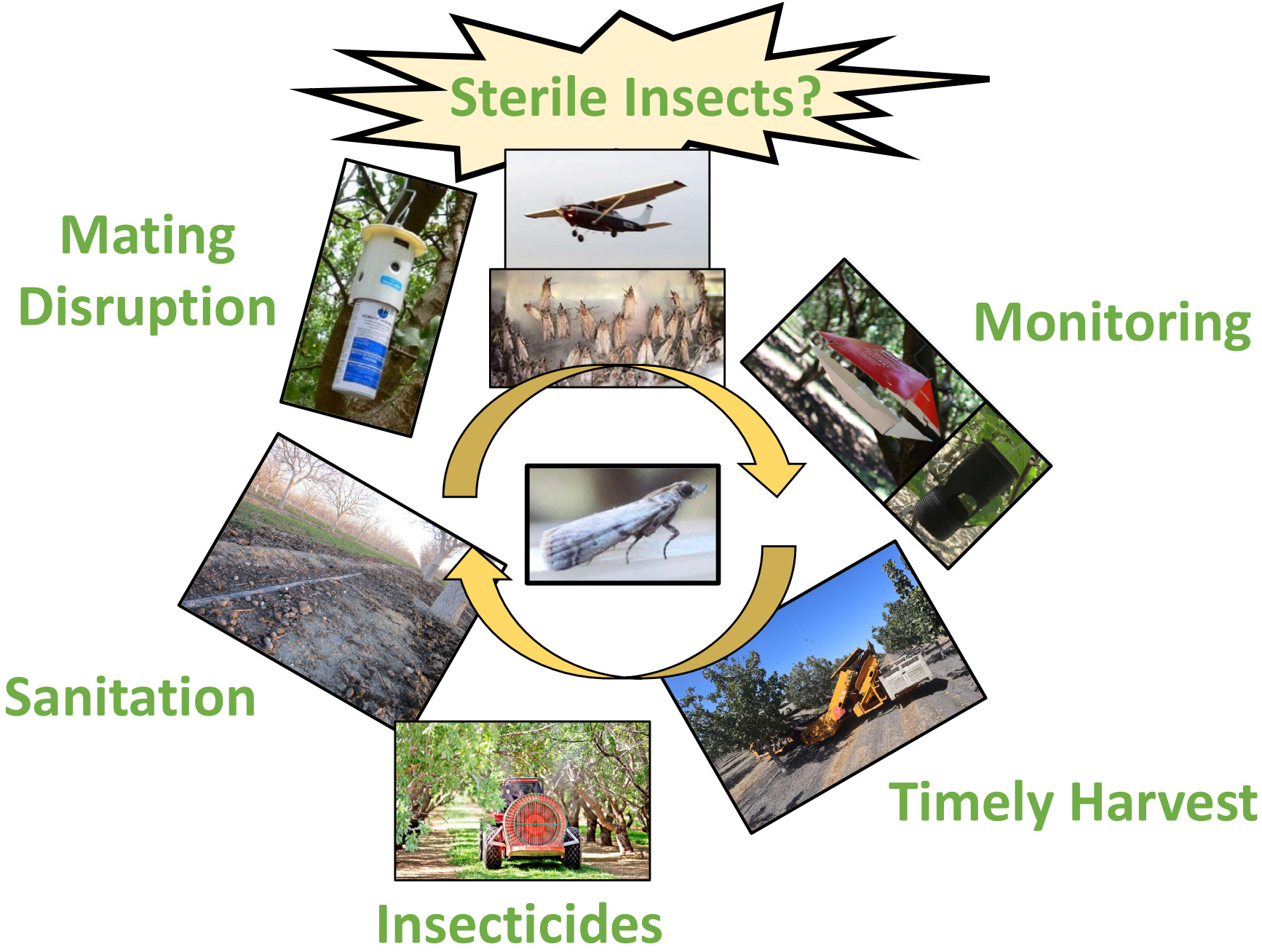


NOW Management in Pistachio/Almond

Use of Multiple Approaches is Key



Sterile Insect Technique for Navel Orangeworm

Key Aspects and Progress to Date

SIT for NOW - Background

Phoenix Irradiation Facility Presents Novel Opportunity

USDA Pink Bollworm Rearing Facility

- **Phoenix, AZ**
- **Operating since 1960s**

Pink Bollworm Eradicated

- **October 2018**

Can the facility be repurposed for NOW?

- **Pistachio Industry + USDA-APHIS**

UNITED STATES
DEPARTMENT OF AGRICULTURE
Office of the Secretary
Washington, D.C. 20250

ERADICATION OF PINK BOLLWORM

By the Secretary of Agriculture of the United States of America

A PROCLAMATION

WHEREAS cotton production is vital to the U.S. economy, accounting for nearly $27 billion in products and services annually according to industry estimates, providing hundreds of thousands of jobs across many sectors, and supplying nearly one-third of the raw cotton that is traded globally; and

WHEREAS for more than 100 years the United States has been battling the pink bollworm, one of the most destructive cotton pests in the world, which has cost U.S. growers tens of millions of dollars annually in control costs and yield losses; and

SIT for NOW - Background

Moth Production/Transportation Process

Egg Production

SIT for NOW - Background

Moth Production/Transportation Process

Rearing Larvae/Pupae

SIT for NOW - Background

Moth Production/Transportation Process

Adult Emergence in Vacuum System

SIT for NOW - Background

Moth Production/Transportation Process

Adults Collected in Cold Chilled “Cyclones”

SIT for NOW - Background

Moth Production/Transportation Process

Moth Irradiated, Packaged and Shipped Out

SIT for NOW - Background

Moth Production/Transportation Process

Sterile Moth Shipped via Commercial Carrier

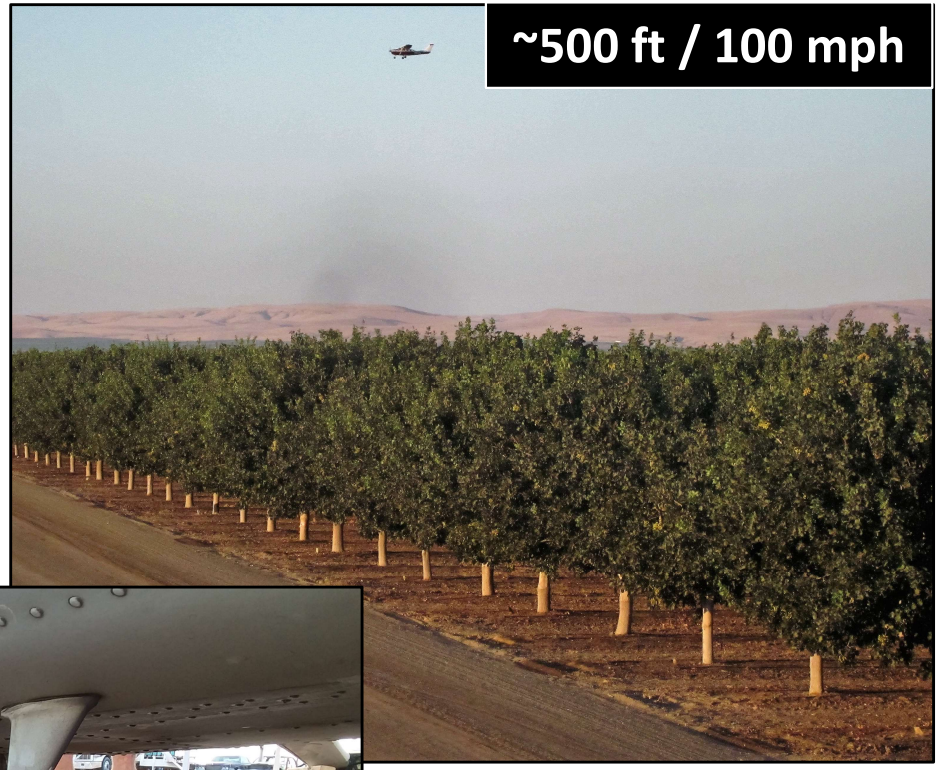
Passive Cooling System

SIT for NOW - Background

Moth Production/Transportation Process

Released Using Modified Small Aircraft

Cooling System + Released from Small Tube Below



Moths released from a small tube below the plane

SIT for NOW - Background

Moth Production/Transportation Process

When? Where? How Many?

Lots of moths…

- **~2,000,000 NOW/day**

…but also lots of crops.

- **1.2M almonds, 300k pistachio, 250k walnuts**
- **Plus alternate hosts**

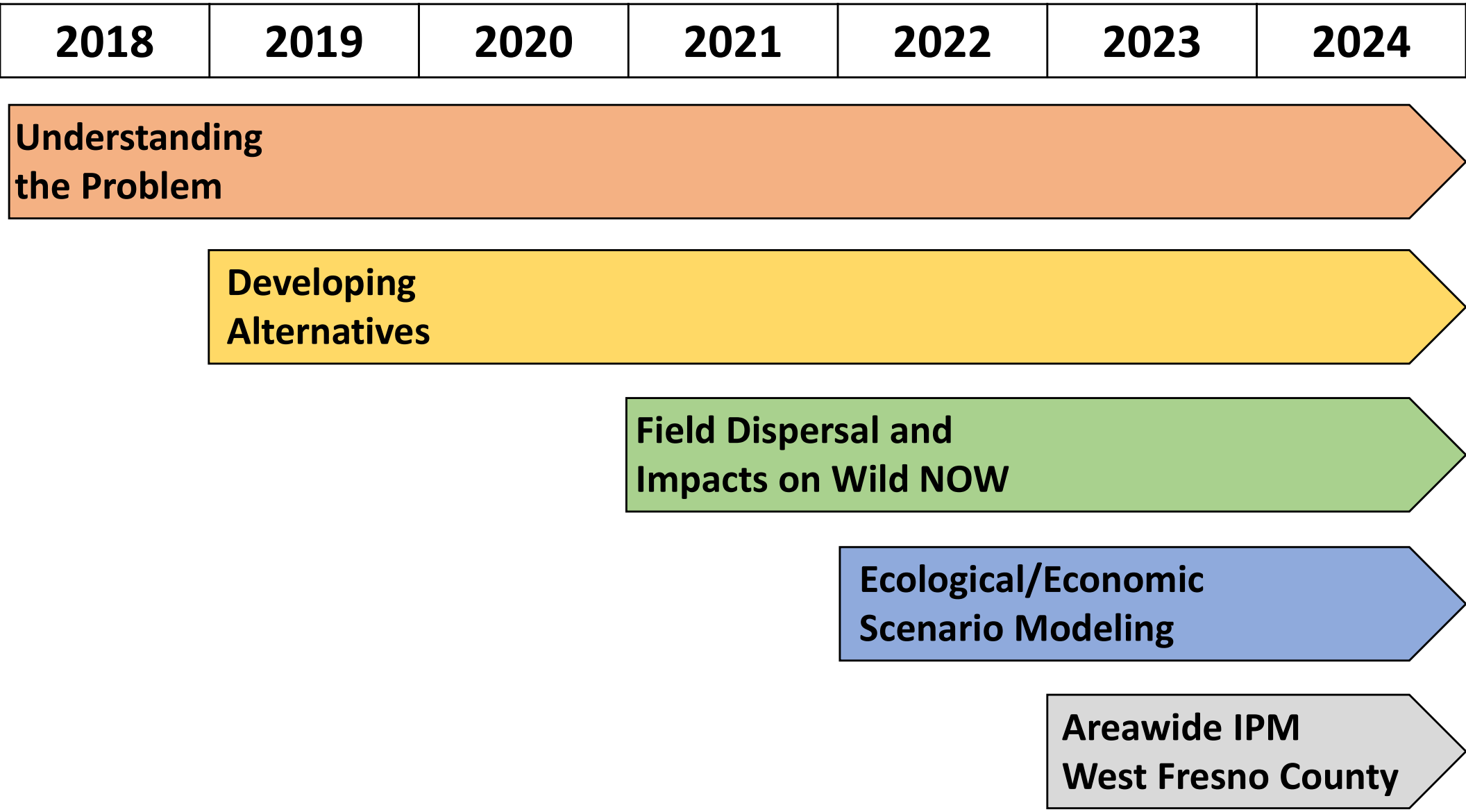
Where to deliver moths? When? How many?

- **Overflooding ratio**
- **Delivery method, timing and location**
- **Integration with existing IPM tools**

Goal = develop a competitive sterile moth, and figure out how to best use it.

Sterile Insect Technique for NOW Project

Project Summary 2018-2024



Research Summary: 2018-2021

Monitoring Techniques and Assays

Pheromone Traps

- Synthetic pheromone lure
- Attracts males
- Large trapping radius (captures lots of moths)

Ovibait Traps

- Pistachio/almond bait
- Attracts mated females
- Smaller trapping radius (captures fewer moths)

Research Summary: 2018-2021

Monitoring Techniques and Assays

Female calling (emitting pheromone) at night

NOW mating

Mating Tables

- Sentinel virgin female with wings clipped
- Exposed overnight
- Check at dawn for paired male
- Dissect moths to determine…
  - Male is sterile vs wild
  - Female is mated

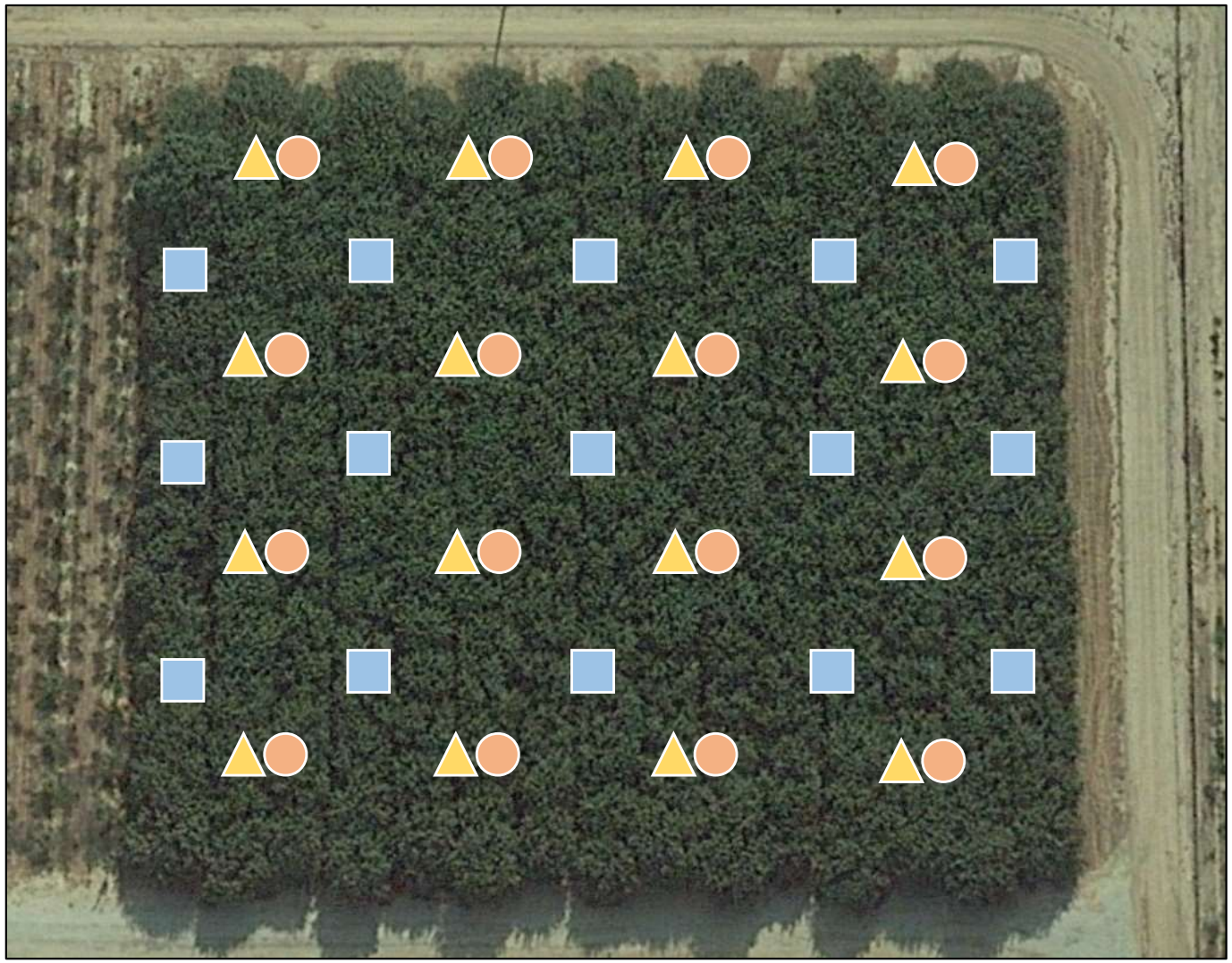
Sentinel Females Used

- Mendota Colony = control moth
  - Can sterile males locate females?
- Phoenix Facility
  - Can sterile females attract wild males?

Research Summary: 2018-2021

Field Release Sites – Two Small Pistachio/Almond Orchards

Grid of Traps and Mating Tables



Pheromone

Ovibait

Mating Table

1-3 acre blocks

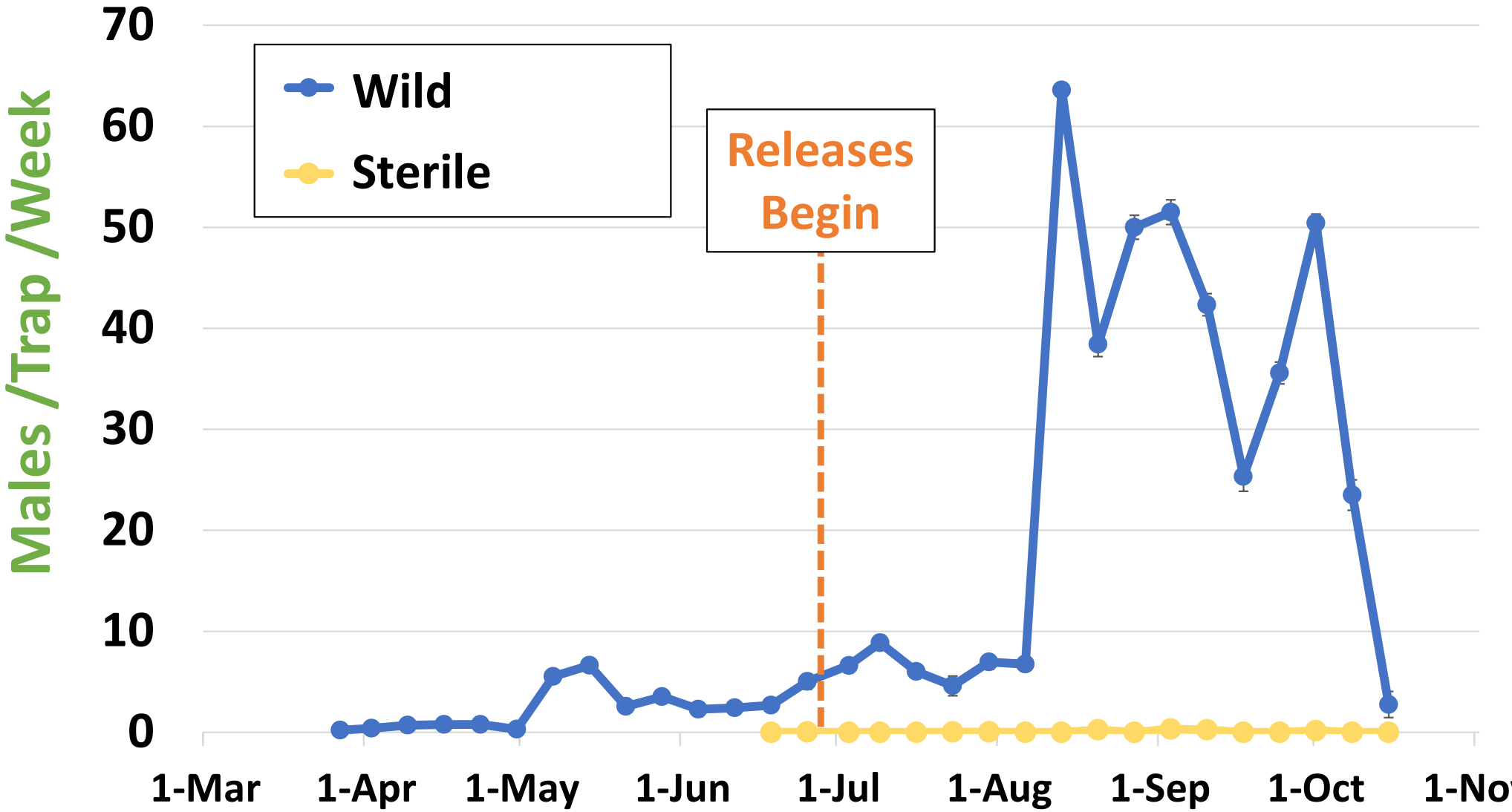
Crop Year 2018

What does moth recapture rate look like?

Crop Year 2018

Poor Recovery of Sterile Males

Flight Traps at Kearney



Crop Year 2019

Poor recovery in 2018

Can males even fly and respond to pheromone?

Crop Year 2019

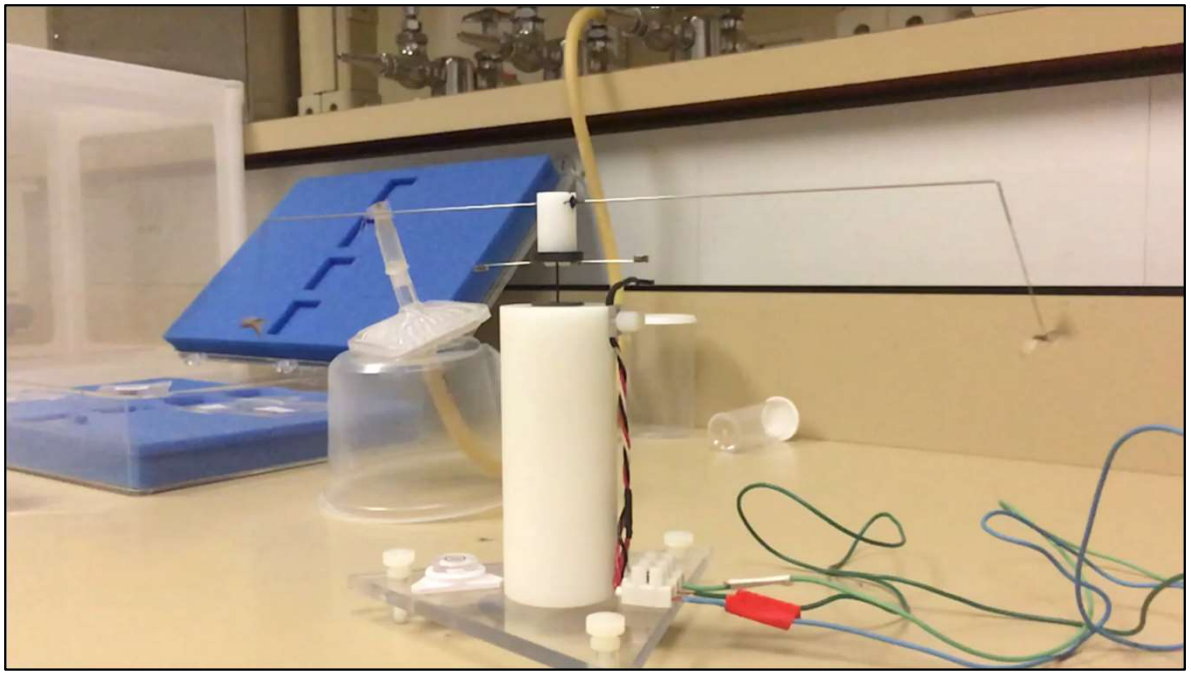
Why Such Poor Recovery of Males?

Can they even fly?

- **Flight mill assays**

Do they respond to pheromone?

- **Wind tunnel assays**



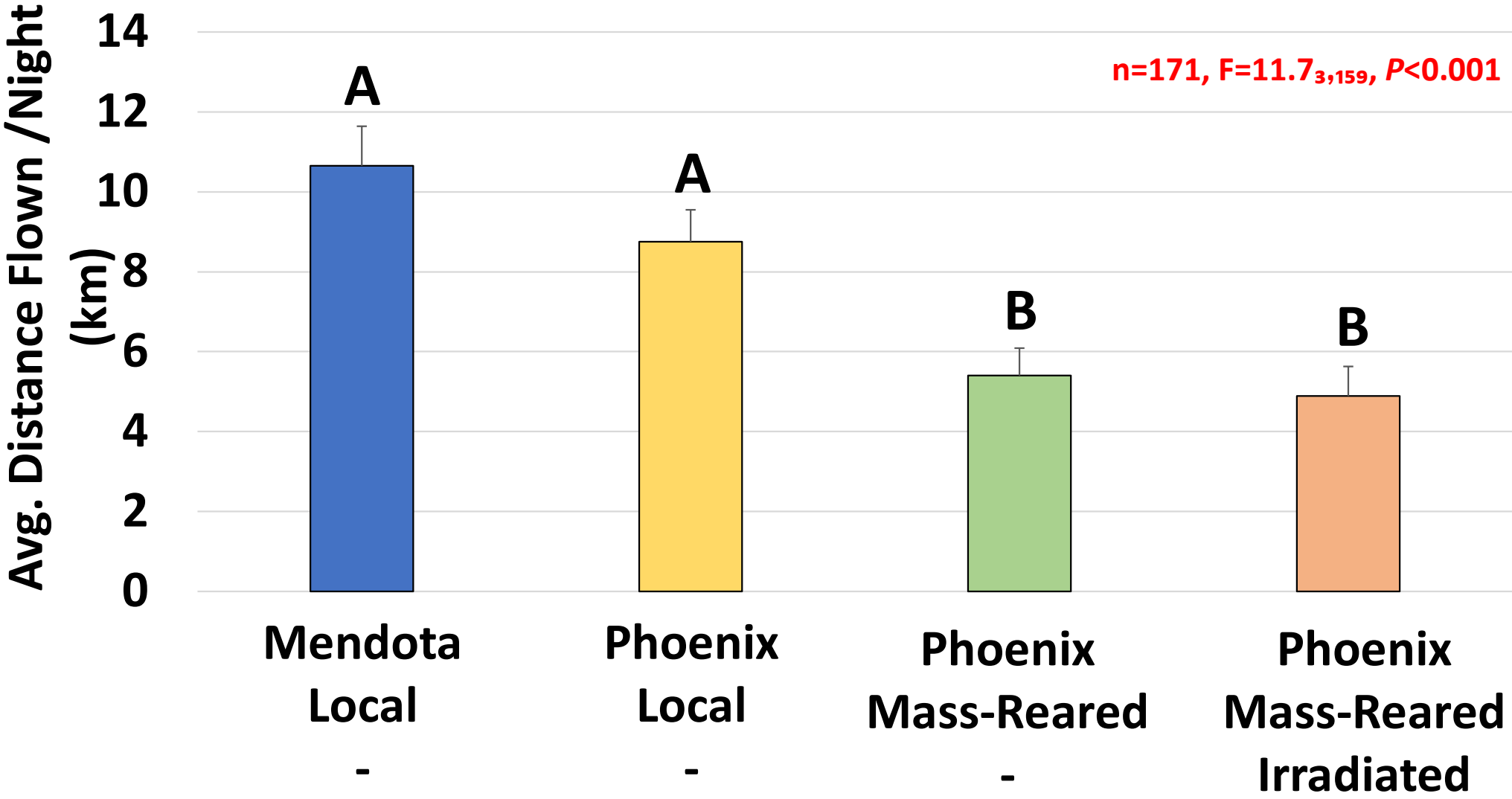
Tandem NOW on a flight mill

Video courtesy of
Joshua Reger, Ph.D. Student
Dept. Entomology, UC Riverside

Crop Year 2019

Evaluating the Phoenix Strain Males

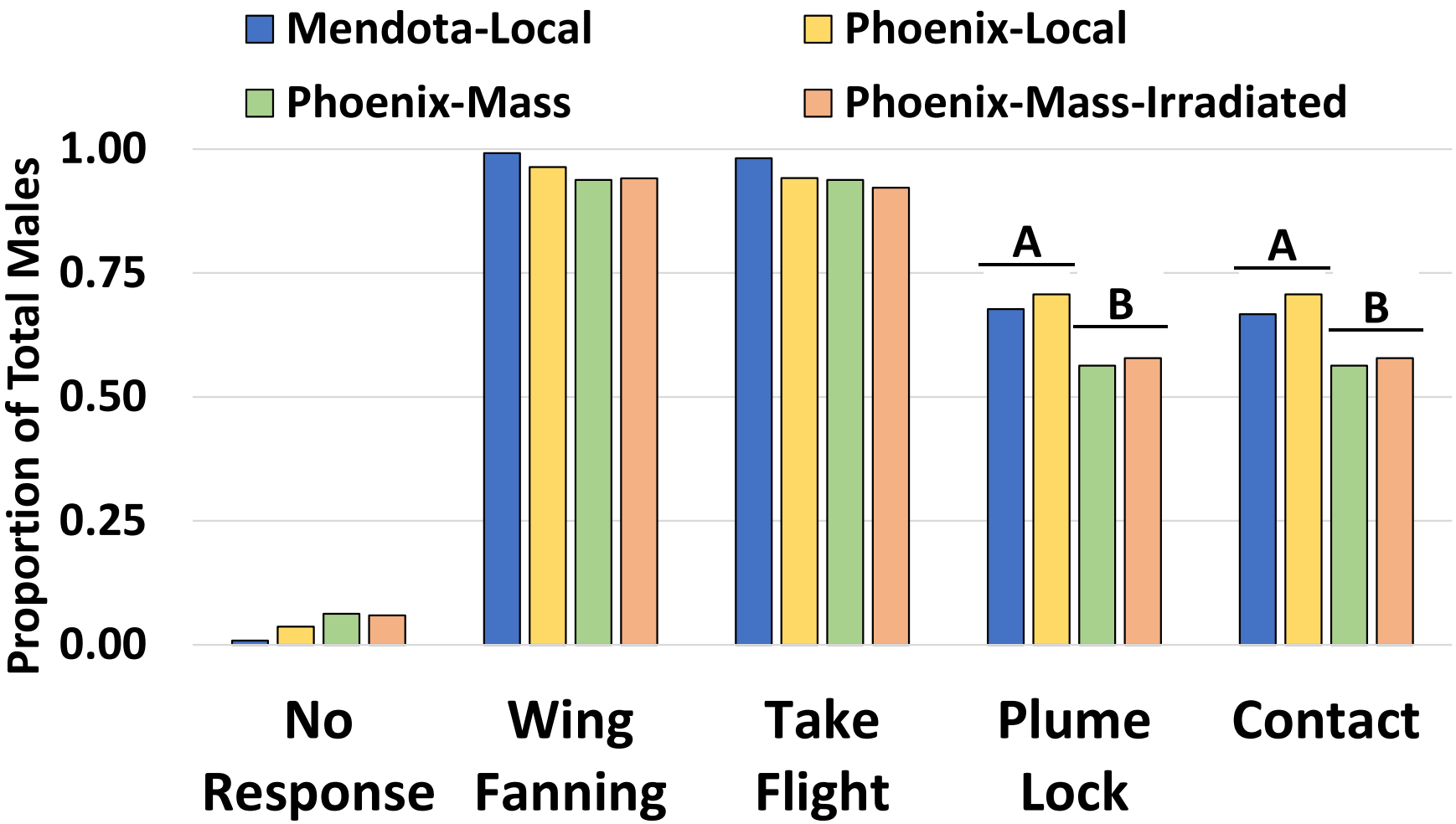
Males can fly – but not as well



Crop Year 2019

Evaluating the Phoenix Strain Males

Males do respond to pheromone



n=372, χ^2=4.09, *P*<0.05

Crop Year 2019

New Release System Provisions Vertical Space

Grocery Bags with Paper Tubes

Crop Year 2019

Recovery Dramatically Increased!

NOW Male Recapture - Kearney

Crop Year 2020-2021

YES - males fly and respond to pheromone

BUT – can they mate in the wild?

ALSO - release system is important

SO - can we improve it further?

Crop Year 2020-2021

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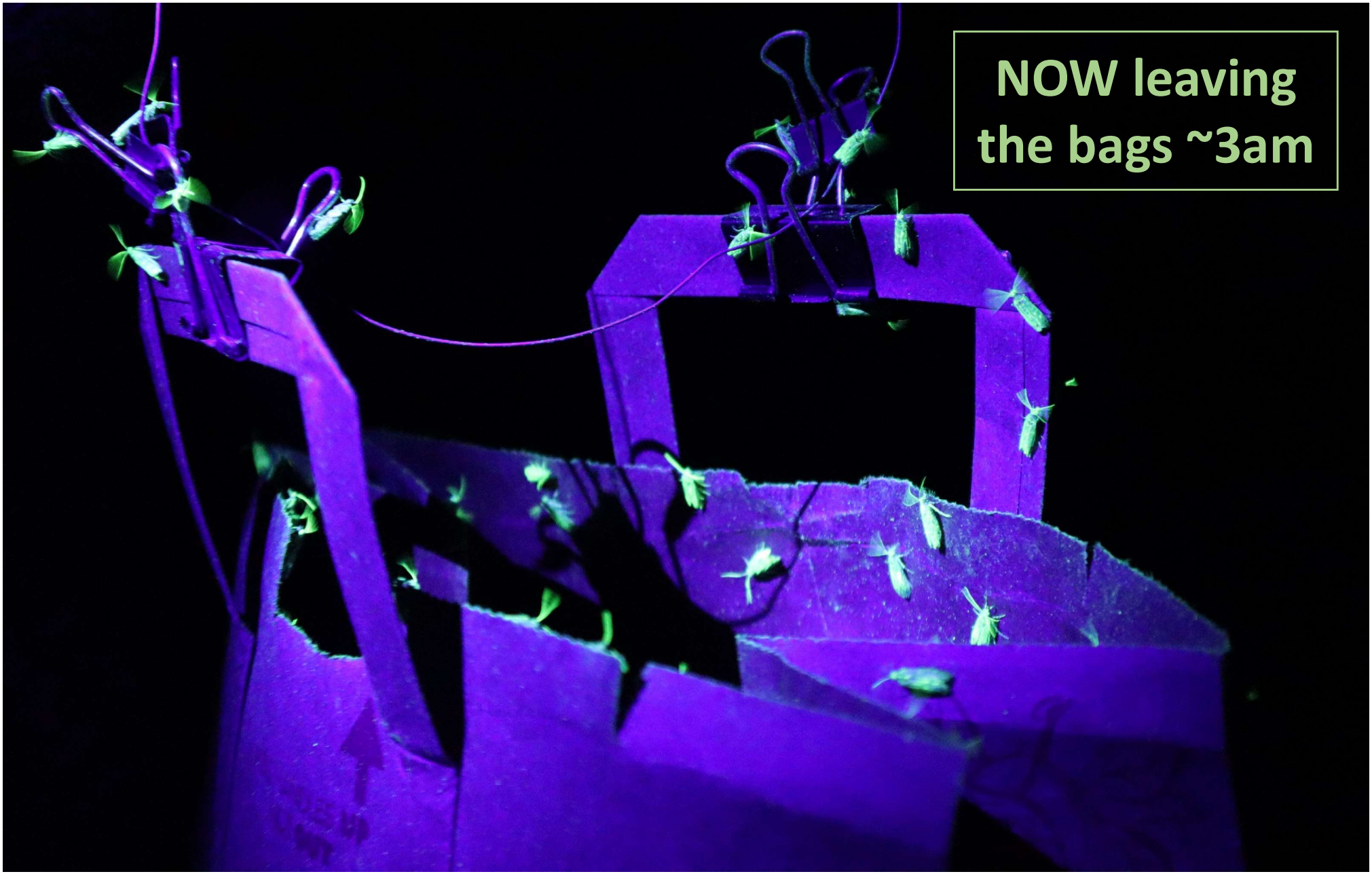
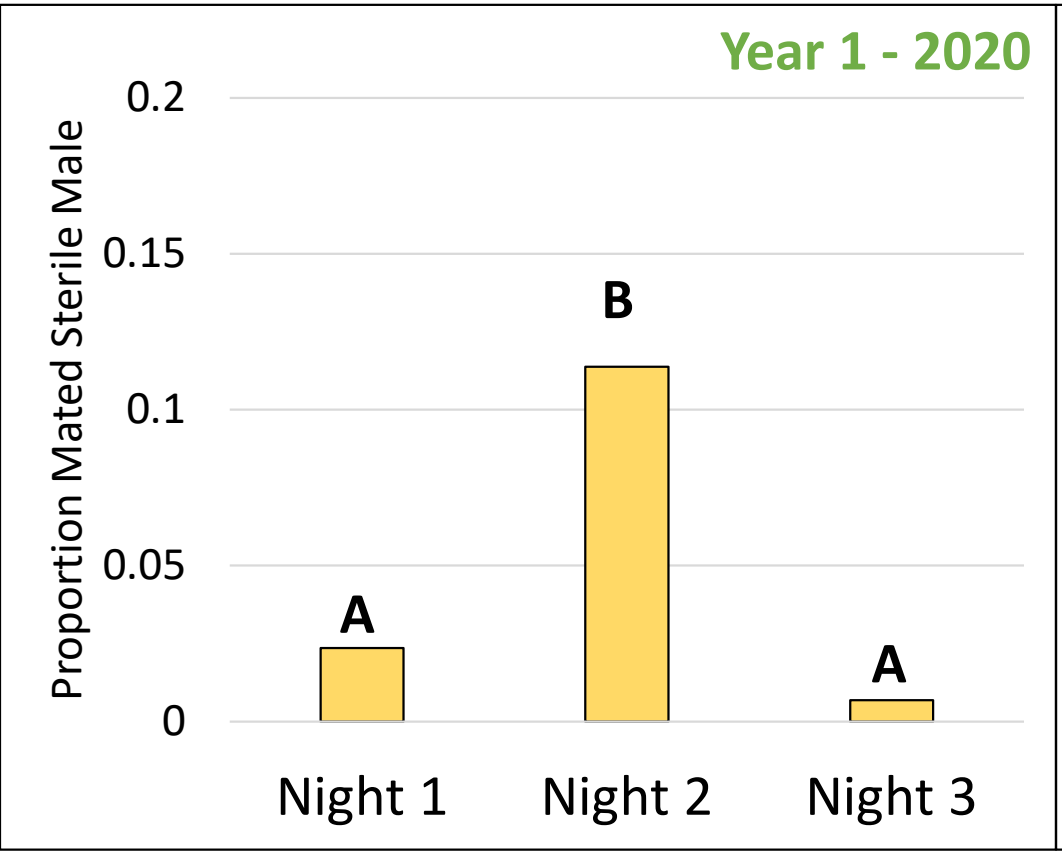
Crop Year 2020-2021

Recovery Improved – But Can They Mate?

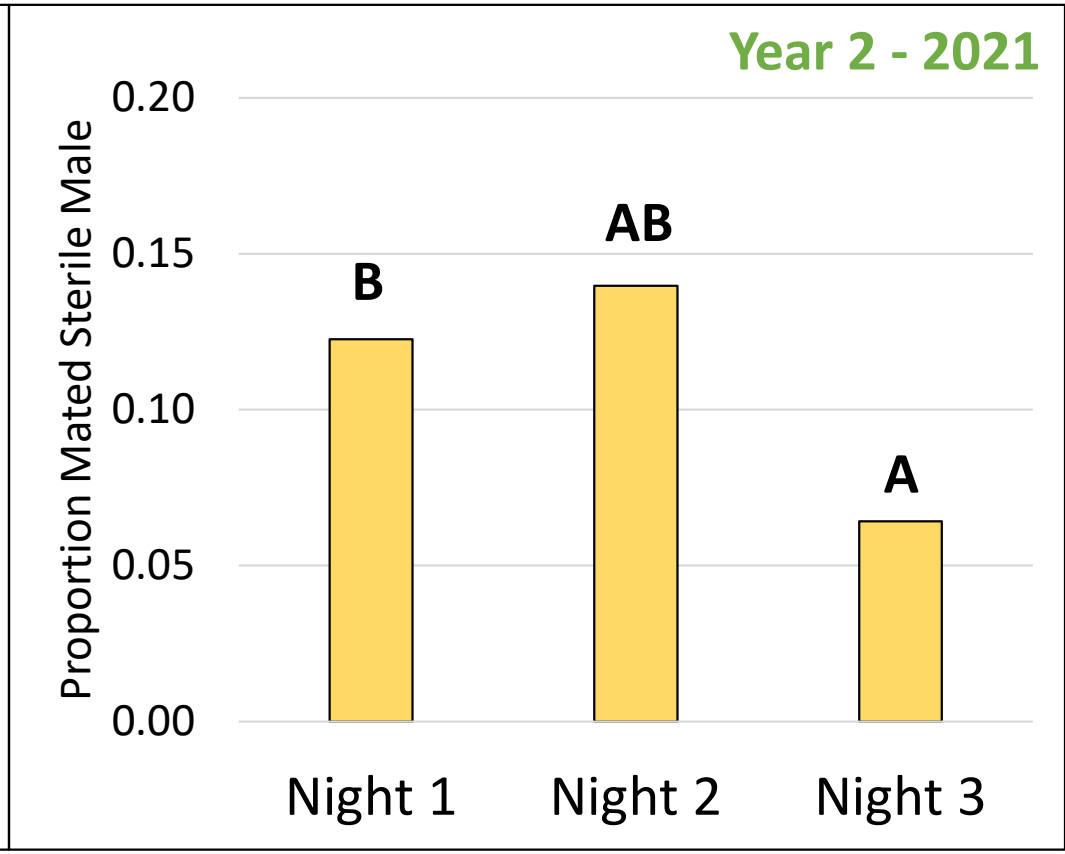


Crop Years 2020-2021

Mass/Sterile Males Can Locate Sentinel Females



χ^2=21.9, n=524, *P*<0.001



χ^2=10.6, n=541, *P*<0.01

Crop Years 2020-2021

Mass/Sterile Females Can Attract Wild Males

χ^2=44.0, n=1,115, *P*<0.001

Crop Year 2020-2021

YES - males fly and respond to pheromone

BUT – can they mate in the wild?

ALSO - release system is important

SO - can we improve it further?

Crop Year 2020-2021

Primary Focus on Transport/Release Methods

Transport

Shipped via UPS

Driven in refrigerated cooler

Vehicle: M3 Agriculture

Release

Paper Bag + Tubes

UAV/ Drone

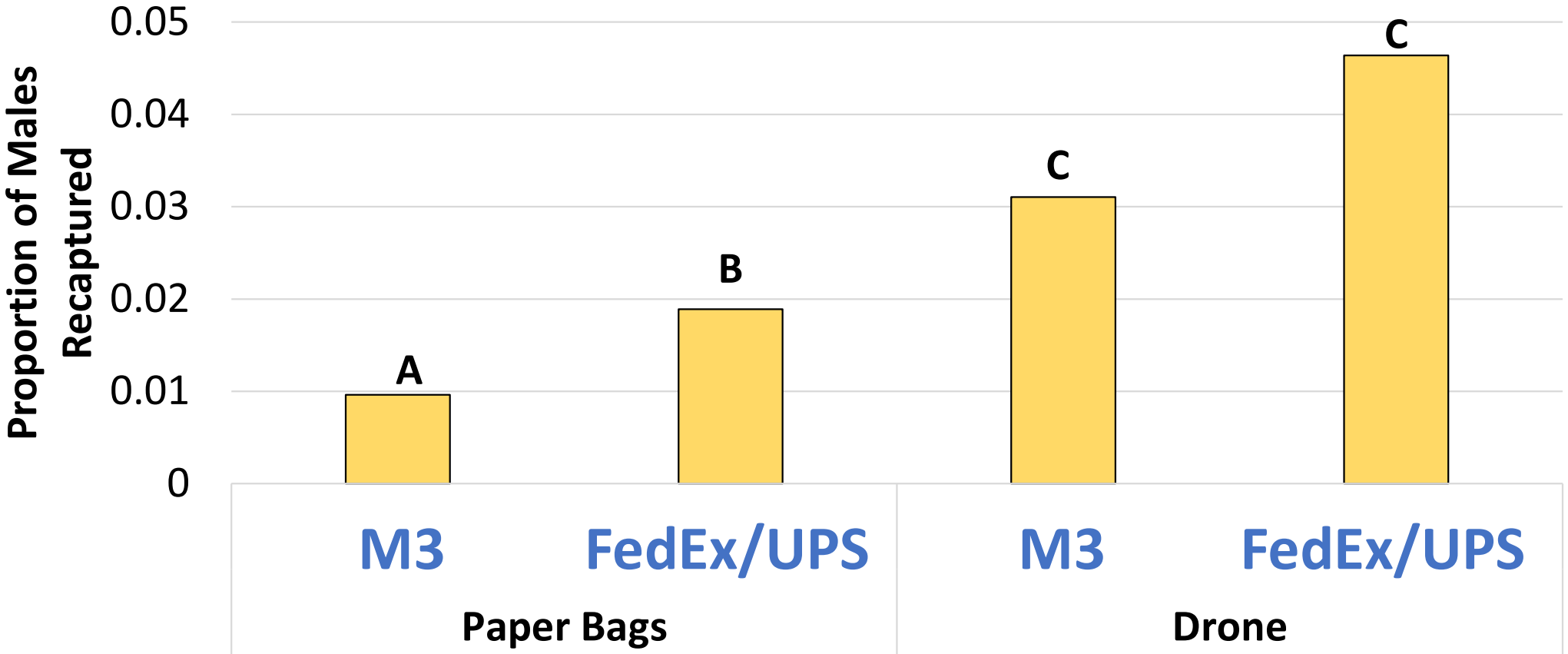
Drone: M3 Agriculture

M3 Agriculture Technologies

Crop Years 2020-2021

Transport and Release Does Influence Performance

Mass-Rear Moths Only

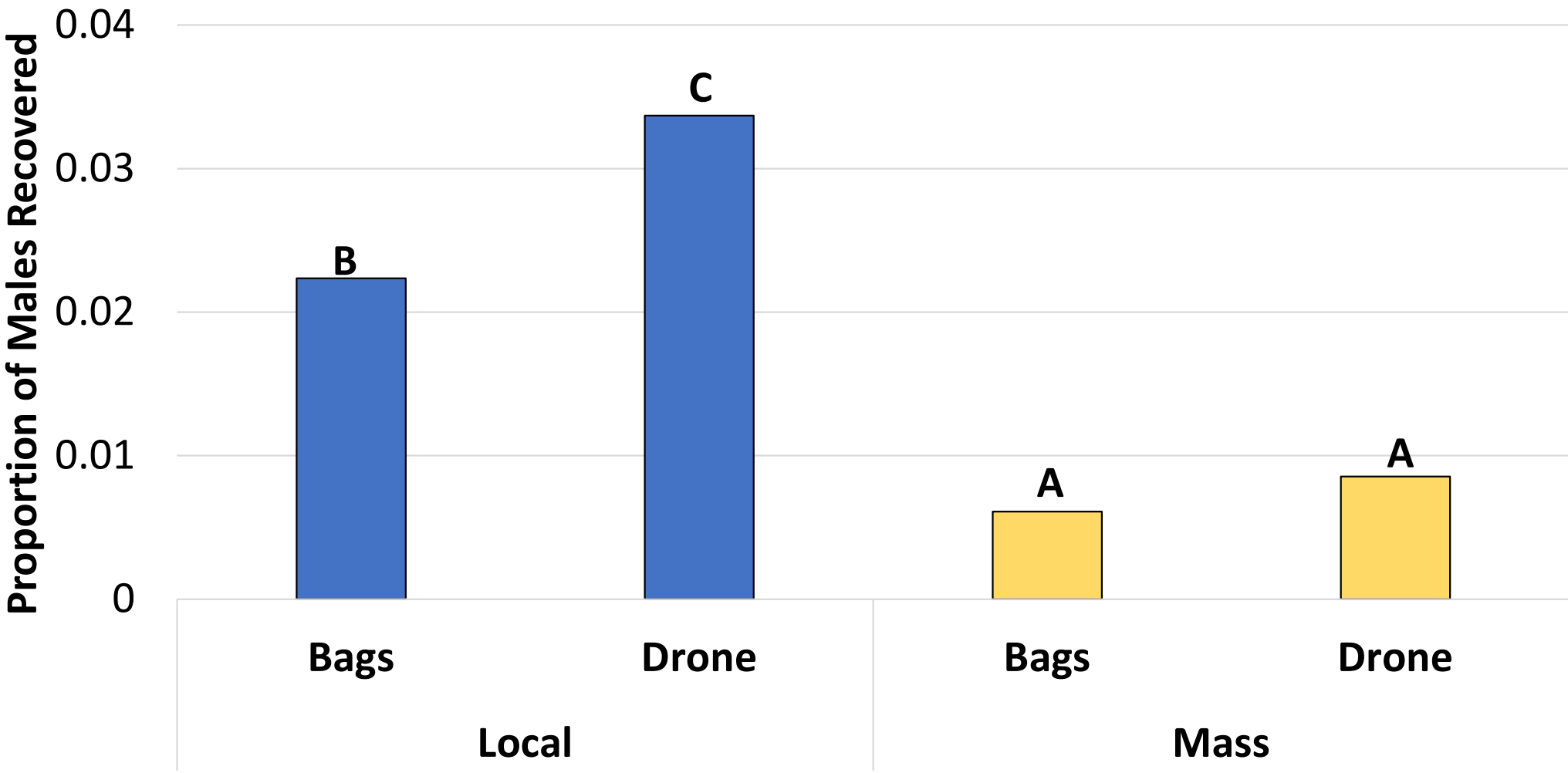


χ^2=9.7, n=19, *P*<0.01

Crop Years 2020-2021

Mass Rearing Negatively Impacts Field Performance

Regardless of Release Device or Transport



χ^2=352.2, n=40, *P*<0.01

Crop Years 2021-2023

Improved Recovery from the Airplane

How do they disperse in large blocks?

Can they impact wild NOW?

Mass-rearing/handling impacts

SO - new "MCS" strain

Where should moths be allocated?

Ecological-economic scenario modeling

Crop Years 2021-2023

Improved Recovery from the Airplane
How do they disperse in large blocks?
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Crop Years 2021/2022

Dispersal in Large Block Setting - Pistachios

Weekly Release with Grid of Traps

Crop Years 2021/2022

Dispersal in Large Block Setting - Pistachios

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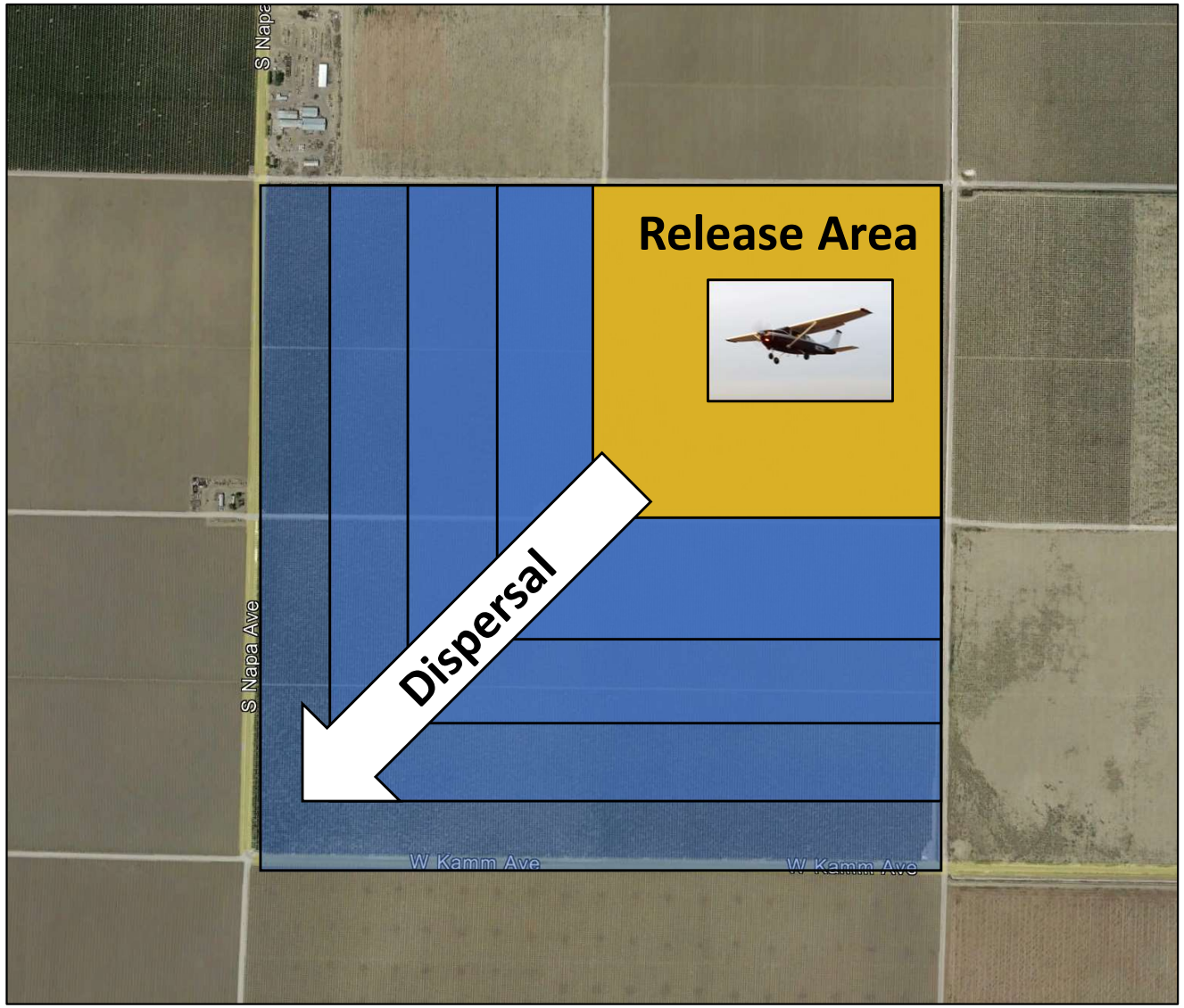
Crop Years 2021/2022

Dispersal in Large Block Setting - Pistachios

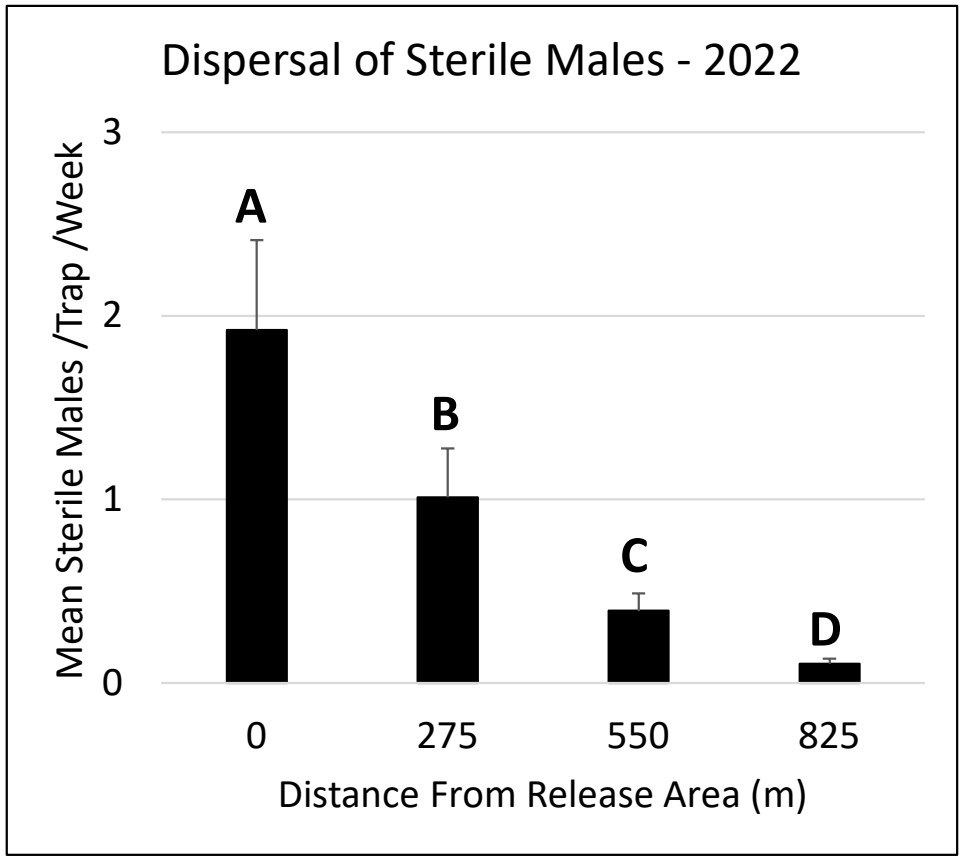
Weekly Release with Grid of Traps



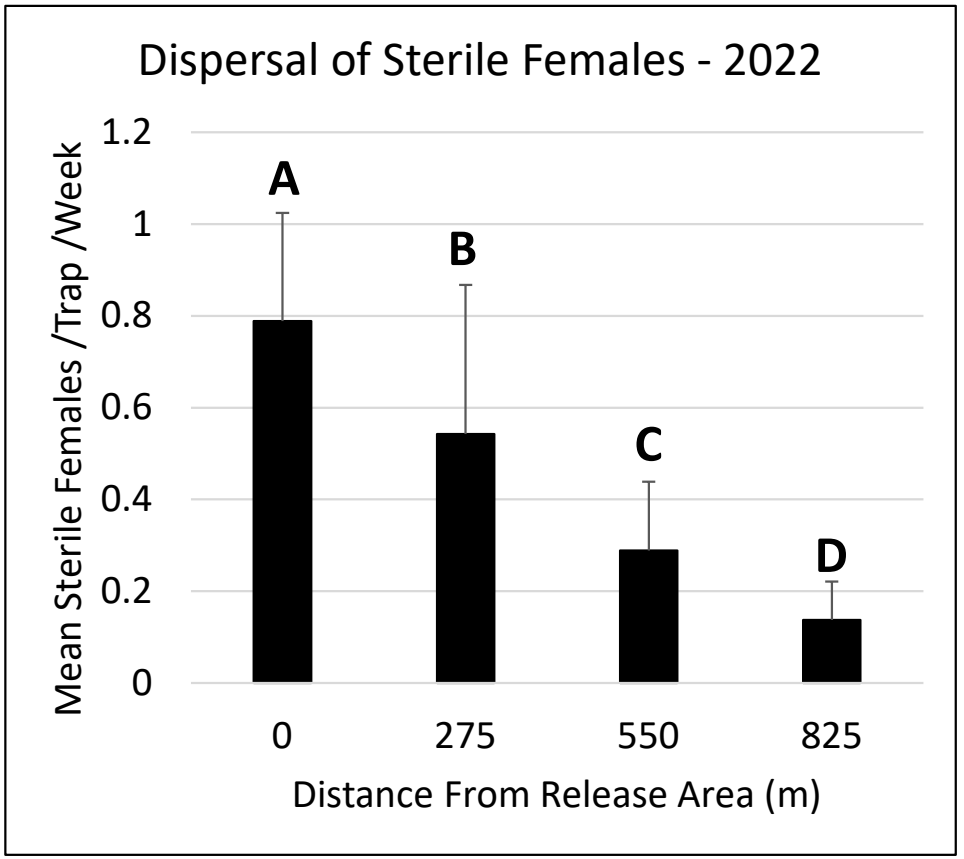
Crop Years 2021/2022

Dispersal in Large Block Setting - Pistachios

~50% remain in the release area – otherwise disperse out



χ^2=300.4, n=459, *P*<0.001



χ^2=53.9, n=350, *P*<0.001

Crop Years 2021/2022

Impact on Wild Populations – Almonds

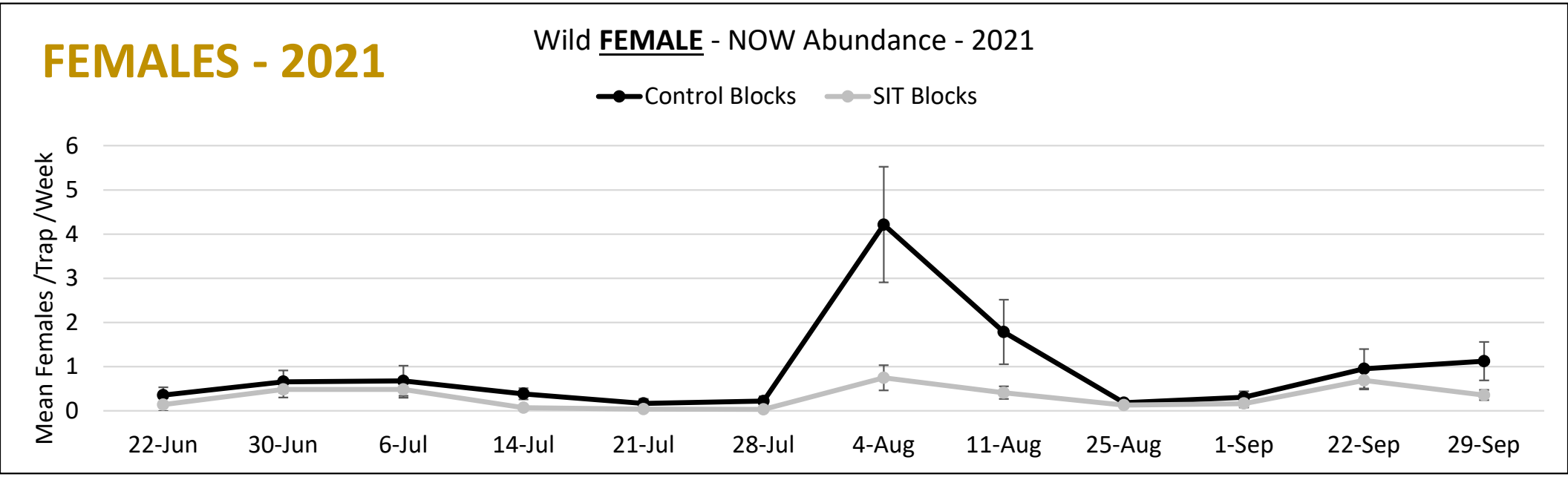
Weekly Release in Paired Plots

Crop Years 2021/2022

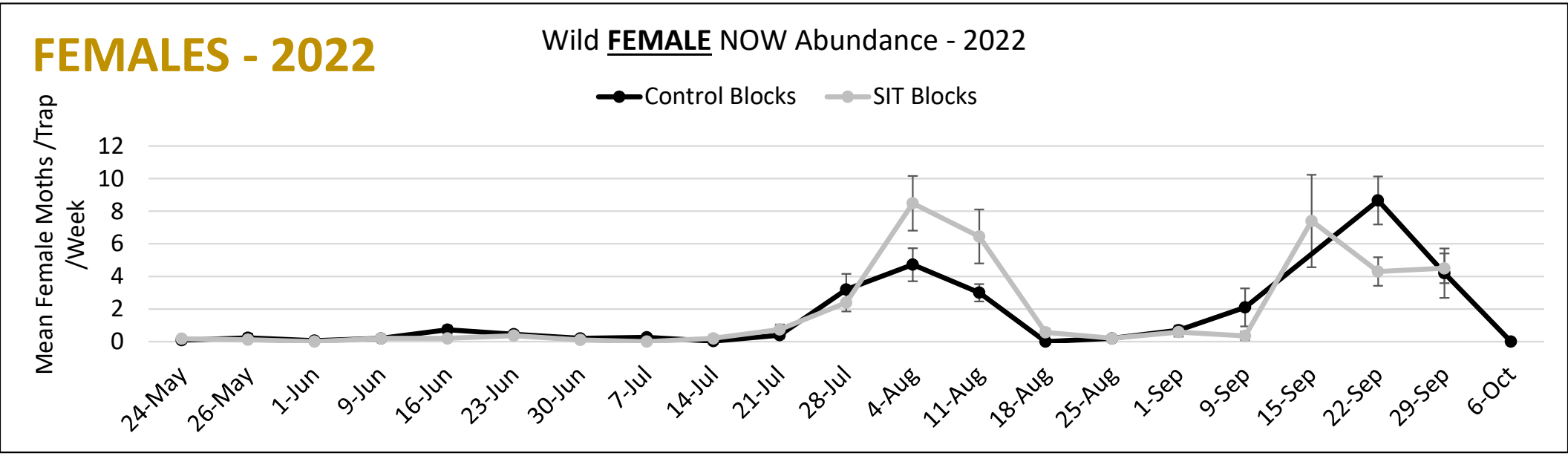
Impact on Wild Populations - Almonds

So Far - Inconsistent Impacts on Wild Populations and Crop Damage

FEMALES - 2021



FEMALES - 2022



Crop Years 2021-2023

Improved Recovery from the Airplane

How do they disperse in large blocks?

Can they impact wild NOW?

Mass-rearing/handling impacts

SO - new "MCS" strain

Where should moths be allocated?

Ecological-economic scenario modeling

Crop Years 2022-2023

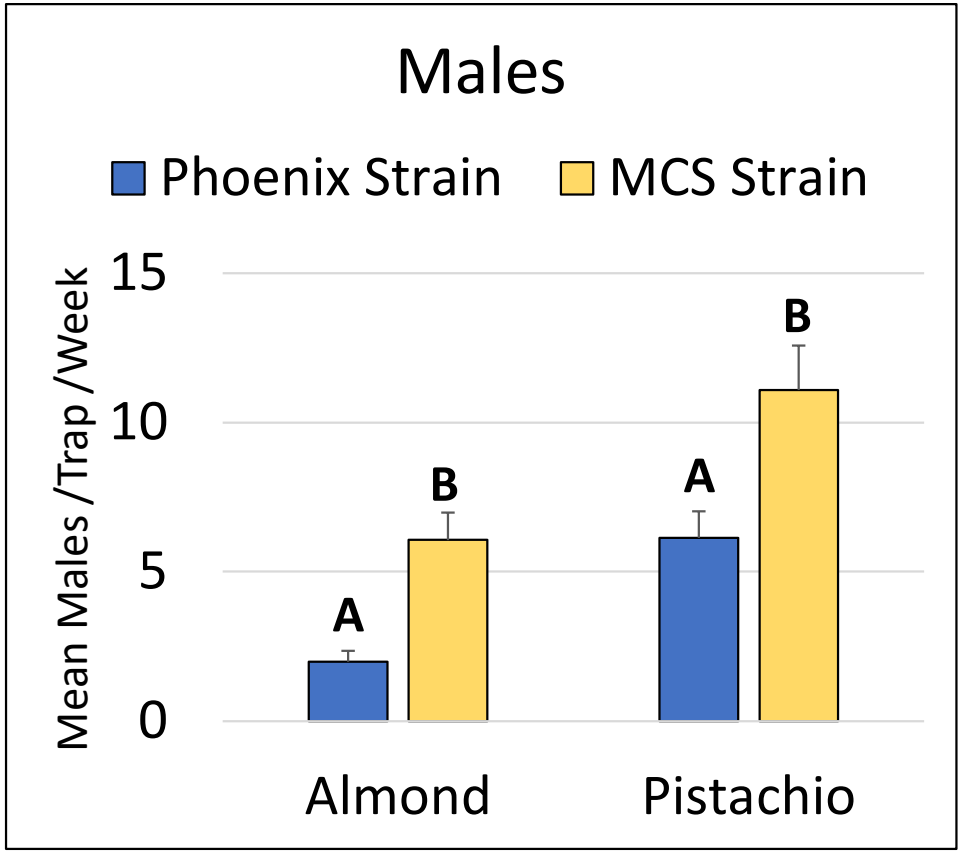
Comparison of Improved Strain for Mass Rearing

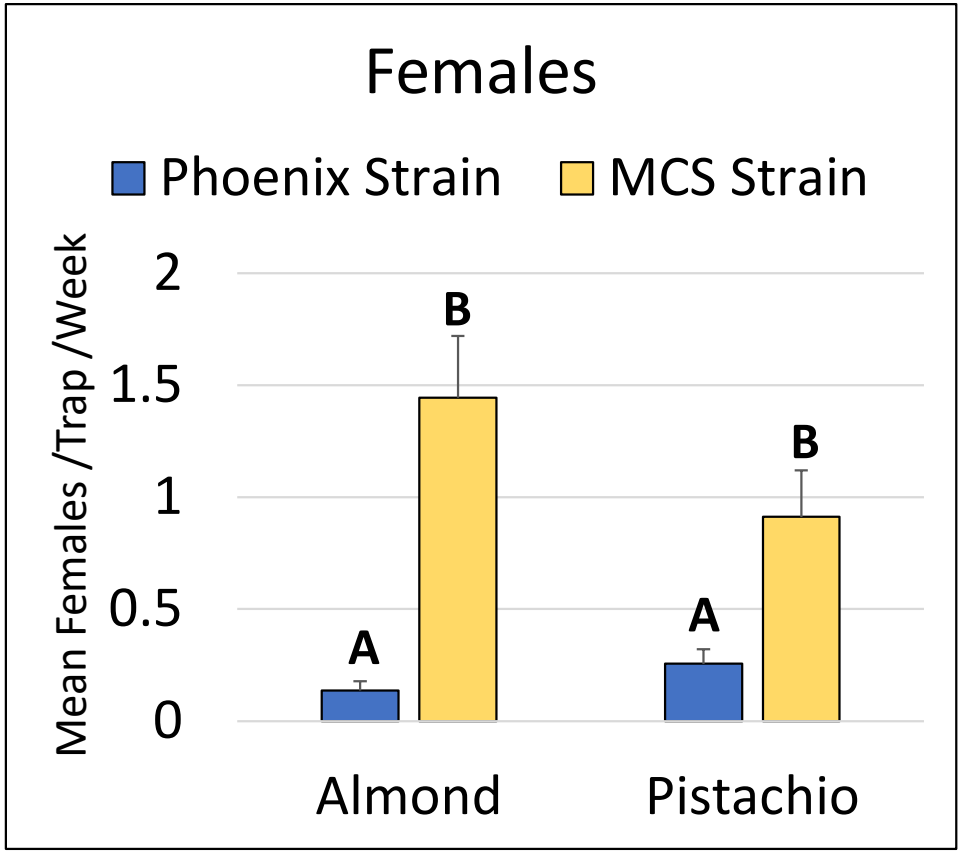
‘MCS’ Strain Selected for Rearing Conditions

Crop Year 2022

Comparison of Improved Strain for Mass Rearing

Small Plot Work - So Far Looks Promising…

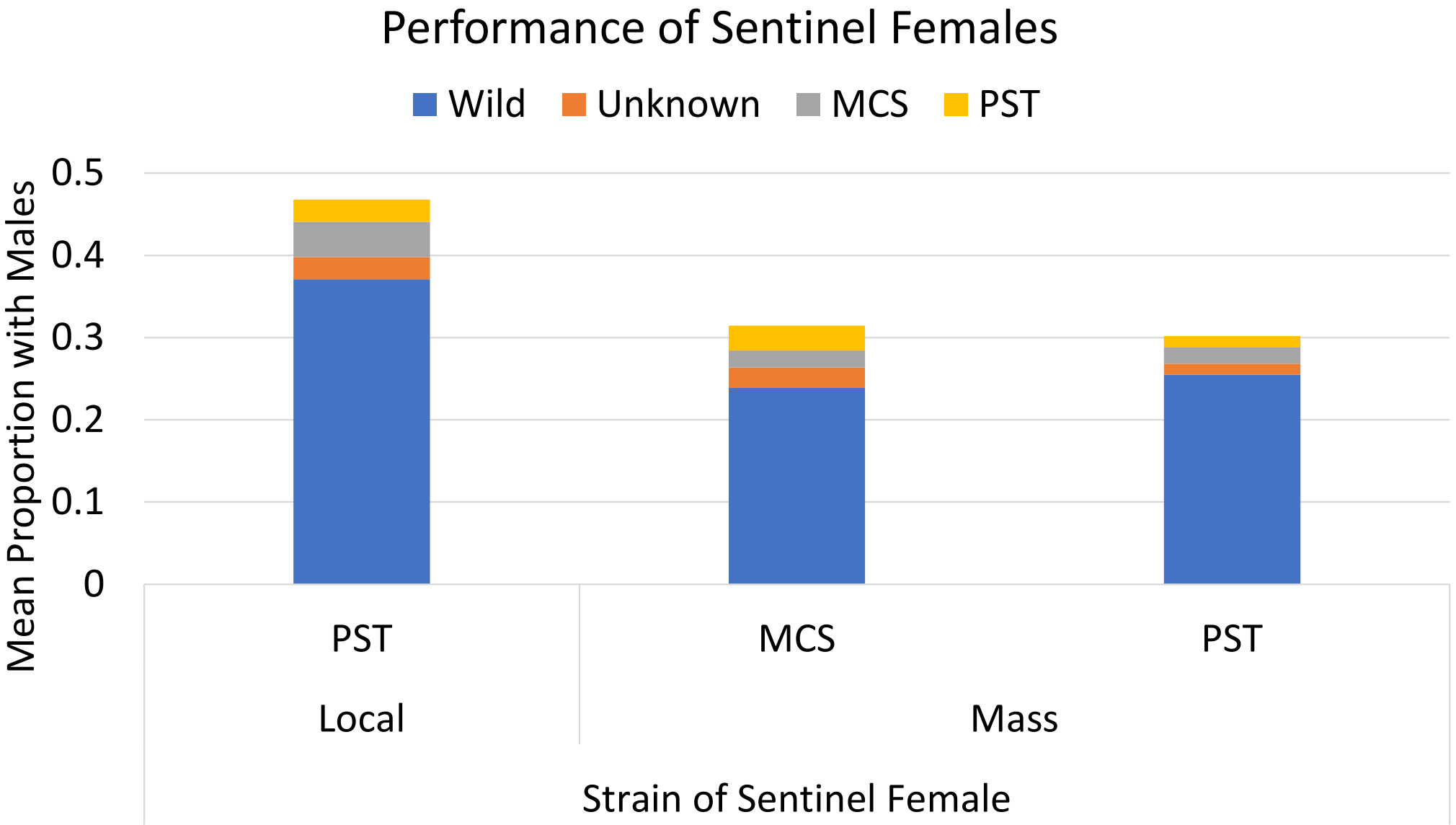




Crop Year 2023

Comparison of Improved Strain for Mass Rearing

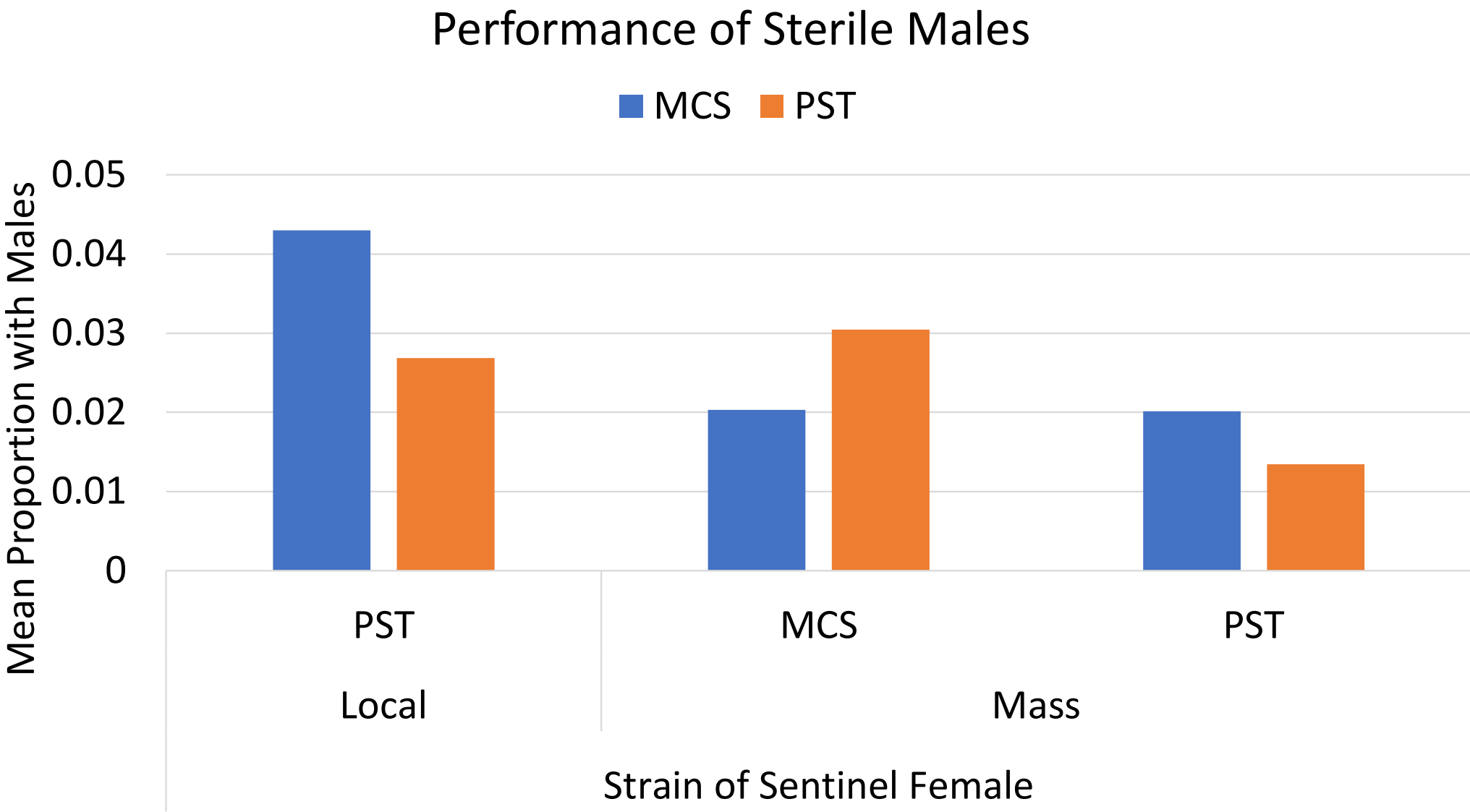
Mating Tables – sterile females can attract wild NOW



Crop Year 2023

Comparison of Improved Strain for Mass Rearing

Mating Tables – sterile males can find sentinel females



Crop Years 2021-2023

Improved Recovery from the Airplane

How do they disperse in large blocks?

Can they impact wild NOW?

Mass-rearing/handling impacts

SO - new "MCS" strain

Where should moths be allocated?

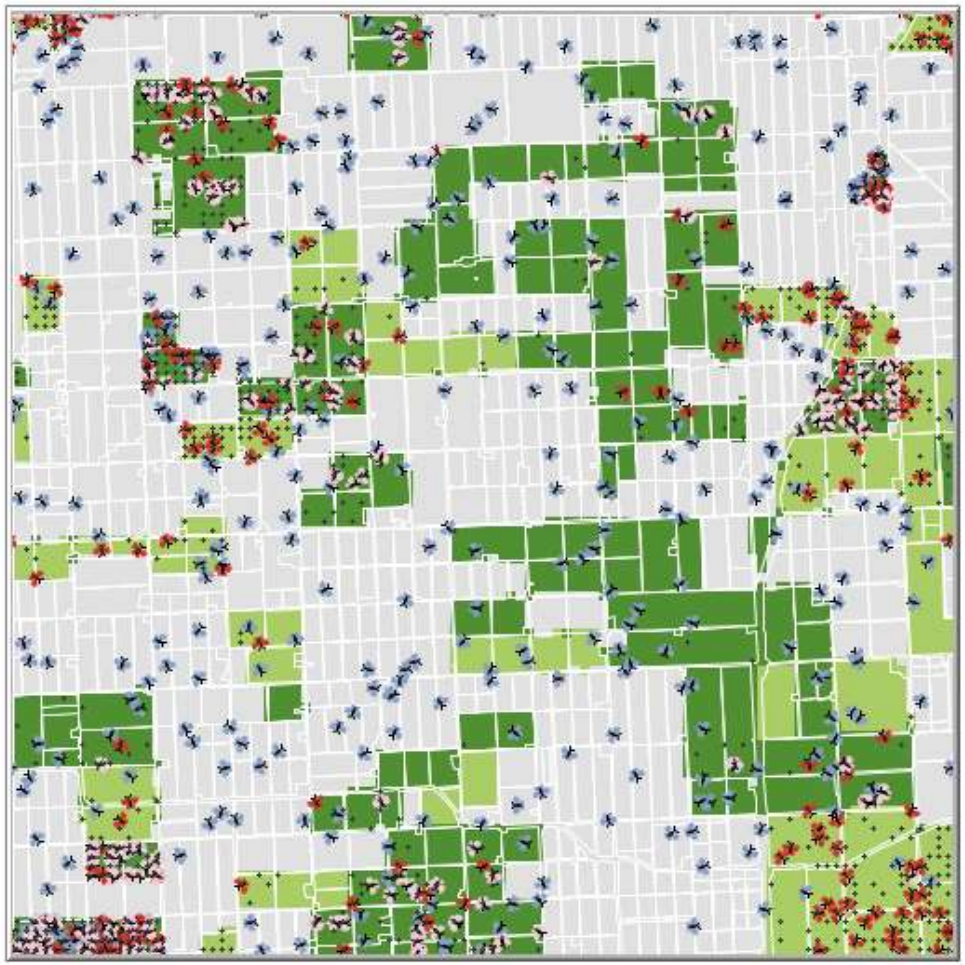
Ecological-economic scenario modeling

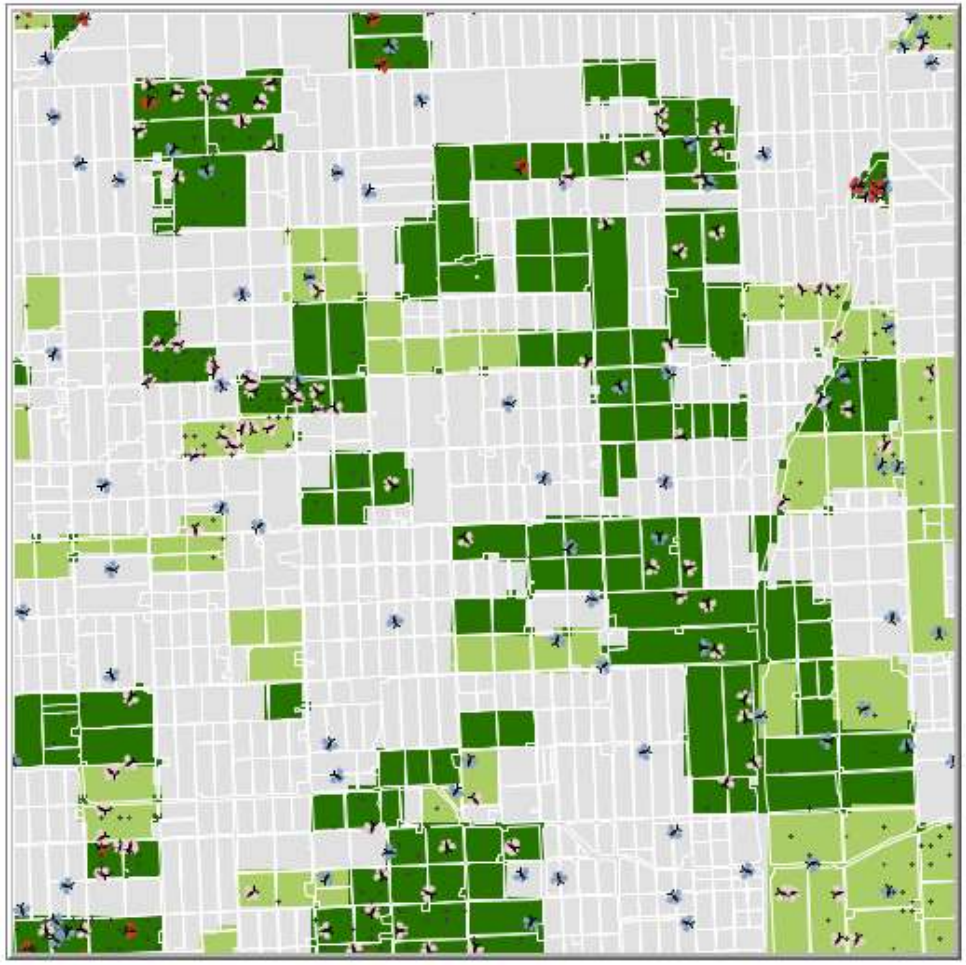
Crop Years 2021-2023

Ecological/Economic Scenario Modeling

Can we determine if/when/where sterile NOW makes sense?

Models incorporate various features to make them realistic, such as data on the distribution and arrangement of tree nut orchards, pesticide use and tree phenology.





Co-PIs: Dr. Ran Wei (UC Riverside) and Dr. Brittney Goodrich (UC Davis)

Crop Years 2021-2023

Ecologica/Economic Scenario Modeling

General Process

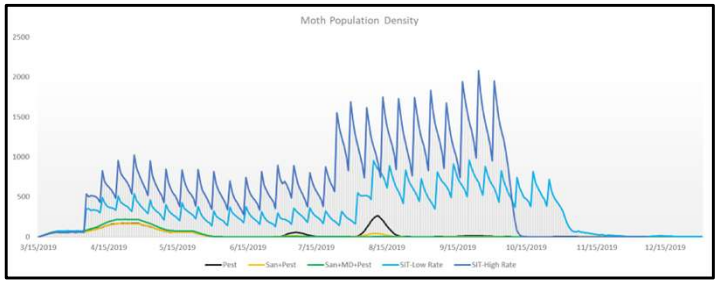
1

Predefined scenarios include different combinations of management practices.

Example Scenarios
1. Pesticides Only
2. Sanitation + Pesticides
3. Sanitation + Mating Disruption (MD) + Pesticides
4. Sanitation + SIT at Low Rate
5. Sanitation + SIT at High Rate

2

Scenarios then generate different population curves for NOW in a given region.



3

Those NOW populations then have differential impacts on crop damage.

% Damage Rate	Almond		Pistachio	
	Nonpareil	Monterey	1st-Harvest	2nd-Harvest
1-Pesticide	0.04	0.04	0.06	0.73
Sanitation + 1-Pesticide	0	0.09	0.01	0.1
Sanitation + MD + 1-Pesticide	0	0	0	0
Sanitation + SIT-Low Rate	1.35	0	1.38	2.42
Sanitation + SIT-High Rate	0	0	0	0

4

Management efforts and crop damage can then be used to estimate economic costs/benefits under each scenario.

IPM	Percent Damage	IPM Cost Per Acre	Revenue Per Acre	Net Benefit Per Acre
Pesticide	0.04	$ 65.46	$ 3,998.50	$ 3,933.04
Sanitation + Pesticide	0	$ 421.00	$ 4,000.10	$ 3,579.10
Sanitation + Pesticide + MD	0	$ 531.00	$ 4,000.10	$ 3,469.10
Sanitation + Low SIT	1.35	$ 355.54	$ 3,902.50	$ 3,546.96
Sanitation + High SIT	0	$ 355.54	$ 4,000.10	$ 3,644.56

Sterile Insect Technique for NOW Project

Key Points 2018-2023

Sterile Insect Technique for NOW Project

Key Points 2018-2023

2018

- **Poor initial recovery, likely due to release method**

Sterile Insect Technique for NOW Project

Key Points 2018-2023

2018

- Poor initial recovery, likely due to release method

2019

- Confirmed male flight and pheromone response
- Improved release method (paper bags) for field experiments

Sterile Insect Technique for NOW Project

Key Points 2018-2023

2018

- Poor initial recovery, likely due to release method

2019

- Confirmed male flight and pheromone response
- Improved release method (paper bags) for field experiments

2020-2021

- Determined that mass-rearing has a clear negative impact
- That said - sterile M/F can locate/attract wild F/M in current form
- New transport and release methods can improve field performance

Sterile Insect Technique for NOW Project

Key Points 2018-2023

2022-2023

- Initial work with ‘MCS’ strain – definitely performs better
- Starting to better understand field dispersal
- Very mixed impacts on wild NOW and crop damage
- Figuring out the ecological/economic scenario modeling

Sterile Insect Technique for NOW Project

Key Points 2018-2023

2022-2023

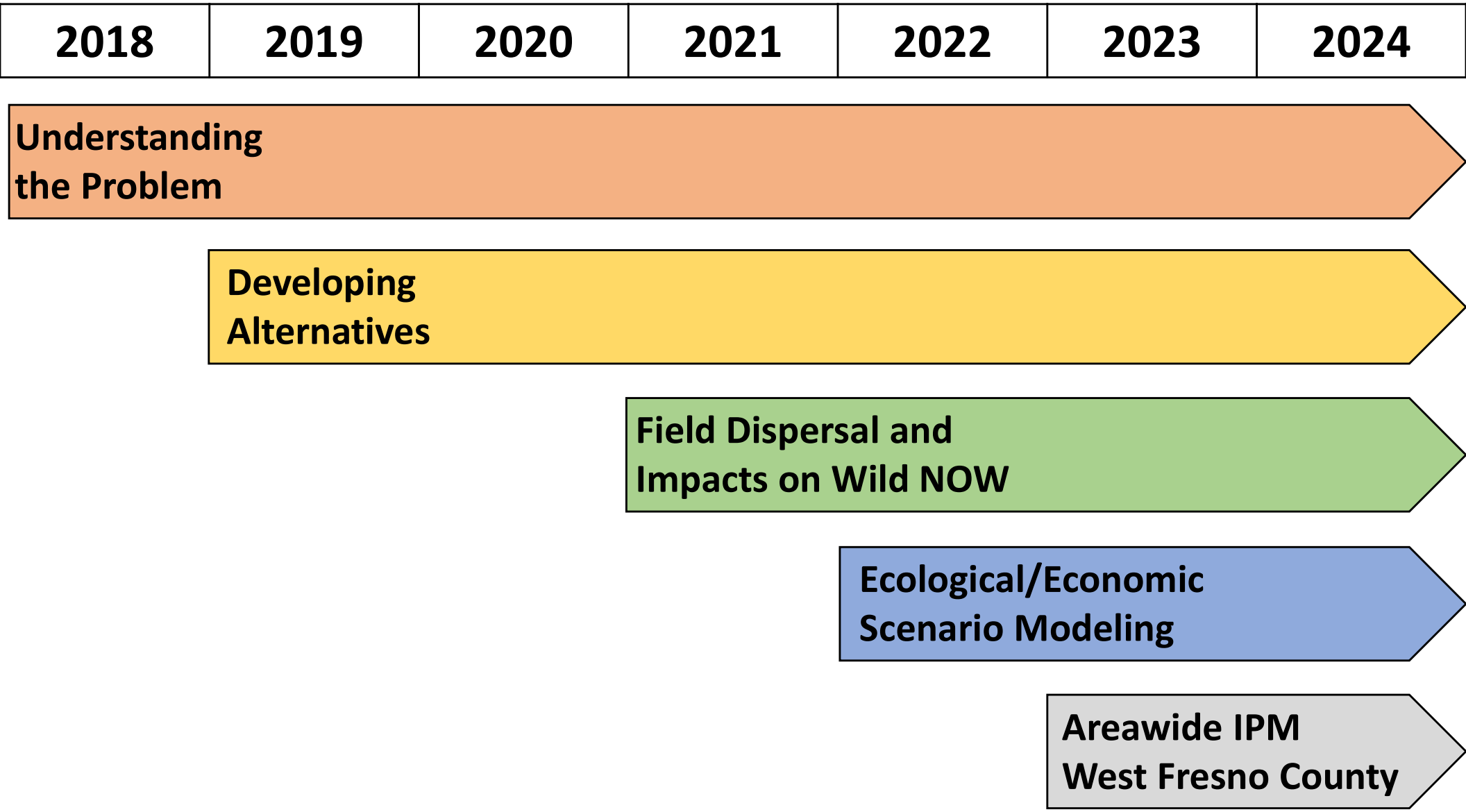
- Initial work with 'MCS' strain – definitely performs better
- Starting to better understand field dispersal
- Very mixed impacts on wild NOW and crop damage
- Figuring out the ecological/economic scenario modeling

2023-2024 and beyond…

- Continued work on dispersal, impacts of wild NOW, modeling etc.
- New markers for sterile male spermatophores
- Exploring X-ray and eBeam as alternatives
- Improving the cold collection and handling system
- New external markers for field studies

Sterile Insect Technique for NOW Project

Project Summary 2018-2024



Thank You!

Houston Wilson

Houston.Wilson@ucr.edu

http://treecrops.ucr.edu/

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USDA ARS Agricultural Research Service

cdfa 100 YEARS CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE 1919 - 2019

APHIS

Development of a Pheromone Lure for Leaffooted Plant Bug (Coreidae: *Leptoglossus zonatus*)

Houston Wilson[1,2], Sarah Meierotto[1,2], Reva Scheibner[1,2], Sean Halloran[1], Jocelyn Millar[1], Kent Daane[2,3]

[1]Dept. Entomology, UC Riverside

[2]Kearney Agricultural Research and Extension Center

[3]Dept. Enviro. Science Policy and Management, UC Berkeley

Leaffooted Bugs (LFB)

Key Species in California

Leptoglossus zonatus

- Two distinct yellow marks on pronotum
- Most common species currently

Leptoglossus clypealis

- Distinct clypeus points outward from head
- Used to be abundant, now less common

Leptoglossus occidentalis

- No marks, no clypeus
- Rare, mostly a forest/conifer pest

Leaffooted Bugs (LFB)

Current Pest Status

Pierce-suck feeder, primarily seeds

- Can attack a wide range of hosts

Directly attack pistachio nuts

Early season (Apr – Jun)

- Epicarp lesion
- Nut drop/abortion

Late season (Jun-Sept)

- Kernal necrosis
- "Achilles heel"

Transmit Pathogens

- Stigmatomycosis
- Botryosphaeria
- Shoot blight

Epicarp Lesion

Kernal Necrosis

Damage through stem base

Current Monitoring

Beat Sampling, Visual Searching

Monitoring Techniques (~April)

1. Beat sampling

- Early in the morning, bugs less active
- Hold tray below, strike clusters
- Examine what falls out

2. Look for egg masses

3. Look for damage (small, black nuts)

Current Monitoring

Beat Sampling, Visual Searching

Monitoring Techniques (~April)

Significant Limitations

- **Monitoring targets "after the fact" signs**
- **Time intensive, active monitoring**
- **No clear thresholds**
- **Arrival can be difficult to predict**

New Traps and Pheromone Lures for LFB

Developing a Passive Sampling System

Active, time intensive sampling of tree canopy

New Traps/Lures

Passive trapping with pheromone lures

Kent Daane
(UC Berkeley)

Jocelyn Millar
(UC Riverside)

Houston Wilson
(UC Riverside)

New Traps and Pheromone Lures for LFB

Current Project Goals and Objectives

Goal = Develop a Trap/Lure System for LFB

Key Project Objectives

1. Find a trap that works
2. Identify key pheromone compounds
3. Synthesize these chemicals
4. Evaluate lures in the field
5. Develop reliable monitoring

Photo: Kent Daane

LFB Pheromone Trap/Lure Project

Progress to Date

Objective 1

Find a Trap that Works

LFB Pheromone Trap/Lure Project

Finding a Trap that Works

Trap Comparison Study – 2017

Pyramid 4-ft

Pyramid 2-ft

Clear Sticky

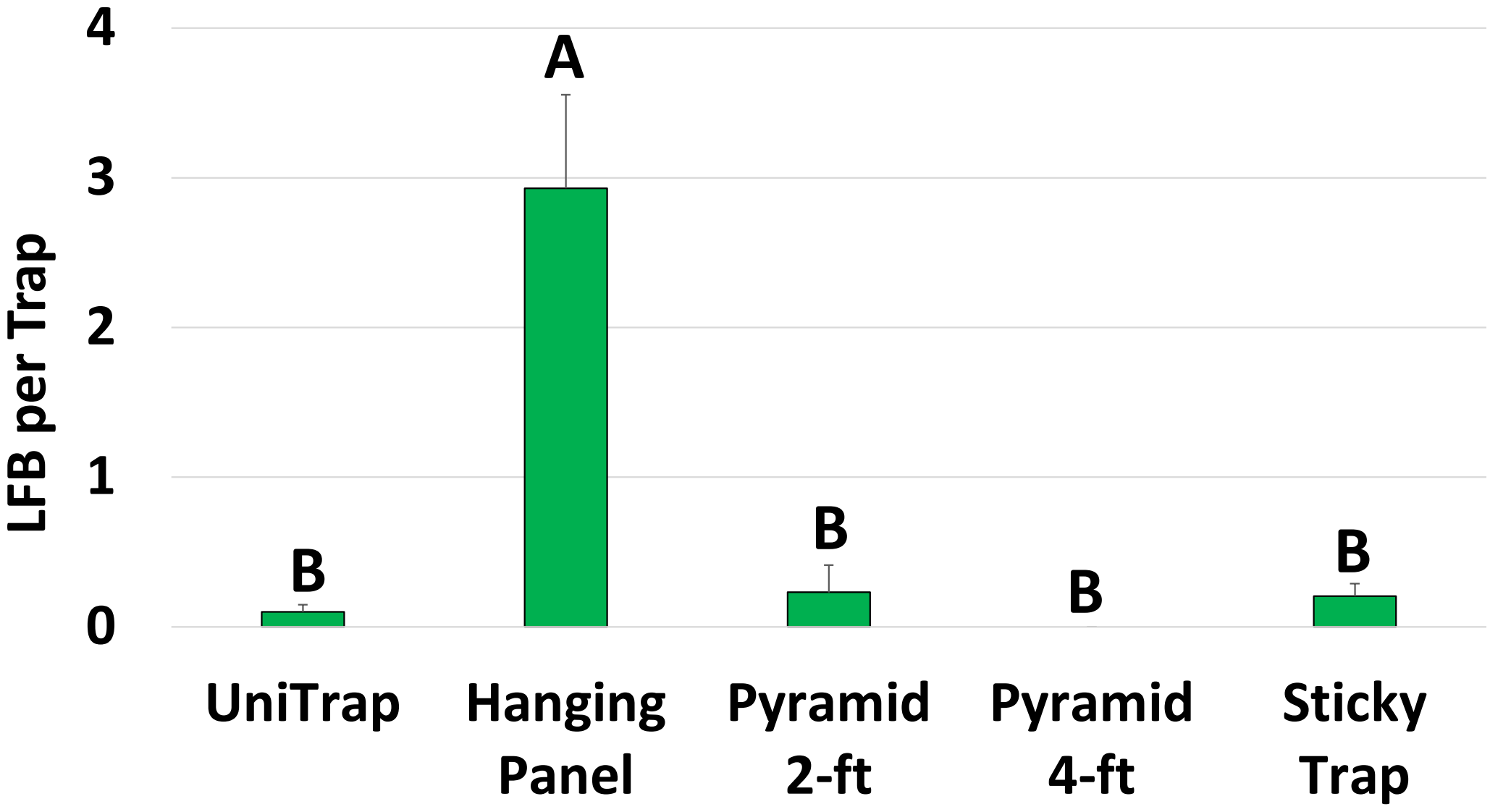
Hanging Panel

UniTrap

LFB Pheromone Trap/Lure Project

Finding a Trap that Works

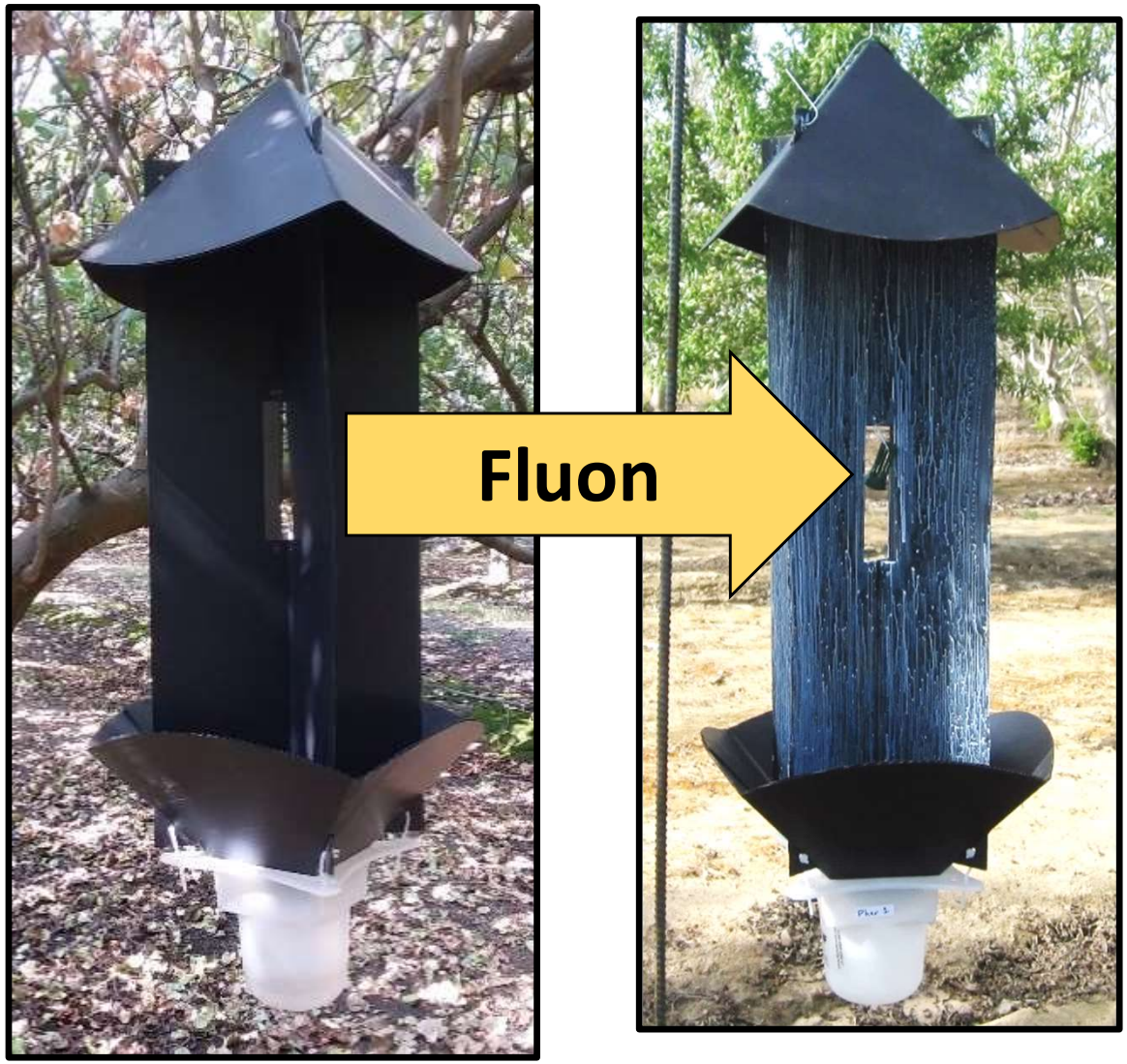
Trap Comparison Study



LFB Pheromone Trap/Lure Project

Finding a Trap that Works

Fluon to Improve Trap Catch



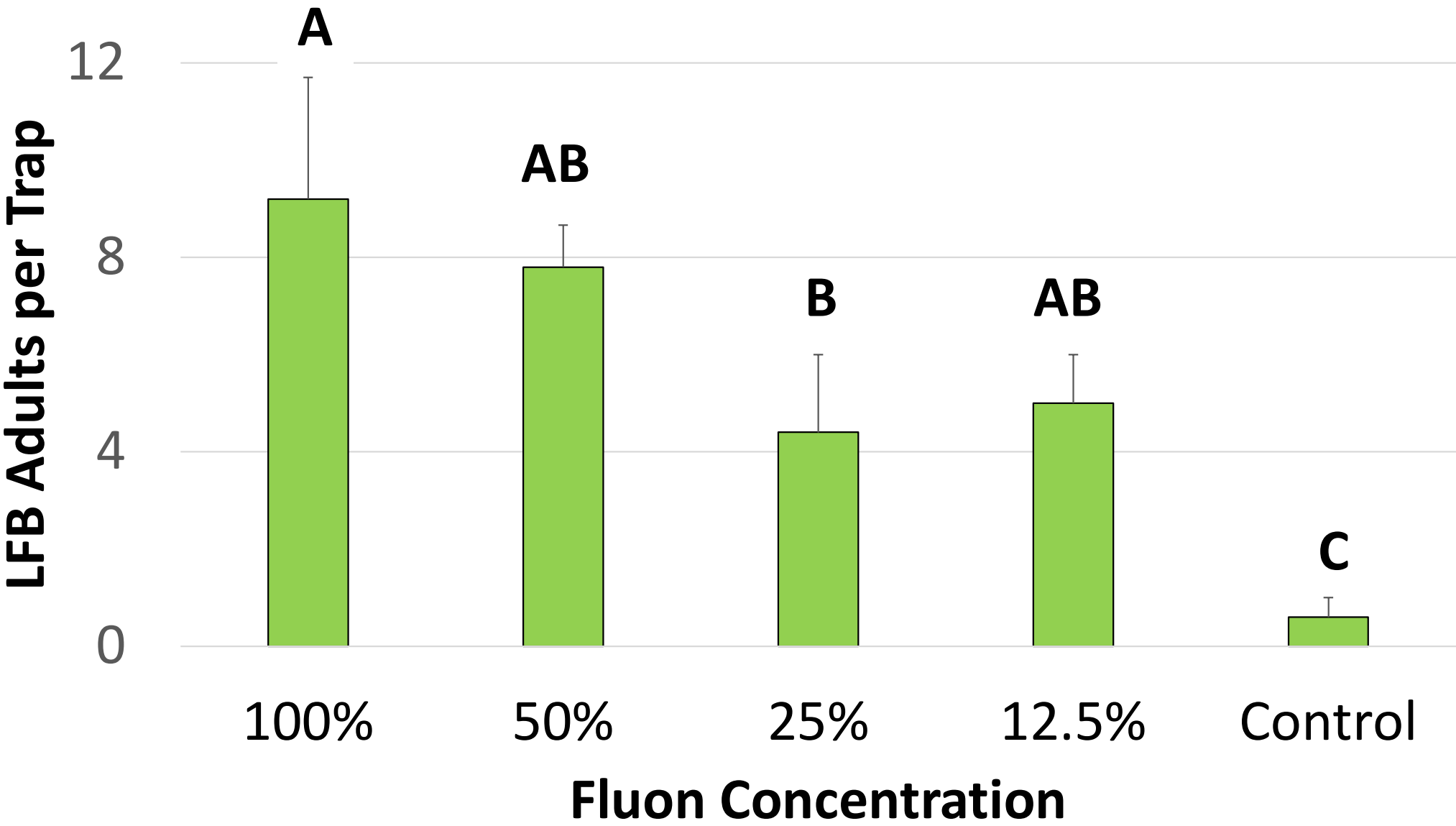
Setup:

- 1 site
- 4 dilutions x 5 reps
- Trap check 2x/month
- Nov. 13 – Dec. 4

LFB Pheromone Trap/Lure Project

Finding a Trap that Works

Fluon to Improve Trap Catch



LFB Pheromone Trap/Lure Project

Finding a Trap that Works

Effect of Trap Color

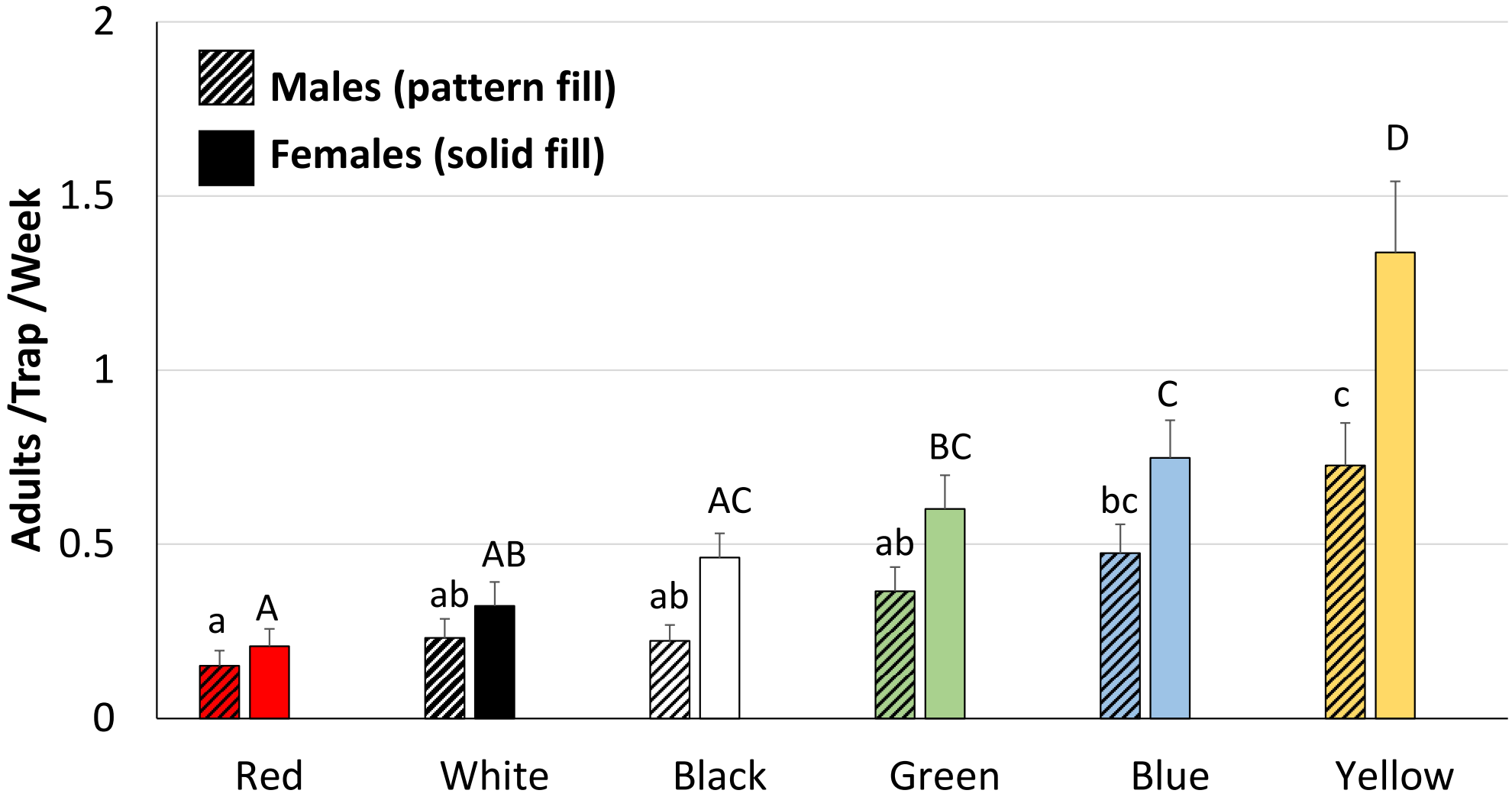





LFB Pheromone Trap/Lure Project

Finding a Trap that Works

Effect of Trap Color



LFB Pheromone Trap/Lure Project

Progress to Date

Objectives 2-3

Identification and Synthesis of Pheromone Compounds

LFB Pheromone Trap/Lure Project

Found a Good Trap…

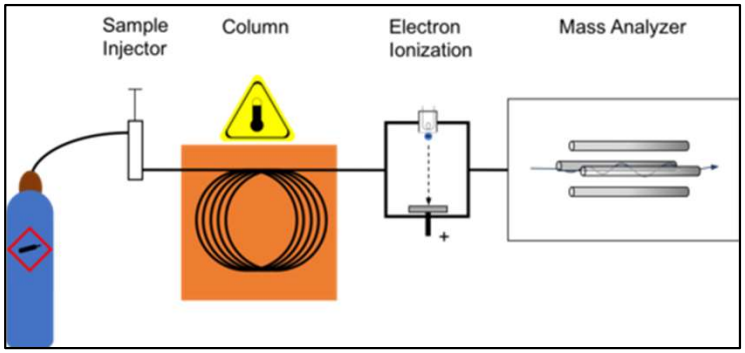
…But We Still Need a Lure!!

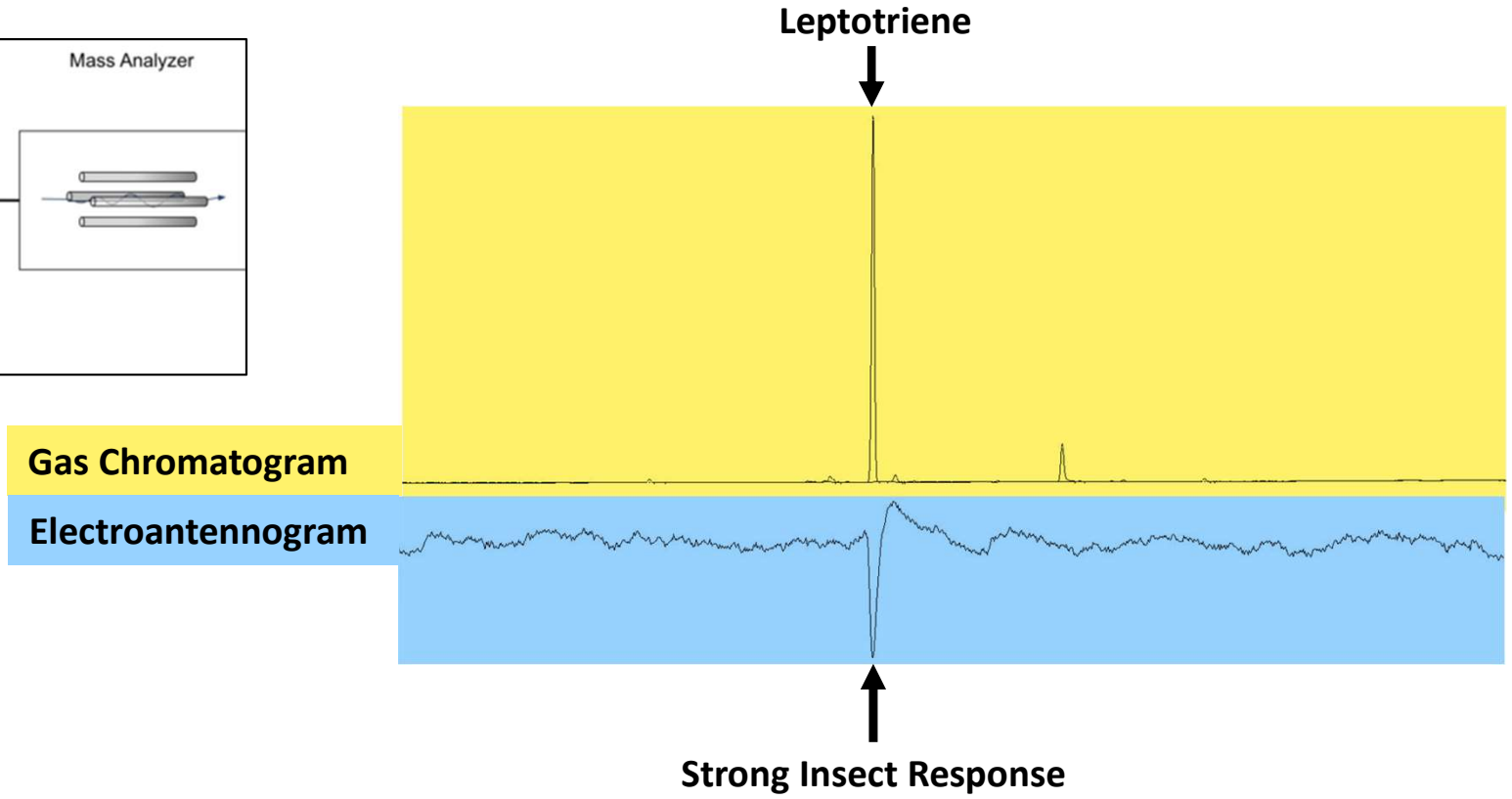
LFB Pheromone Trap/Lure Project

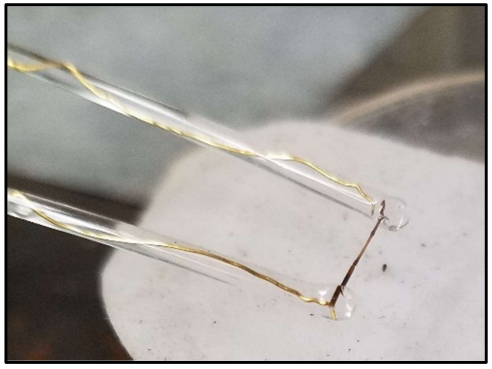
Pheromone Characterization and Synthesis

General Approach

- Isolate reproductively mature males
- Capture and analyze pheromones
- Measure adult response to individual compounds







LFB Pheromone Trap/Lure Project

Pheromone Characterization and Synthesis

Key Aspects of the Pheromone

- Composed of 9 compounds
- *Leptotriene* is entirely new to science!

Next Step – Synthesize the Compounds

- Multi-year effort
- Various elements assembled 2018-2021
- Finally have all components in place by summer 2021
- Work in 2022-2023 focused on improving efficiency/yield of compounds

Field Trials with the Candidate Compounds

- Kearney Ag. Center – spring/fall 2021-2023
- Commercial orchards – spring/fall 2022-2023

LFB Pheromone Trap/Lure Project

Progress to Date

Objective 4

Lab/Field Tests of New Lures

LFB Pheromone Trap/Lure Project

Preliminary Candidate Pheromones

Field Assays in Infested Orchards

Comparison of Blends

Almonds (spring) + Pomegranates (fall)

Commercial Sites + Kearney Ag. Center

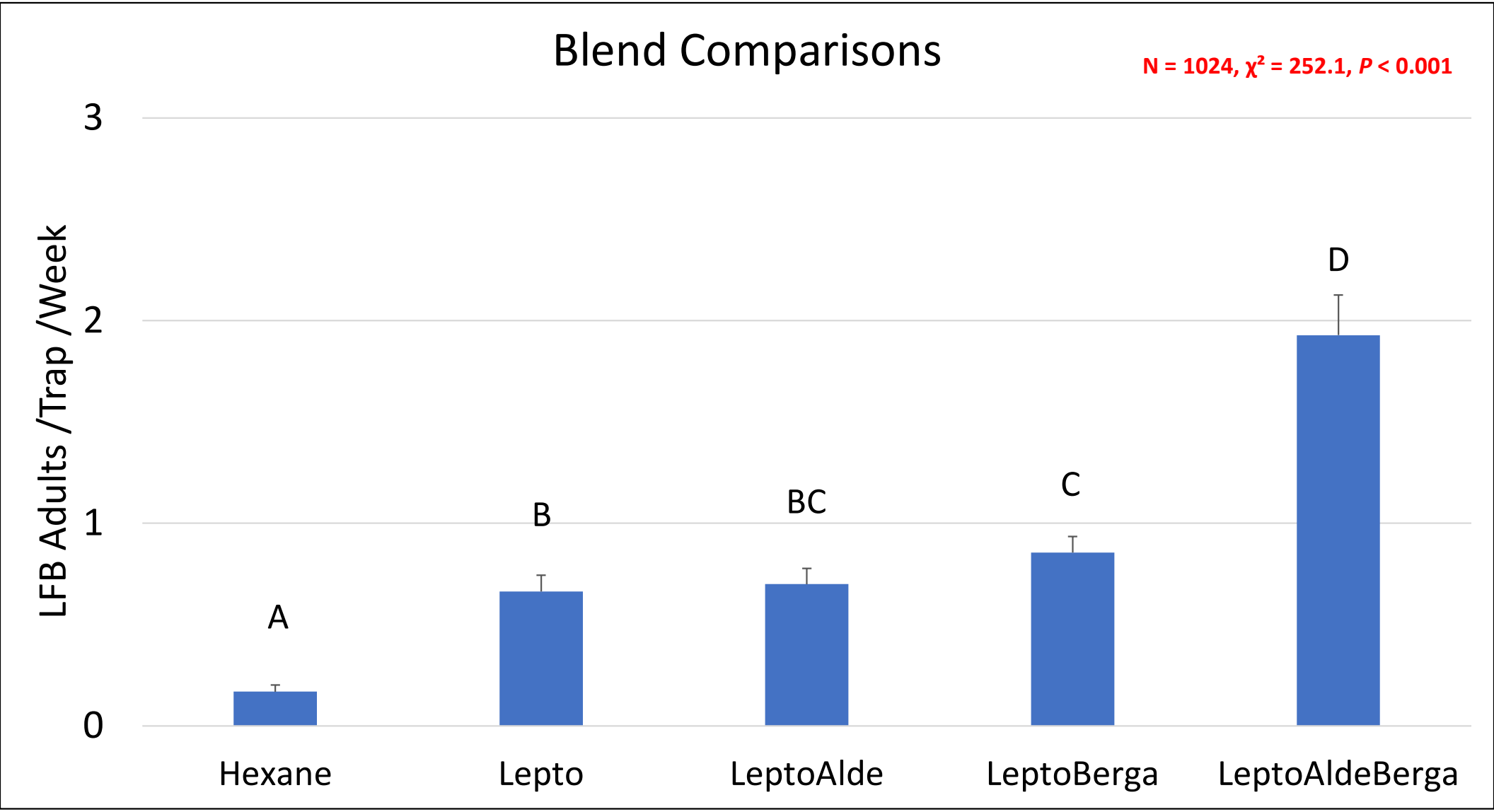
2021-2023

LFB Trap/Lure Project

Leptotriene and Blend Comparisons

Leptotriene is Consistently Attractive

Enhanced by Additional Components – But Expensive



Season Long Attractancy of Lures

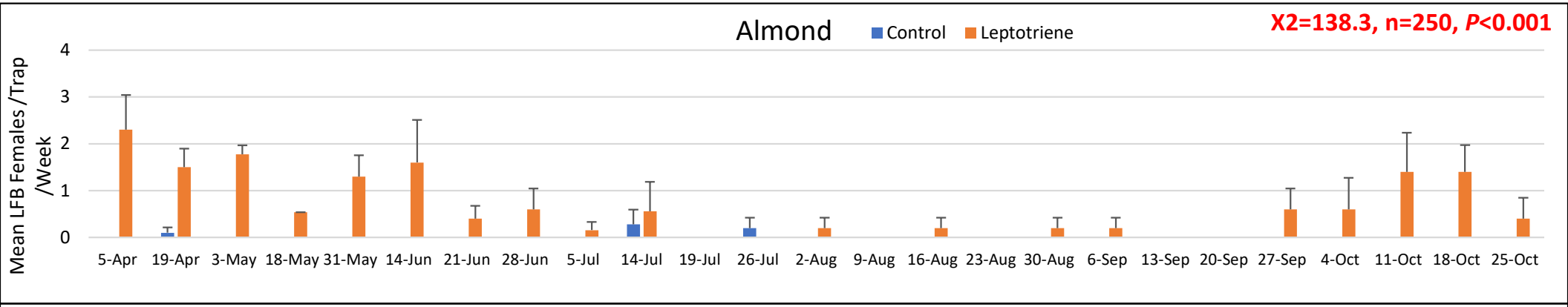
Almond + Pistachio + Pomegranate @ Kearney Ag. Center

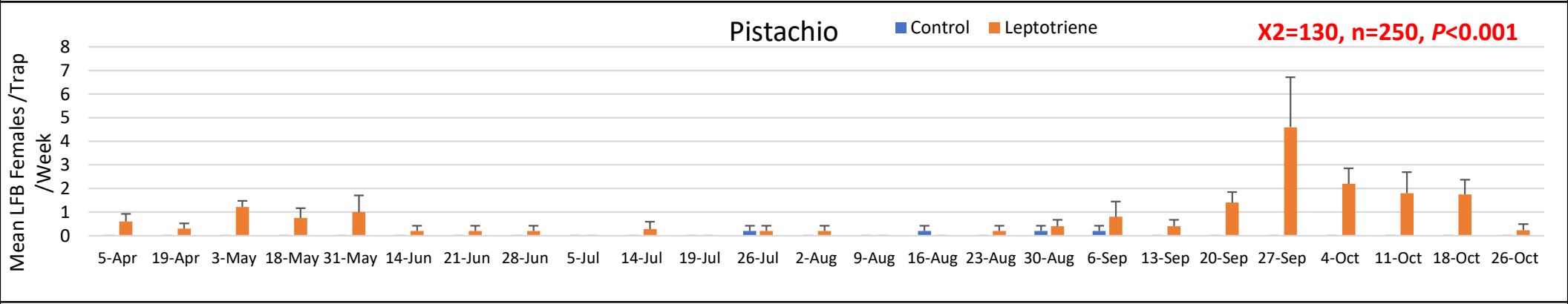
2022

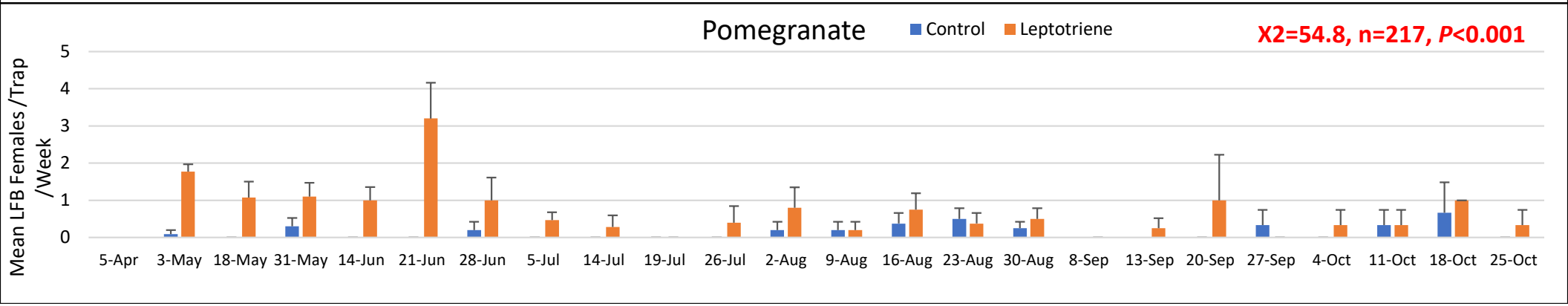
LFB Trap/Lure Project

Season Long Attractancy of Lures

LFB Attracted to Leptotriene All Year







Cheaper “Technical Grade” Leptotriene

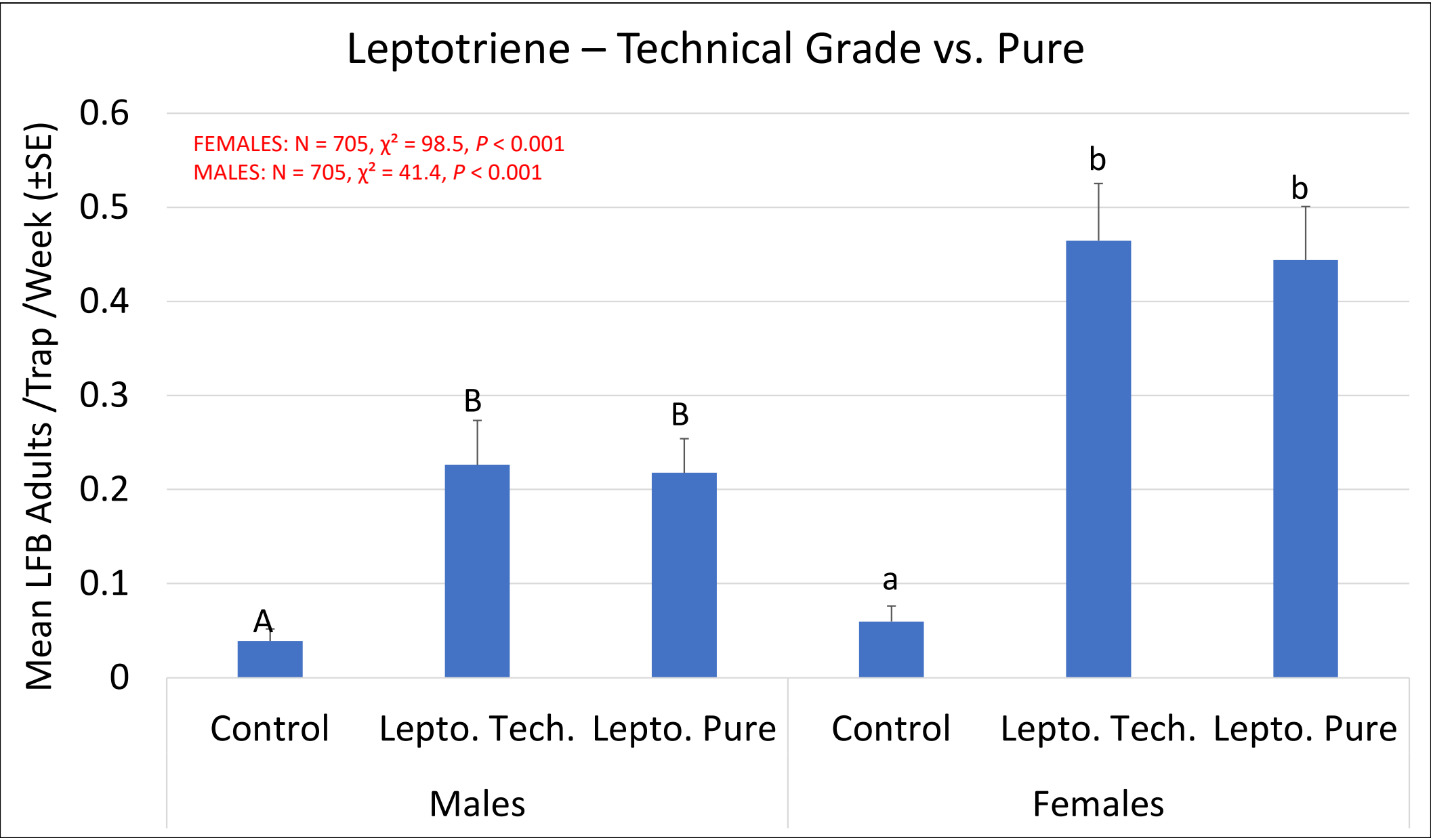
Almond + Pistachio + Pomegranate @ Kearney Ag. Center

2023

LFB Trap/Lure Project

Cheaper "Technical Grade" Leptotriene

Appears to be equally attractive



Evaluation of a Commercial Lure

Produced by Sterling International (Spokane, WA)

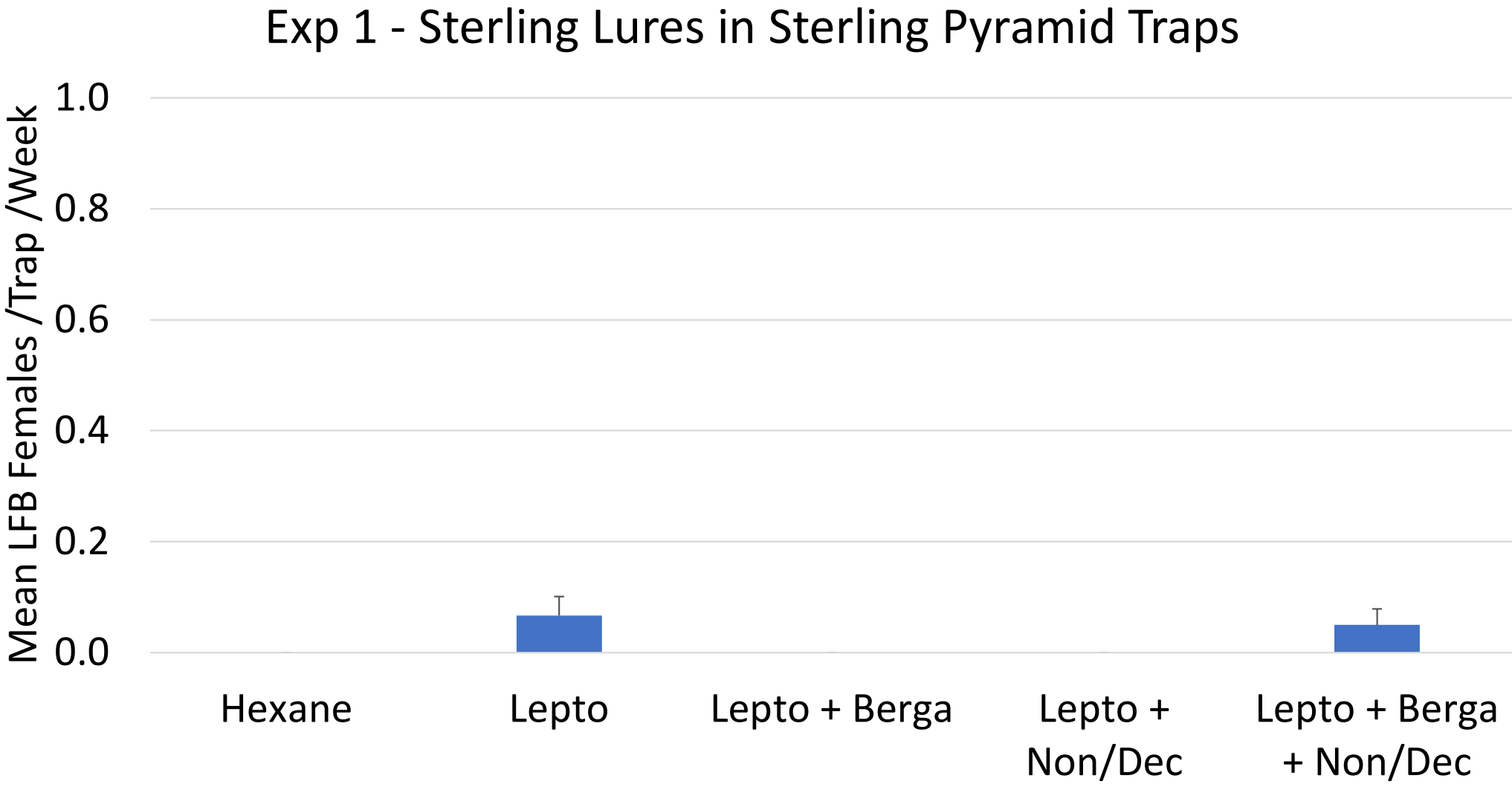
Spring 2023 (Almonds)

LFB Trap/Lure Project

Evaluation of a Commercial Lure – Sterling International

Not Quite There Yet…But More to Come

Note - these are NOT the UCR-made lures!



LFB Pheromone Trap/Lure Project

Summary of Experiments – 2017-2022

LFB Traps

Hanging panel trap is best

- Yellow/blue most attractive
- Absolutely needs a lure



LFB Lures

Pheromones

- Identified and synthesized all 9 pheromone compounds
- Documented LFB response to certain blends – leptotriene is key!
- Optimized synthesis 4.5x of leptotriene
- Demonstrated season-long attraction
- Developed a cheaper version of leptotriene (“technical grade”)

LFB Pheromone Trap/Lure Project

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- Demonstrated season-long attraction
- Developed a cheaper version of leptotriene ("technical grade")

Now starting to work with private companies to scale-up production

LFB Pheromone Trap/Lure Project

Concluding Remarks

Key Project Objectives/Achievements

- ✓ Find a trap that works
- ✓ Identify key pheromone compounds
- ✓ Synthesize these chemicals
- ✓ Evaluate lures in the field
- ➢ Develop reliable monitoring

Next Steps

- Further improve synthesis of compounds
- Quantify cost/time savings
- Develop a commercial lure
- Relate trap catch to orchard populations

LFB Pheromone Trap/Lure Project

Plans for 2024

- Continue to refine the synthesis
- Revisit trap selection (with lure)
- Explore commercial lure production

Thank You!!

Houston Wilson

houston.wilson@ucr.edu | http://treecrops.ucr.edu/

[Collaborators] Jocelyn Millar, Sean Halloran (UCR), Kent Daane (UCB), Sarah Meierotto (UCR), Reva Scheibner (UCR), Jessica Maccaro (UCR)

[Funding] CA Pistachio Research Board + Almond Board of CA

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