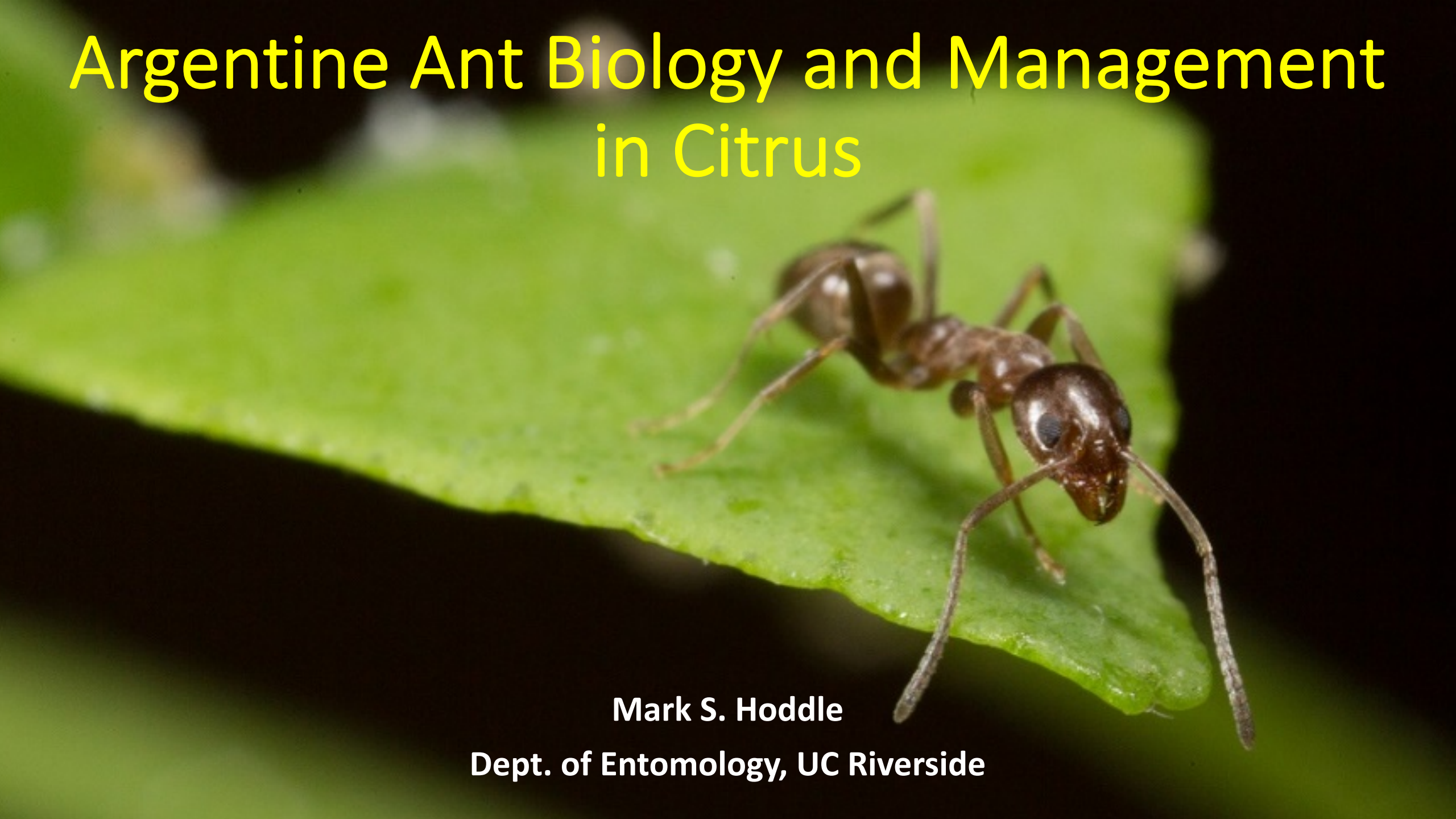
Argentine Ant Biology and Management in Citrus



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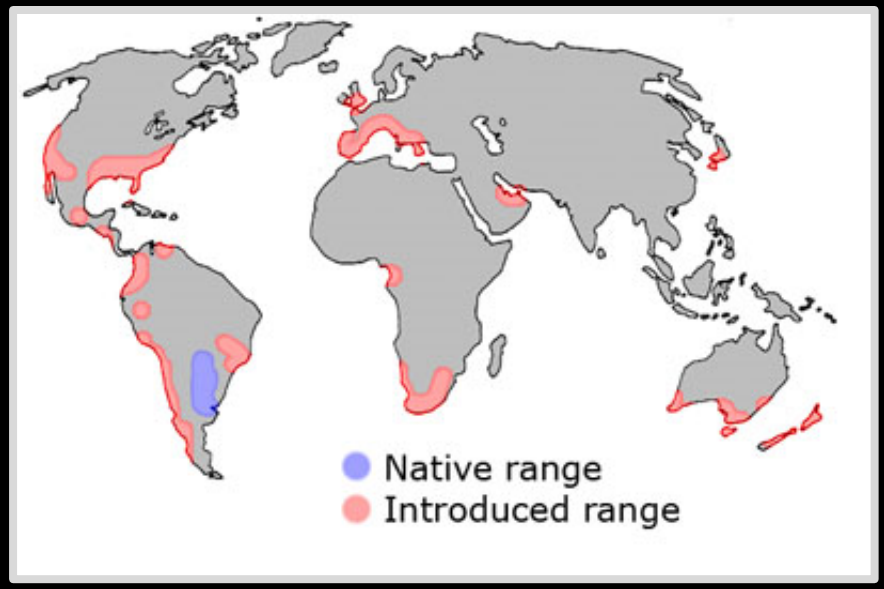
Things to Discuss

- Argentine ant invasion history and biology
- Food for protection mutualisms
  - Why does this cause a problem for pest management?
- Monitoring tools
  - Visual counts
  - Monitoring vials
  - Infrared sensors
- Control options for Argentine ant
  - Physical exclusion
  - Cultural control
  - Insecticides and delivery systems
- Field studies documenting benefits of ant control

Argentine Ant Invasion History

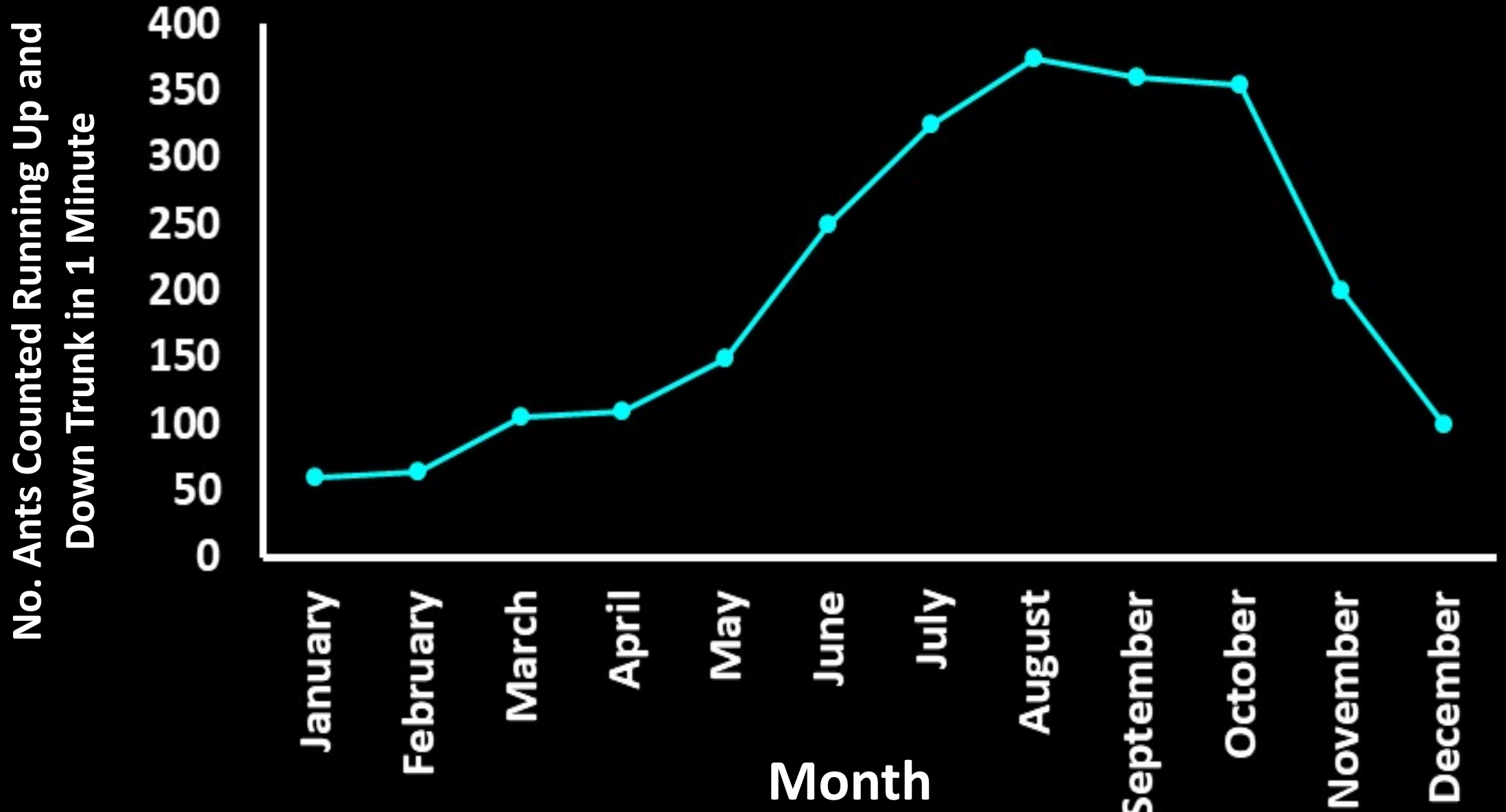
- Native the Paraná river basin in Sth America
- Spread globally by humans
  - Established in SoCal in 1905
  - Flourishes in a Mediterranean type climate
    - Dry hot summers, cool wet winters
    - Soil moisture drives ant abundance and margins of activity
- Populations in CA, the Mediterranean, and Japan represent a global mega-colony
  - No aggression, groom each other!
    - The most populous recorded animal society on earth!
  - Other super colonies fight along boundaries
  - Native range - competition limits range to < 100 m



Argentine Ant Biology

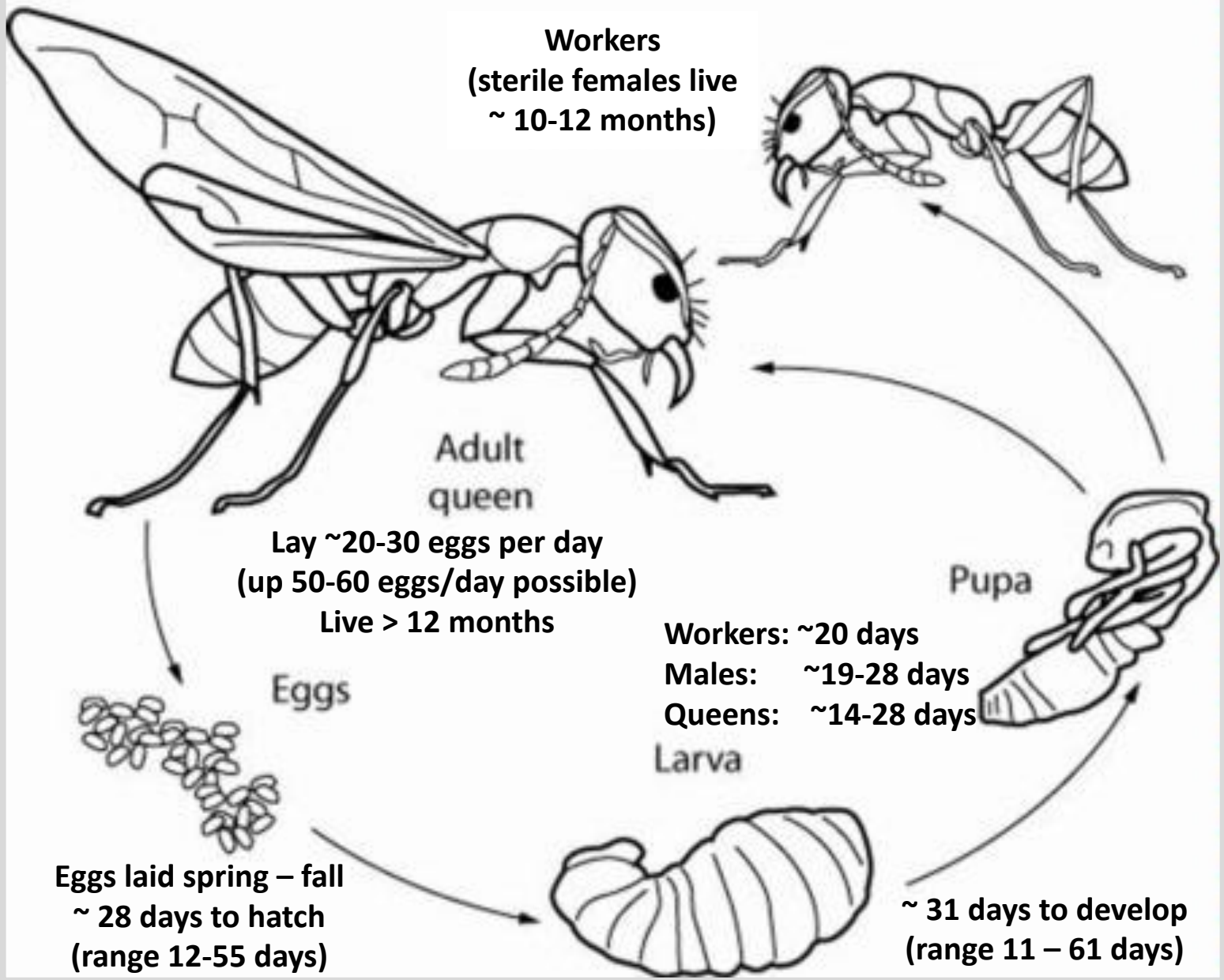
- **Colonies are subterranean**
  - Queens, males, workers, brood
  - Mating occurs in nests
  - Budding not nuptial flight results in local range expansion
  - Polygynous (multiple queens) and polydomous (multiple connected nests)
    - 90% nest queens executed each spring
    - Least productive queens killed
- **Specialized liquid sugar feeders**
  - Outcompete/deter/exclude other insects/humming birds from nectar
  - Activity at flowers reduces pollination and seed set
- **Aggressive resource capture**
  - Rapidly exclude native ants from resources
    - Horned lizard populations reduced

Argentine Ant Phenology in SoCal



Life Cycle of the Argentine Ant

Average developmental time egg to adult ~ 74 days



Mating occurs late spring into summer inside nests

Queens can have wings but seldom disperse from nests

Males are winged and may leave nest to join nuptial flights

Males either return to original nest or join a new nest (risk of aggression)

Queens bite males to stop mating (may kill male), will copulate with multiple males but only 1 male will successfully inseminate the queen

Males die after mating (live days to a couple of months)

Mated females lay eggs following spring if they survive that long

Colonies don't appear to suffer from inbreeding depression

Pop Up Quiz – 1

- **What is the major way Argentine ant spreads long distances?**
  - **1) Nuptial flights and wind dispersal**
  - **2) Rafting during floods**
  - **3) In soil of potted plants**
  - **4) Hitch-hiking on bird feet and feathers or in fur of migrating animals**

Pop Up Quiz - 2

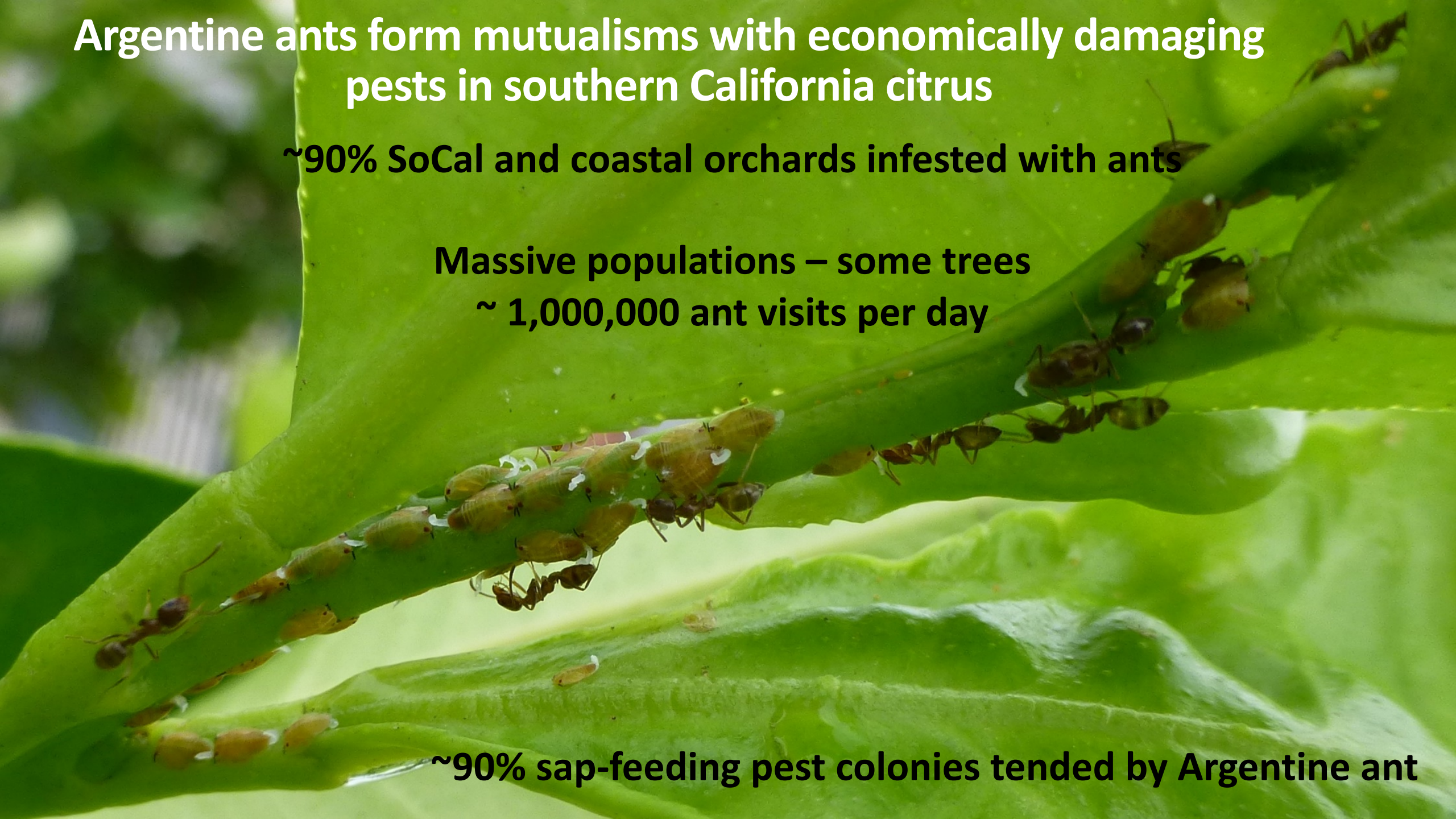
- **Which of the following bests describes Argentine ant?**
  - **1) Nests are small, have only 1-2 queens, mating occurs during nuptial flights, workers forage mainly for protein**
  - **2) Nests are large, have multiple queens, mating occurs in nests, workers forage mainly for liquid sugars**
  - **3) Nests are polydomous and polygynous, mating occurs during nuptial flights and workers forage primarily for protein and take liquid sugars opportunistically**

Pop Up Quiz - 3

- **What is the approximate length of the Argentine ant life cycle?**
  - **1) 55 days**
  - **2) 65 days**
  - **3) 75 days**
  - **4) 85 days**

Food for Protection Mutualisms

- **Argentine ant feeds on honey dew a sugary waste product excreted by phloem feeding pests**
  - Mealybugs, aphids, whiteflies, soft scales, psyllids
  - Recognized problem in CA citrus since at least the 1920's
- **In return for food ants protect pests from natural enemies**
  - Promotes pest population growth
  - Drives ant infestation severity
- **Ants drive pest infestation severity in other ways:**
  - Honey dew harvesting causes pests to feed more and they grow faster
    - Poor producers are killed!
  - Ants herd and move pests into new areas of the orchard
  - Honey dew removal sanitizes pest colonies
    - Prevents drowning in honey dew
    - Reduces risk from fungal infections



Argentine ants form mutualisms with economically damaging pests in southern California citrus

~90% SoCal and coastal orchards infested with ants

Massive populations – some trees
~ 1,000,000 ant visits per day

~90% sap-feeding pest colonies tended by Argentine ant

Argentine ant killing *Tamarixia radiata*, a parasitoid of Asian citrus psyllid nymphs


Sanitation[1]
R. J. Baker


Increased development rate & reproduction
Dr. Dong-Hwan Choe; UC Riverside


Transportation


Mike Lewis
Natural enemy interference

Pop Up Quiz - 4

- **How do Argentine ants drive pest population growth in citrus orchards?**
  - **Ants protect pests from natural enemies**
  - **Ants herd “life stock” and relocate them to new areas in the orchard**
  - **Ants sanitize pest colonies by removing honey dew**
  - **All of the above**

Monitoring Tools to Estimate Ant Densities

Monitoring vials – changes in volume of sugar water over 24 hr can be used to estimate the number of ant visits

This is a poor method as ants recruit to this food source

Monitoring Tools to Estimate Ant Densities

Counts ants moving past a landmark on a tree trunk. Good approach for estimating ant activity in a tree. Action threshold is around ~20 ants per minute of visual observation

Ants Use Irrigation Pipes to Move Between Trees

Manipulative foraging studies indicate that Argentine ants develop foraging routes that minimize travel distance and maximize linearity

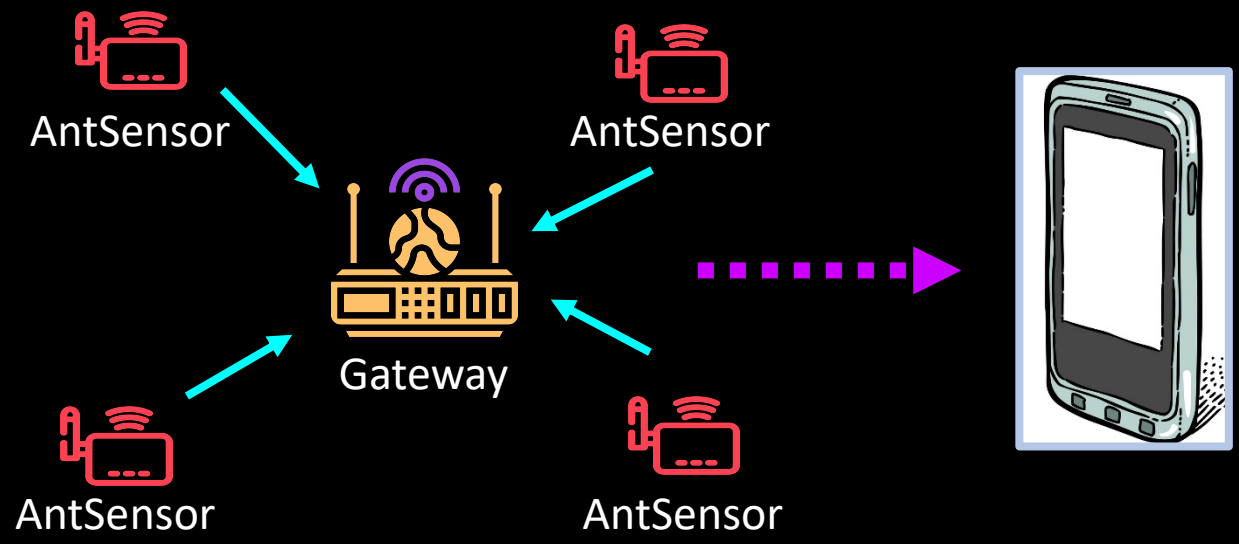
Uneven terrain reduces ant travel speeds by up to 42%

Irrigation pipes are ideal “super highways” laid across orchard floors that connect nests to trees!

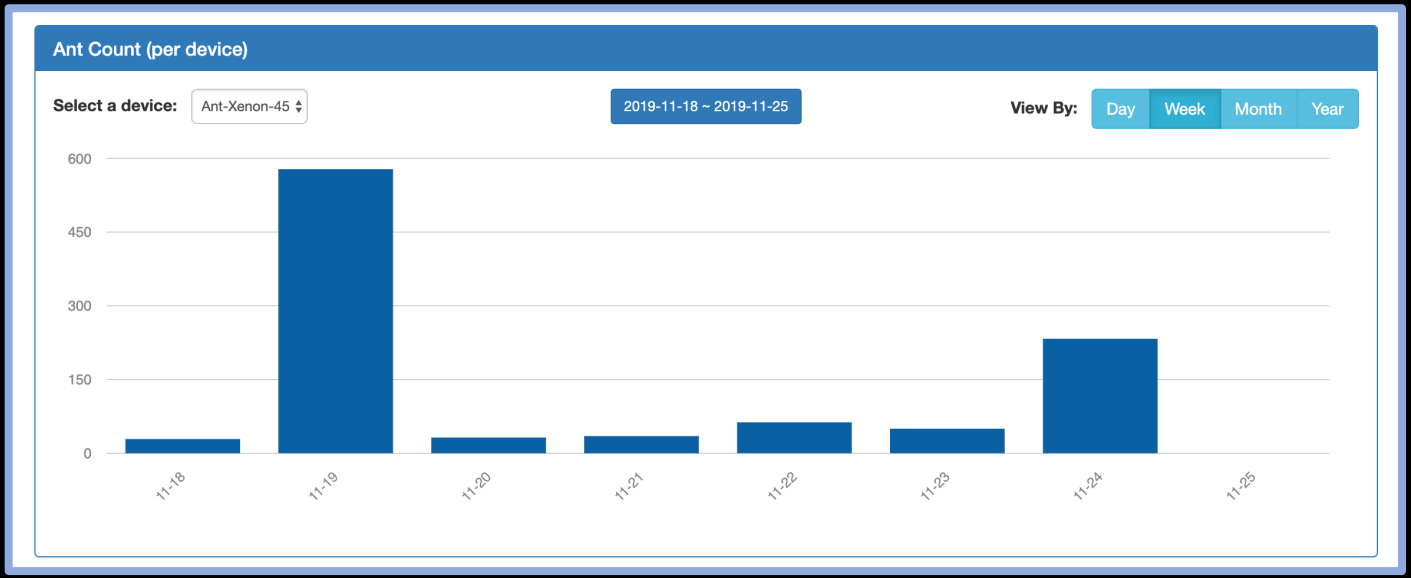
Pop Up Quiz - 5

- **What key factors affect travel routes taken by foraging Argentine ants?**
  - **Ants wander at random there is no optimization**
  - **Ants prefer rough ground because they get better footing**
  - **Ants prefer to move in straight lines**
  - **Ants preferentially move in straight lines on smooth surfaces**

IoT for Ant Monitoring



IoT for Ant Monitoring – Data Summaries



Cloud-based software can provided summarized data counts by hour, day, month, etc.

Data specific to orchard sectors due to GPS tag

Sensor units fitted with humidity and temperature sensors provide environmental data with high levels of resolution

Device Status

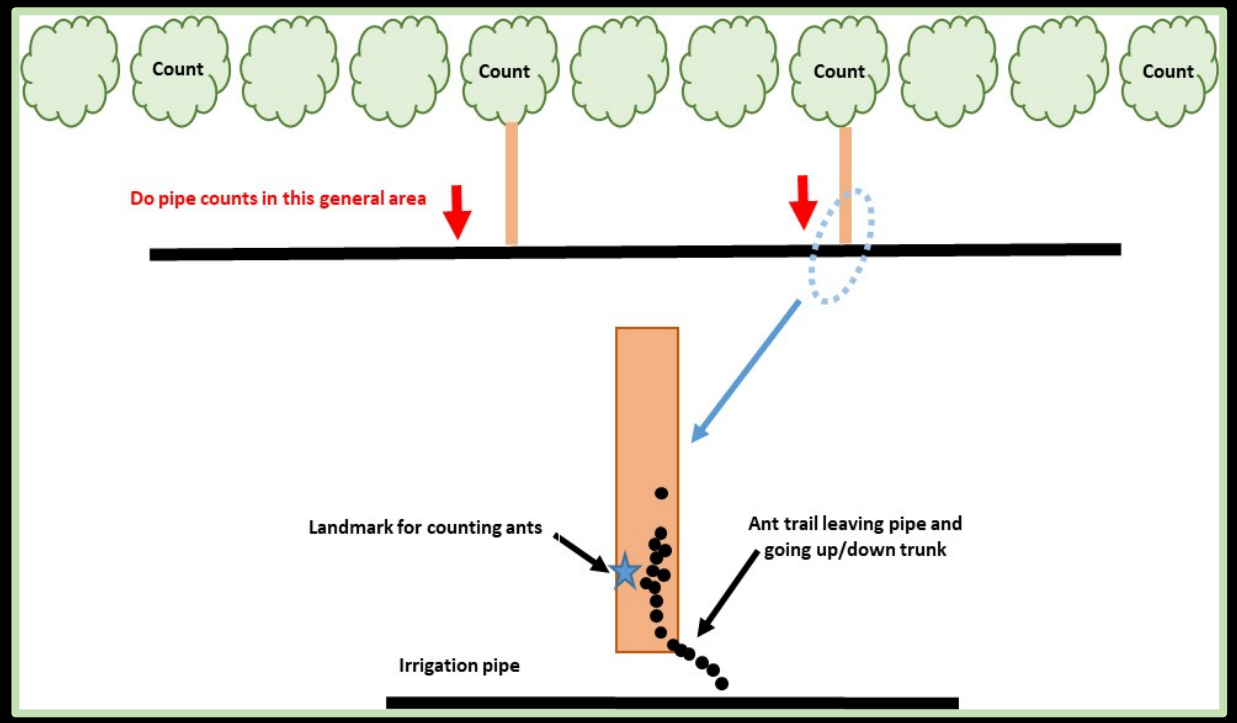
Show 25 entries

Search:

Device Id	Device Name	Hourly Count	Battery Level	Humidity (RH)	Temperature	Last Update (PST)
e00fce6822be18c3d688a926	Ant-Xenon-42	0	3.49V	56.64%	53.46°C	2019-11-25 05:15:45
e00fce68f0cdefe960970a9d	Ant-Xenon-45	0	3.62V	56.64%	53.46°C	2019-11-25 05:11:42
e00fce68c9ac7e4014cccc68	Ant-Xenon-43	0	3.74V	79.29%	9.19°C	2019-11-25 04:11:55
e00fce68ebd3be8e71243f65	Ant-Xenon-44	1	3.74V	81.92%	9.17°C	2019-11-25 02:46:01
e00fce681447c58930999fd1	Ant-Xenon-30	1	3.92V	56.64%	53.46°C	2019-11-20 07:03:43
e00fce689ee1f0e2c50f3124	Ant-Xenon-34	13	3.76V	56.64%	53.46°C	2019-11-20 06:21:53
e00fce689b0d04e9b379d0f3	Ant-Xenon-32	12	3.74V	56.64%	53.46°C	2019-11-20 06:20:29
e00fce68f566a41b4a953f50	Ant-Xenon-36	12	3.77V	56.64%	53.46°C	2019-11-20 06:18:17

Next Steps for IR Sensor Research

Determining the relationship between the number of ants running along a pipe and going up and down tree trunks



Determining the minimum number of sensors needed per acre to get estimate accuracies > 80%

Pop Up Quiz - 6

- **The Internet of Things (IoT) has the potential to revolutionize ant monitoring in perennial orchards. What do you think are the most important potential benefits of this technology?**
  - **1) You don’t have to pay people to sit under trees counting ants**
  - **2) Sensors work 24/7/365 and detect activity when humans are not around**
  - **3) Sensors provide orchard specific ant counts so control is targeted to areas that need it**
  - **4) All of the above**

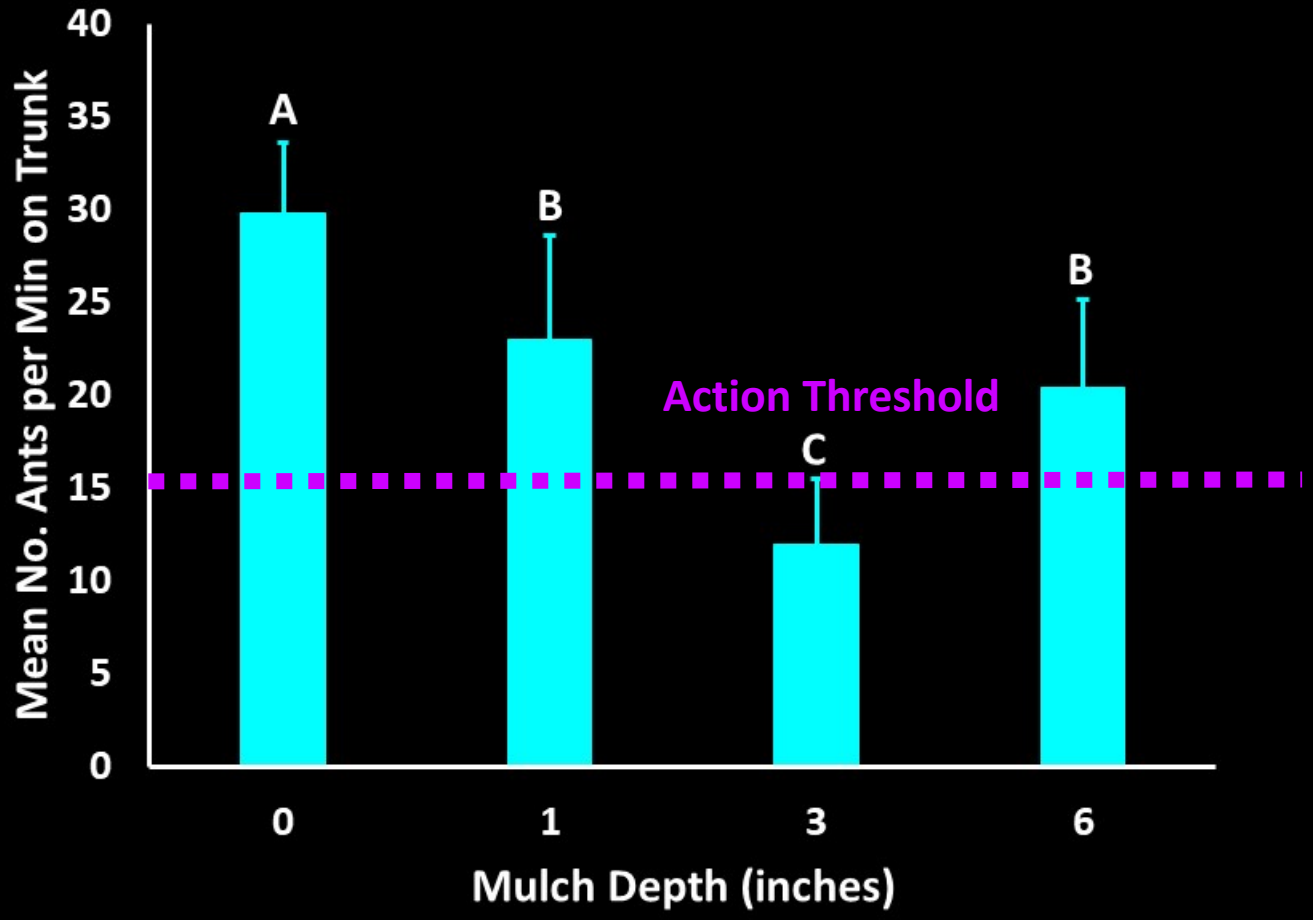
Control Options for Argentine Ant

Cultural Control - Exclusion

Physical barrier to exclude ants from sap sucking pests. Expensive, impractical, easily crossed via bridges, difficult and time consuming to apply, messy!

Control Options for Argentine Ant

Cultural Control - Mulches



Why would mulch affect ant activity?

Lab research assessing effects of terrain (3-D plastic printed substrates) illustrated that uneven terrain reduces walking speeds by 42%

Mulch is good for the orchard: improved soil water retention, weed control, soil fertility, stabilizes soil temperatures, & fruit retention increases

Fake et el. 2020. Foothill mandarin orchards benefit from mulch. Citrograph 11(1): 38-41

Control Options for Argentine Ant

Insecticides – Barrier Sprays

Chlorpyrifos barrier sprays applied to soil and trunks to kill foraging workers

Residues last about 30 days

Does not kill queens in subterranean nests

Ants avoid residues and use bridges to circumvent residues

Broad spectrum insecticide kills natural enemies – high level of irony as ants are being killed to promote biocontrol

Chlorpyrifos use in CA ceases 31 Dec. 2020

Control Options for Argentine Ant

Insecticides – Liquid Bait Stations

Bait Stations

Loaded with 25% sucrose water & 0.0001% thiamethoxam

Expensive to buy ~$20 each (negotiable by amount)

Expensive to deploy, & maintain (collect, wash/reload/redeploy)

Need to use about > 50 bait stations per ha (or > 20 per acre) to see reductions in ant numbers, perhaps as many as 100/acre(??) needed to get excellent(??) suppression in orchards

Foraging distances by ants in vineyards is ~ 36 m

Maximum distances moved by foraging workers may only be 50-100m

Pop Up Quiz - 7

- Composted organic mulch laid under citrus trees has potential ant suppression capabilities because …….
- 1) Mulch controls weeds that ants need for food
- 2) Mulch improves soil water retention which drowns nests
- 3) Ants can not walk as fast because the terrain is uneven
- 4) Mulch stabilizes soil temperatures which increases ant development times

6 SoCal navel groves (6-12Ha):

6 plots/grove

3 trees/plot

18 plots, 108 trees total

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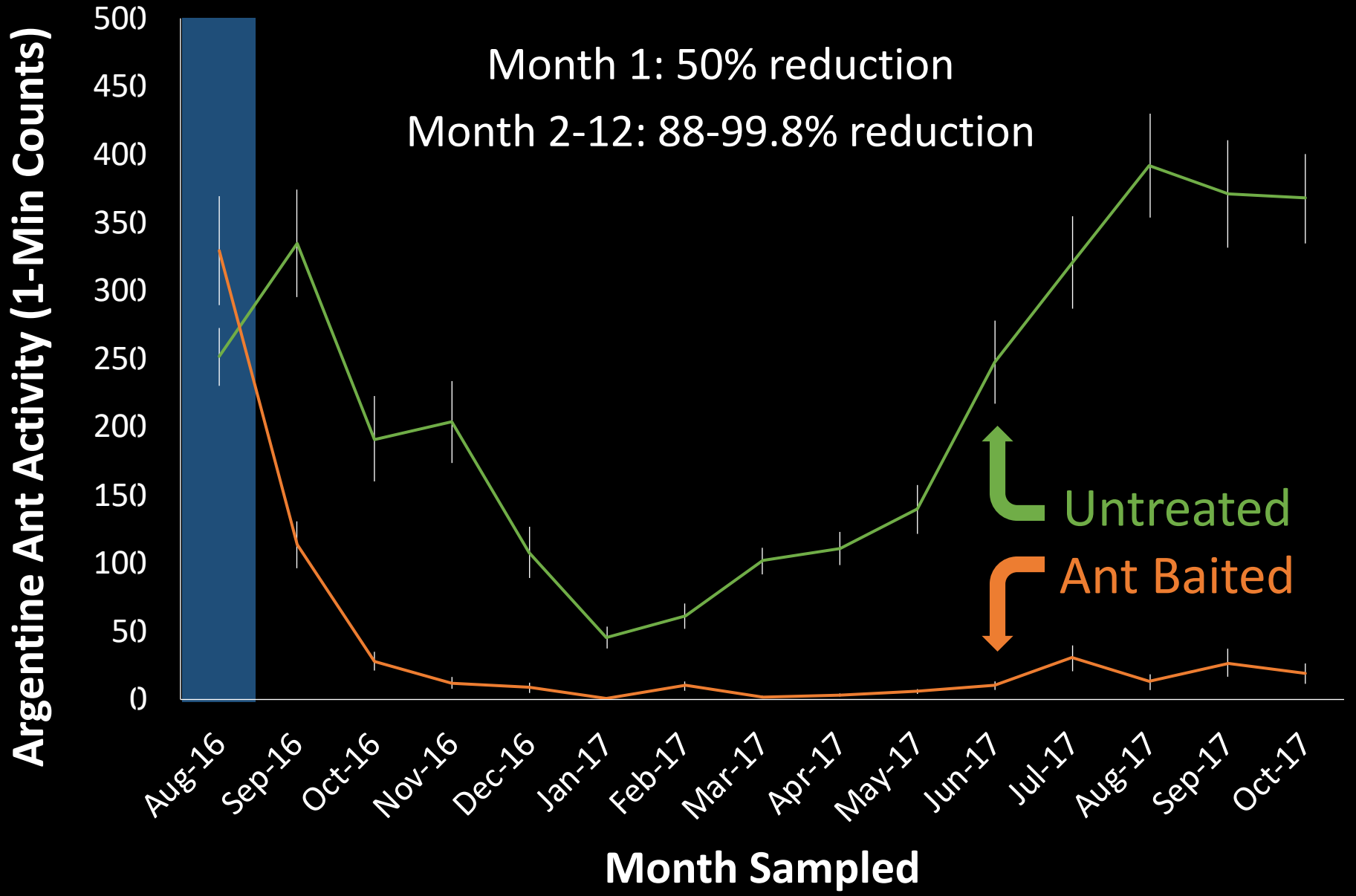
Average Argentine Ant Activity (Visual Counts) Over Time vs. Ant Control Treatment



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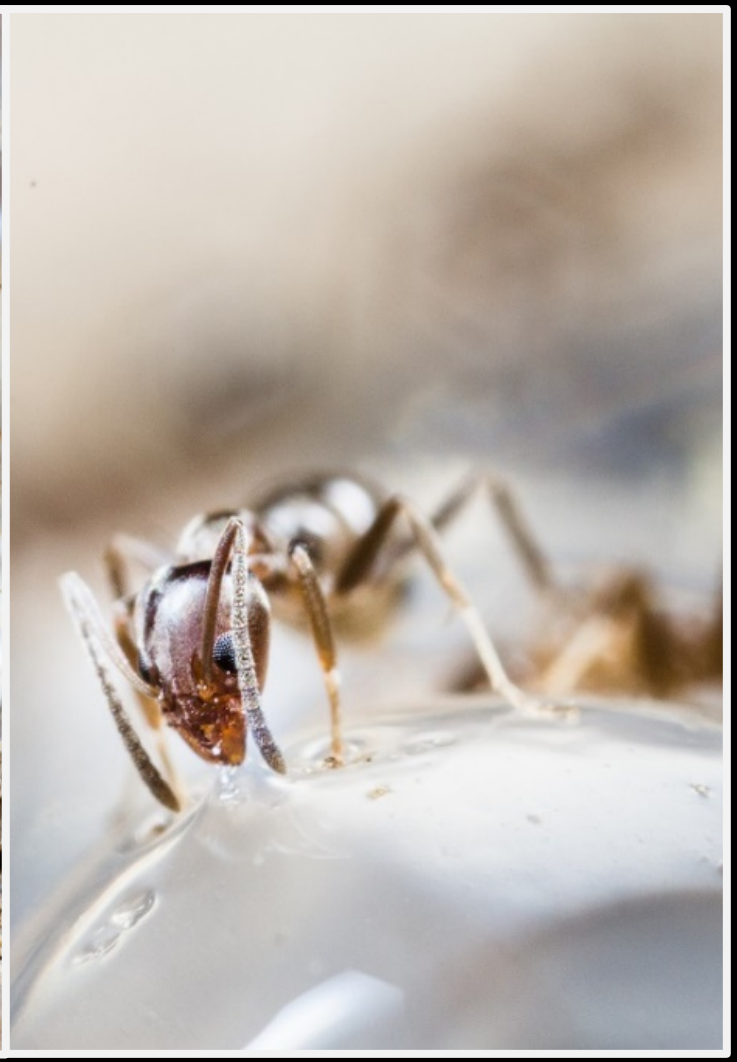
Control Options for Argentine Ant

Insecticides – Biodegradable Hydrogel Beads

Loaded with 25% sucrose water & 0.0001% thiamethoxam

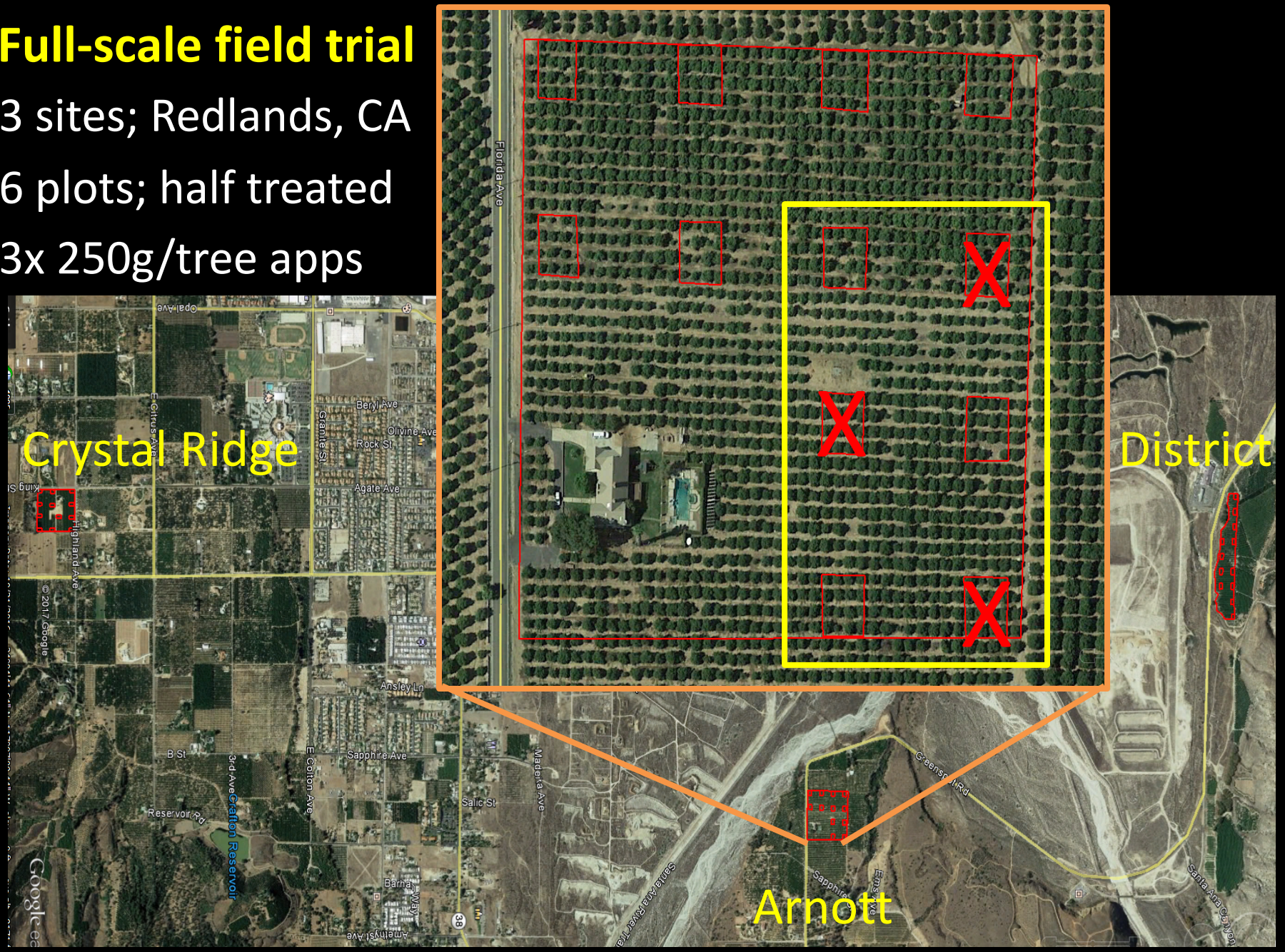


Full-scale field trial

3 sites; Redlands, CA

6 plots; half treated

3x 250g/tree apps



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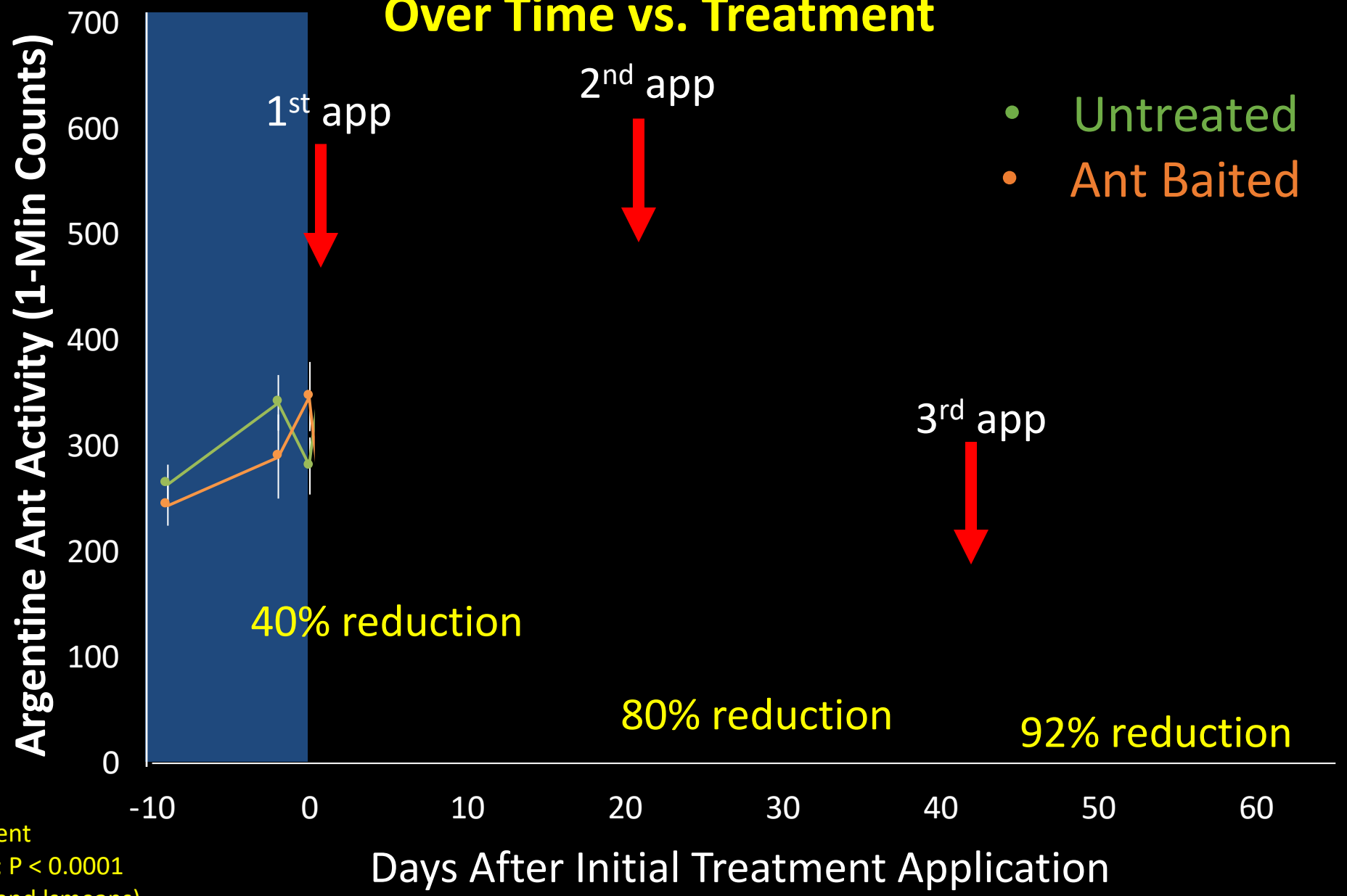
Average Argentine Ant Activity (Visual Counts) Over Time vs. Treatment



Ant activity sig different between treatments; P < 0.0001 (linear mixed model and lsmeans)

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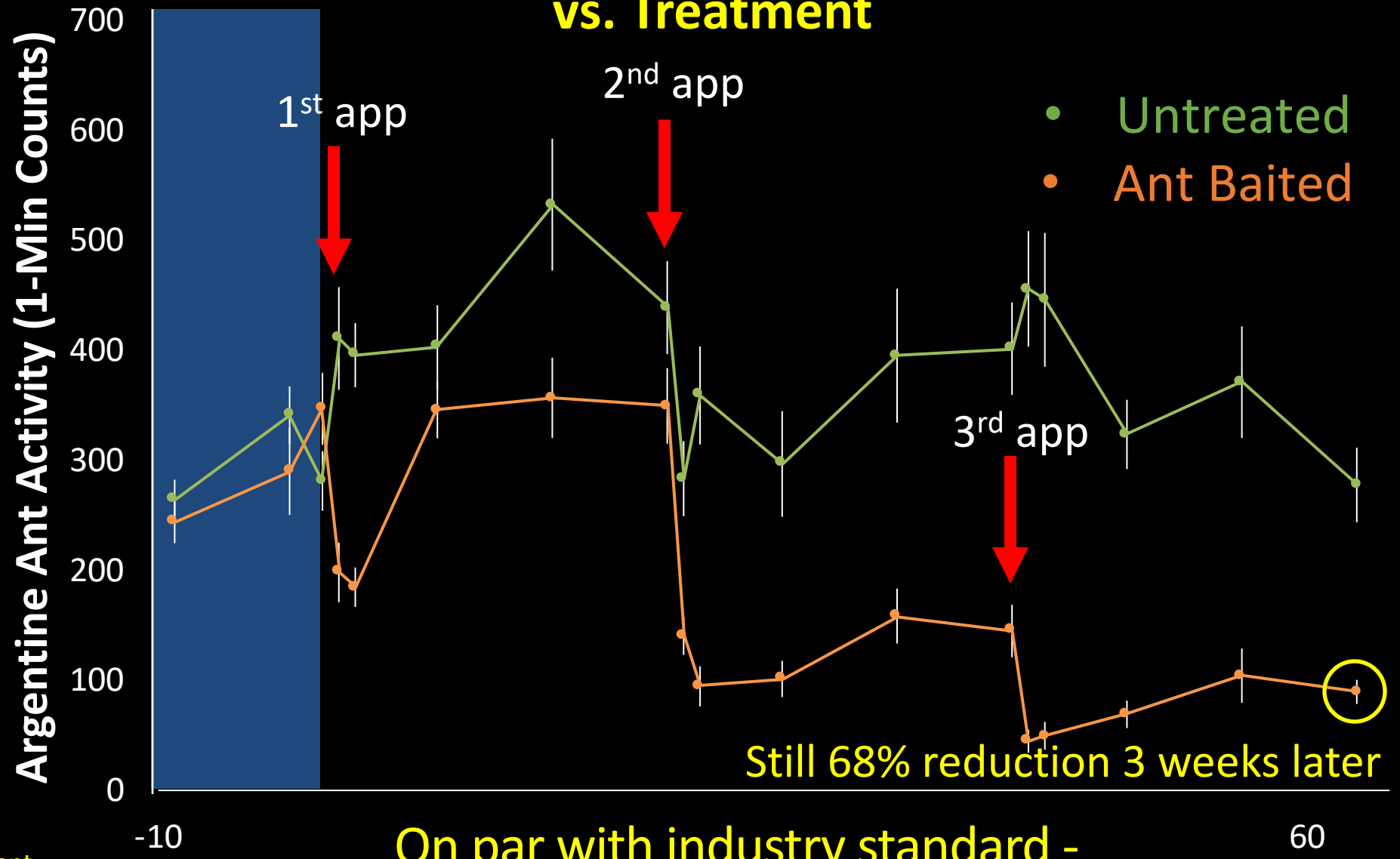
Argentine Ant Activity (Visual Counts) Over Time vs. Treatment



On par with industry standard - biocontrol beneficial level

Ant activity sig different between treatments; P < 0.0001 (linear mixed model and lsmeans)

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Pop Up Quiz - 8

- Why do liquid baits provide effective long term ant control?
  - Ants get intoxicated from fermenting sugar water
  - Ultra low doses of insecticide are drunk and delivered slowly into the nest and fed to workers, brood, and queens killing them
  - Ants get poisoned from touching the bait stations
  - Ant nests are destroyed when bait stations explode in the sun

Measuring the impact of Argentine ant control in commercial citrus groves

[4] Yoo et al., 2013

Photos:
Jeanette Warner, 2014
Ken Kupfer, kmantpro.com
Regents of California, Center for Invasive Species Research
Mike Lewis; Kelsey Schall; University of California Riverside
Lyle Buss; Division of Plant Industry; University of Florida

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Avg Pest Infestation Rate (%)

Niche type:			
Aug 2016 (pre-treatment)	**16**	**42**	**25**
Aug 2017 (ant baited)	**0.3**	**0.4**	**7**
Aug 2017 (untreated)	**4**	**27**	**26**

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Infestation Rate of Niche (%)

Date Sampled	Branches	Fruit	Flush
June 2017 (untreated)	5	16	43

Year-round trend

Biological control driven

Difficult to track natural enemies

Biodiversity survey → determining major players

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Pop Up Quiz – 9

- **California red scale doesn't produce honey dew but it benefits from Argentine ant protection. How does this occur?**
  - **CA red scales are protected because ants like to eat *Aphytis* eggs and larvae**
  - **CA red scales benefit from patrolling ants protecting honey dew producing neighbors**
  - **CA red scale crawlers are moved by ants to new twigs and fruit**
  - **CA red scale wax coverings are collected by ants to waterproof nests**

Pop Up Quiz - 10

- **Why do populations of sap sucking pests decline when ants are controlled?**
  - **Pests drown in their honey dew**
  - **Pests die from black sooty molds that grow on honey dew**
  - **Pests can’t move to new areas without ants helping them**
  - **Natural enemies devour pests and wipe them out**

What is the Future of Ant Control in Perennial Orchards?

Questions?