CAN THE STERILE INSECT TECHNIQUE HELP TO CONTROL THE SPREAD OF ASIAN CITRUS PSYLLID IN CALIFORNIA?

Jedeliza B. Ferrater[1], Gregory S. Simmons[2], Matthew P. Daughtery[1], & Paul F. Rugman-Jones[1]*

[1]University of California, Riverside, California; [2]USDA-APHIS-PPQ, Salinas, California

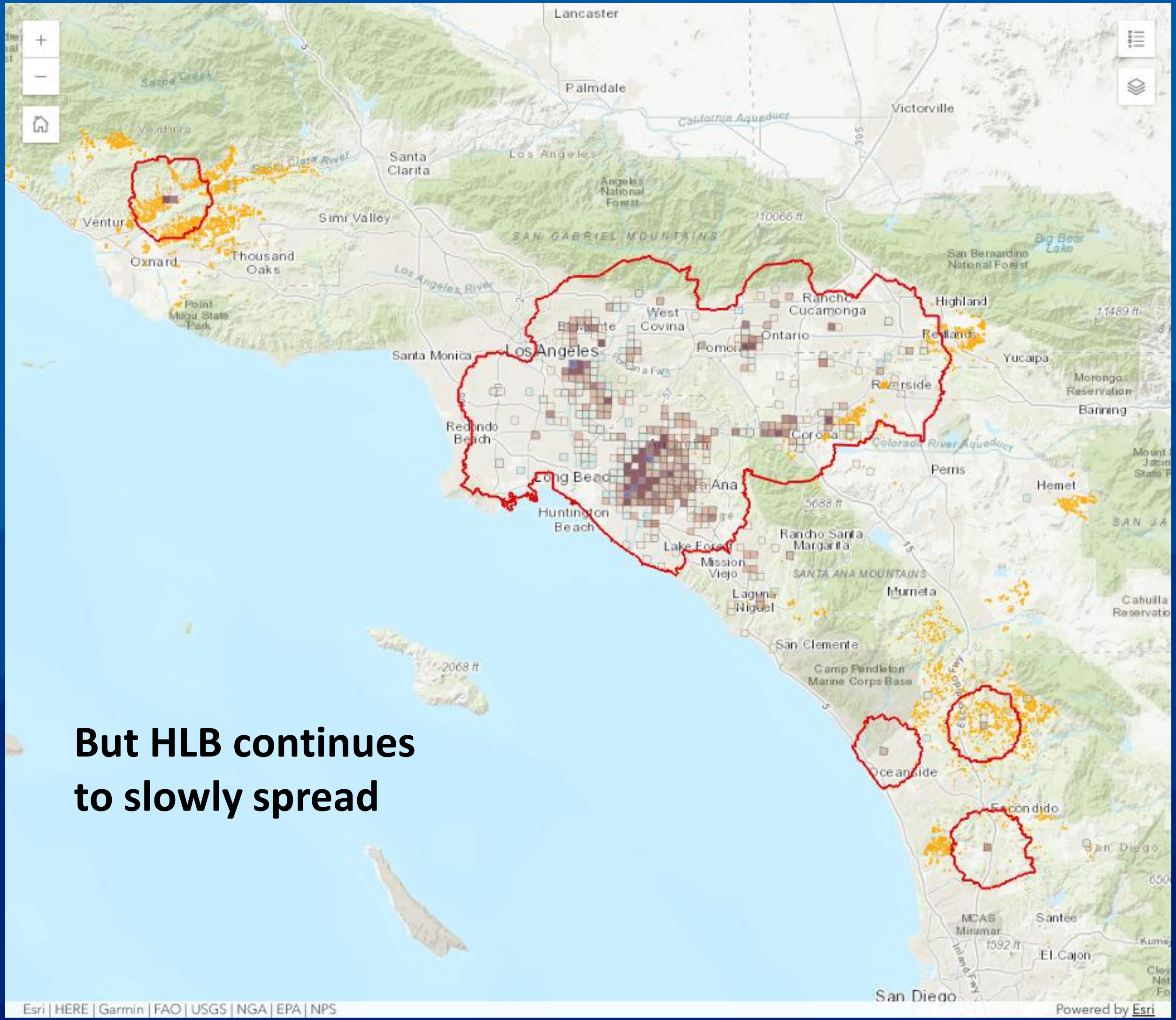
2026 ACP-HLB GROWER MEETING, 12th MAY 2026, OXNARD, CA

Background

- HLB is the most devastating citrus disease worldwide.
- Florida has lost >80% of its citrus production since 2010.
- California now accounts for ~79% of U.S. production ($2.55 billion).
- Infected trees have been found in Southern California.
- HLB is associated with the pathogen *Candidatus* Liberibacter asiaticus (*C*Las)
  - Asian Citrus Psyllid (ACP) is the major vector of *C*Las
  - ACP transmits *C*Las into the phloem when it is feeding on citrus flush.
  - The bacterium multiplies in the tree's phloem tissue, blocking the flow of nutrients
  - And killing the tree within 3 to 5 years.
- Best management practices center around removing infected trees, and **controlling ACP**.

Current practice

Bugguide.net - Copyright © 2022, Salvador Vitanza



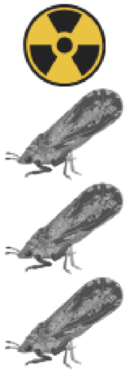
https://ucanr.edu/site/asian-citrus-psyllid-distribution-and-management/distribution-acp-hlb-and-parasitoids

Birth control for bugs: how does the sterile insect technique (SIT) work?

1

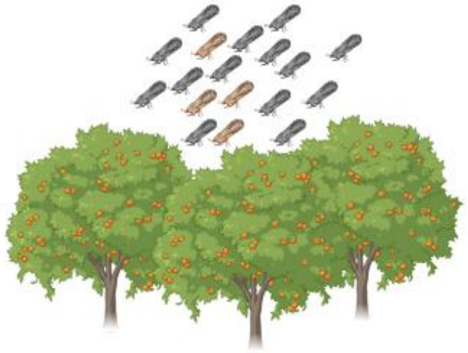
Insect Rearing: "Clean" psyllids are bred in large numbers in specialized insectaries on curry leaf, *Bergera koenigii*, a citrus relative that cannot harbor the bacterium that causes citrus greening.

2



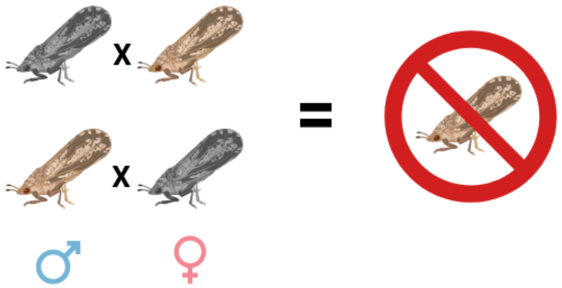
Sterilization: Adult psyllids are sterilized using X-ray radiation. This does not affect their ability to fly or mate, but does make them incapable of producing offspring.

3



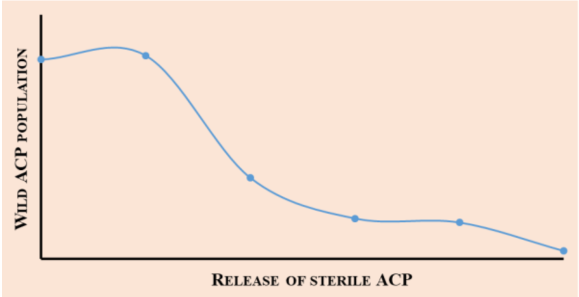
Release: The sterile psyllids are released into a grove where they mingle with the wild population. Releasing clean adults is a key component of the process since, as adults, the sterile psyllids are no longer able to effectively acquire and transmit citrus greening.

4



Mating: Sterile psyllids mate with wild individuals and although these encounters typically result in the production of eggs, the eggs are not fertile. Thus, no new psyllids are created.

5



Population Decline: Over time (i.e. multiple releases), sterile individuals continue to outcompete fertile ones, fewer psyllids are born, and the overall population of the Asian citrus psyllid drops.

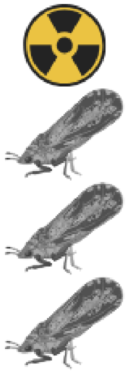
From: "Using the ACP as a weapon against itself"
Citrograph, Vol. 16, No. 2

Wait! Won't you be releasing thousands of vectors, albeit sterile ones?

1

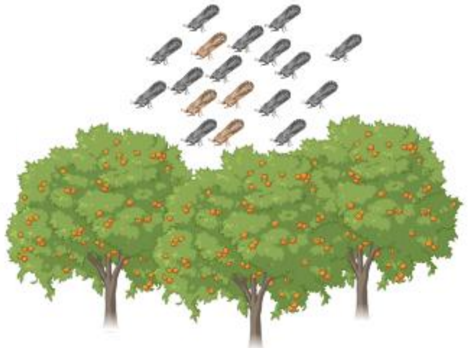
Insect Rearing: "Clean" psyllids are bred in large numbers in specialized insectaries on curry leaf, *Bergera koenigii*, a citrus relative that cannot harbor the bacterium that causes citrus greening.

2



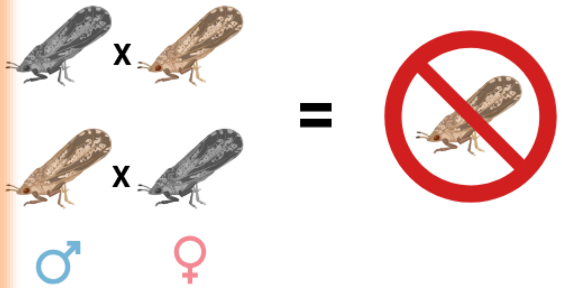
Sterilization: Adult psyllids are sterilized using X-ray radiation. This does not affect their ability to fly or mate, but does make them incapable of producing offspring.

3



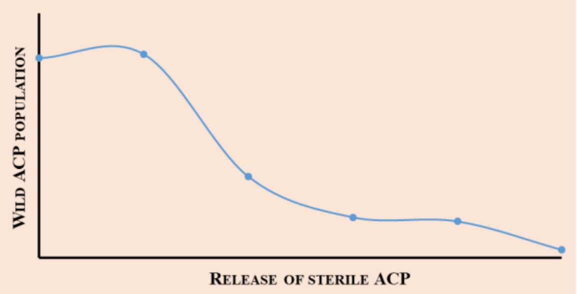
Release: The sterile psyllids are released into a grove where they mingle with the wild population. Releasing clean adults is a key component of the process since, as adults, the sterile psyllids are no longer able to effectively acquire and transmit citrus greening.

4



Mating: Sterile psyllids mate with wild individuals and although these encounters typically result in the production of eggs, the eggs are not fertile. Thus, no new psyllids are created.

5



Population Decline: Over time (i.e. multiple releases), sterile individuals continue to outcompete fertile ones, fewer psyllids are born, and the overall population of the Asian citrus psyllid drops.

From: "Using the ACP as a weapon against itself"
Citrograph, Vol. 16, No. 2

Wait! Won't you be releasing thousands of vectors, albeit sterile ones?

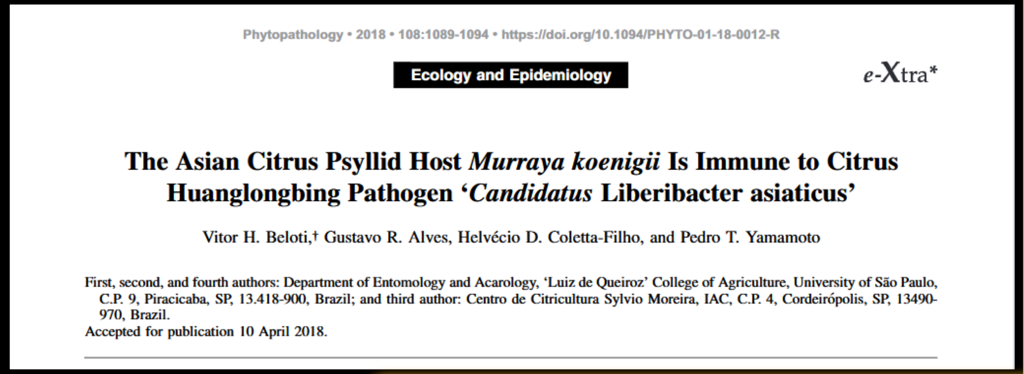
Insect Rearing: "Clean" psyllids are bred in large numbers in specialized insectaries on curry leaf, *Bergera koenigii*, a citrus relative that cannot harbor the bacterium that causes citrus greening.

rilization: Adult

ducing offspring.

Release: T

and transm



Phytopathology • 2018 • 108:1089-1094 • https://doi.org/10.1094/PHYTO-01-18-0012-R

Ecology and Epidemiology

e-Xtra*

The Asian Citrus Psyllid Host *Murraya koenigii* Is Immune to Citrus Huanglongbing Pathogen '*Candidatus* Liberibacter asiaticus'

Vitor H. Beloti,† Gustavo R. Alves, Helvécio D. Coletta-Filho, and Pedro T. Yamamoto

First, second, and fourth authors: Department of Entomology and Acarology, 'Luiz de Queiroz' College of Agriculture, University of São Paulo, C.P. 9, Piracicaba, SP, 13.418-900, Brazil; and third author: Centro de Citricultura Sylvio Moreira, IAC, C.P. 4, Cordeirópolis, SP, 13490-970, Brazil.

Accepted for publication 10 April 2018.

Arthropods in Relation to Plant Disease

Transmission Parameters for *Candidatus* Liberibacter asiaticus by Asian Citrus Psyllid (Hemiptera: Psyllidae)

K. S. PELZ-STELINSKI,[1,2] R. H. BRLANSKY,[3] T. A. EBERT,[1] and M. E. ROGERS[1]

J. Econ. Entomol. 103(5): 1531–1541 (2010); DOI: 10.1603/EC10123

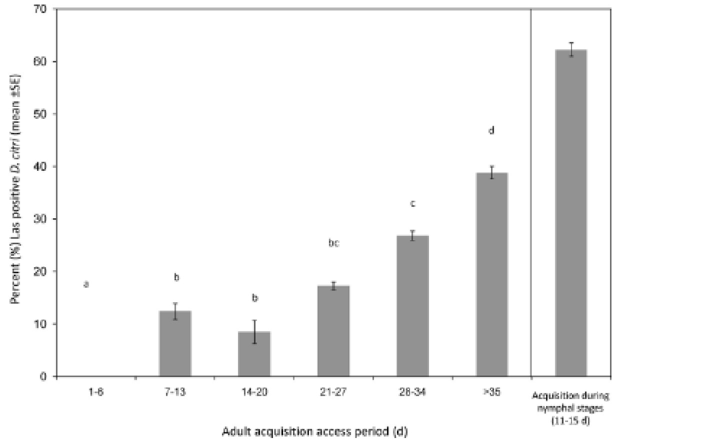


Fig. 1. Percentage of *D. citri* (mean ± SE) that tested positive for Las in laboratory experiments after feeding on infected citrus for AAPs lasting 1–45 d (adults) or for the duration of nymphal development from the egg stage through the fifth instar (11–15 d). Presence of Las was assessed using qPCR after each AAP. AAPs for adults were grouped by week for analysis. Means for adult AAPs with different letters are significantly different (α = 0.05; Fisher protected LSD).

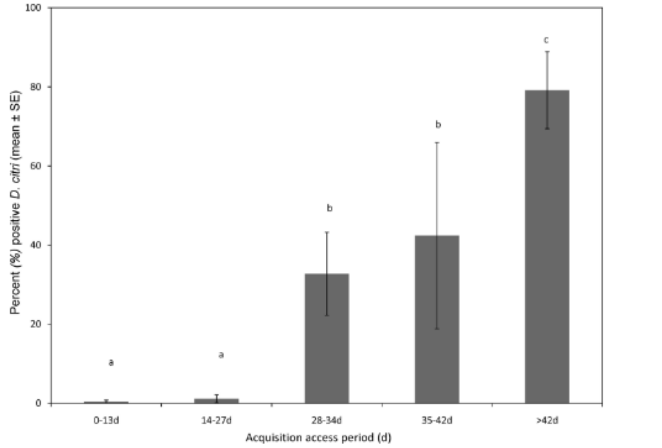
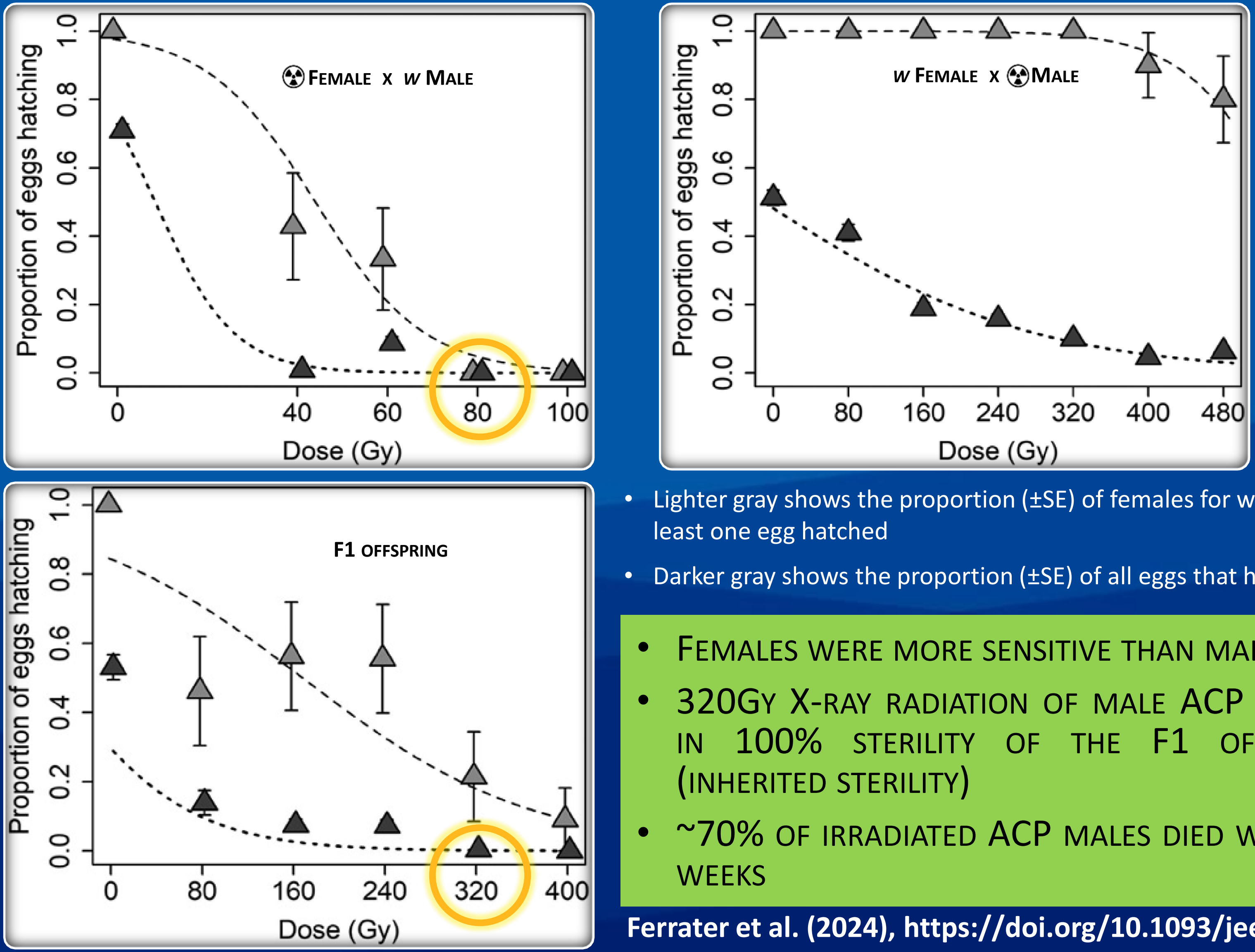


Fig. 2. Percentage of *D. citri* (mean ± SE) that tested positive for Las under field conditions after feeding on infected citrus for AAPs of 1–51 d. Presence of Las was assessed using qPCR after each AAP. AAPs for adults were grouped for analysis. Means for adult AAPs with different letters are significantly different (α = 0.05; Fisher protected LSD).

Development of SIT for ACP

Determine the dose of radiation required to render ACP sterile [without compromising their ability to compete with wild ACP for mating opportunities]

Effective radiation dose

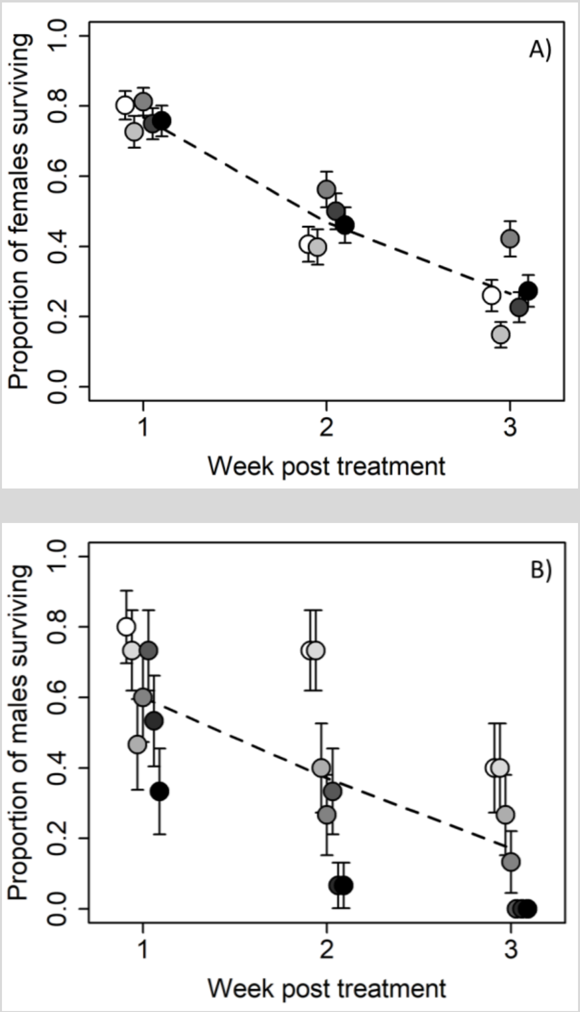


- Lighter gray shows the proportion (±SE) of females for which at least one egg hatched
- Darker gray shows the proportion (±SE) of all eggs that hatched.

- FEMALES WERE MORE SENSITIVE THAN MALES
- 320GY X-RAY RADIATION OF MALE ACP RESULTS IN 100% STERILITY OF THE F1 OFFSPRING (INHERITED STERILITY)
- ~70% OF IRRADIATED ACP MALES DIED WITHIN 2 WEEKS

Ferrater et al. (2024), https://doi.org/10.1093/jee/toae098

… & survival



- Darker colors indicate increasing dose

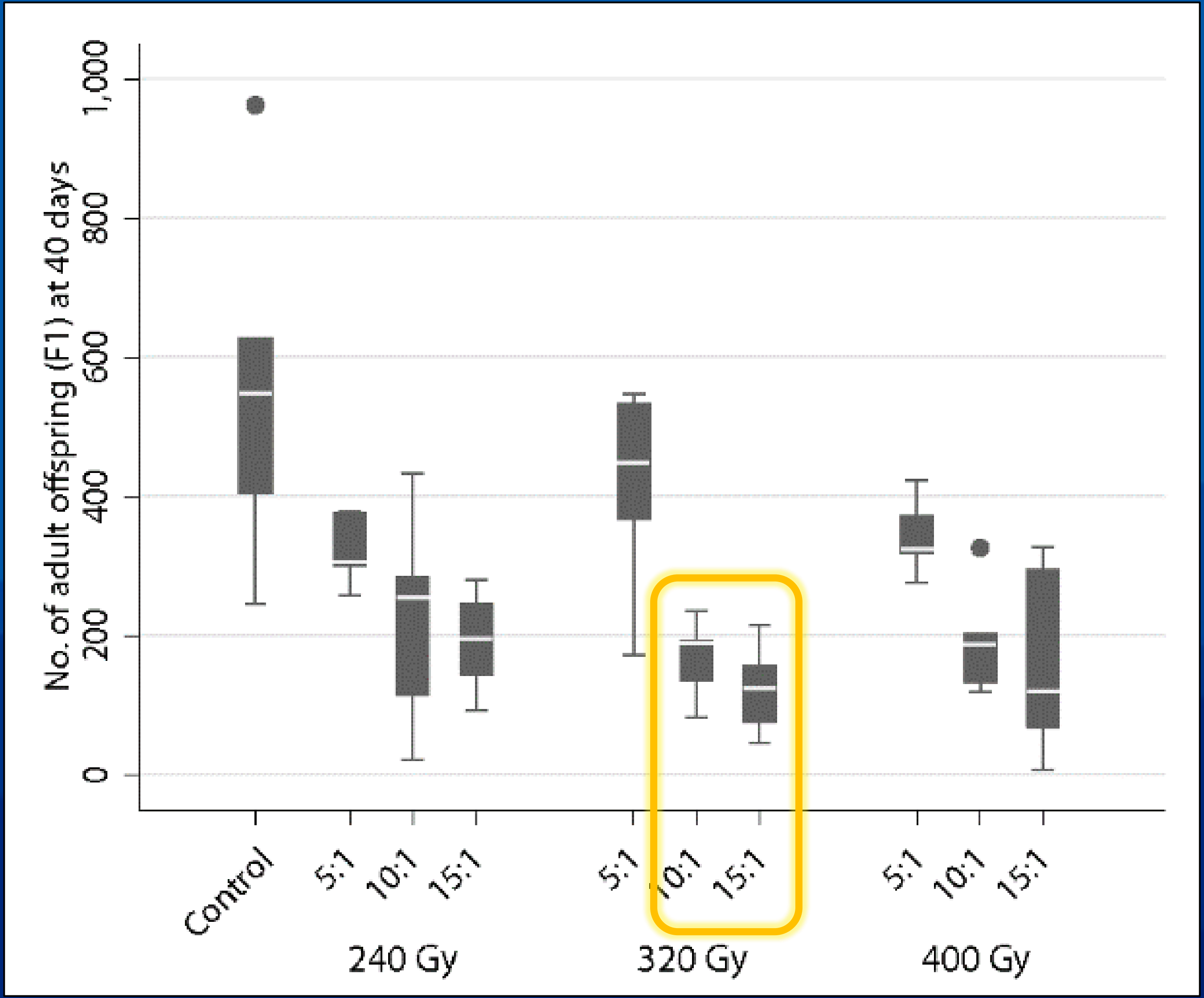
Development of SIT for ACP

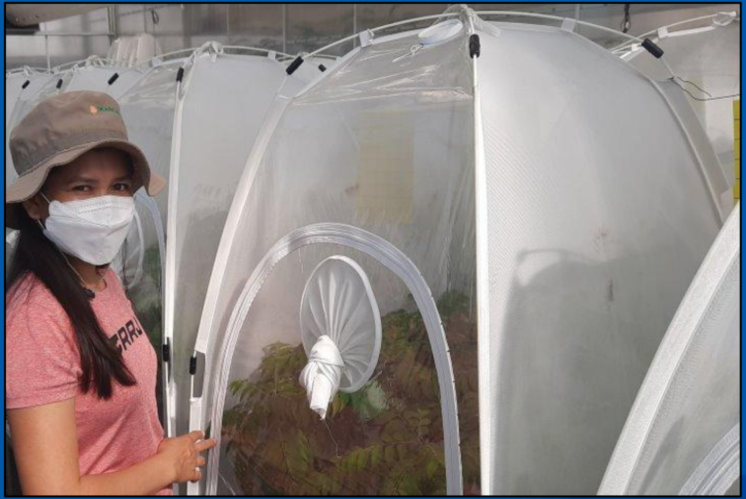
Determine the number of sterile ACP that need to be released to suppress a “wild” population

- *__the overflooding ratio__

✓ Radiation Dose

Effective overflooding ratio





At 320 Gy, ratios of 10:1 and 15:1 suppressed population growth up to 78%

Ferrater et al. (2026), https://doi.org/10.1093/jee/toag116

✓ Release rate (SIT-ACP:wild ACP)

✓ Radiation Dose

Looks good, but can it work in the field?

23-PMG-R001

Photo: Mike Lewis, UCR

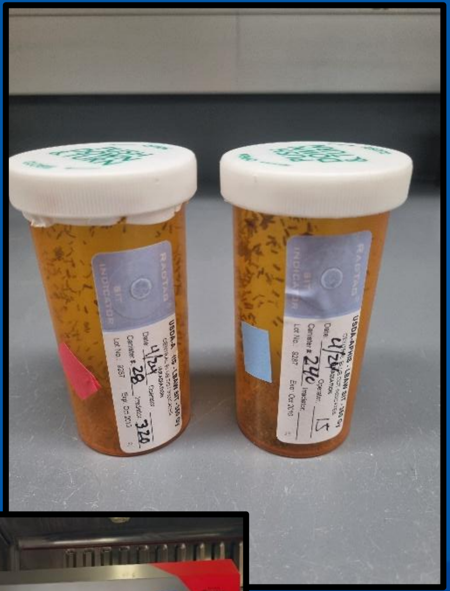
Preparation of sterile ACP?

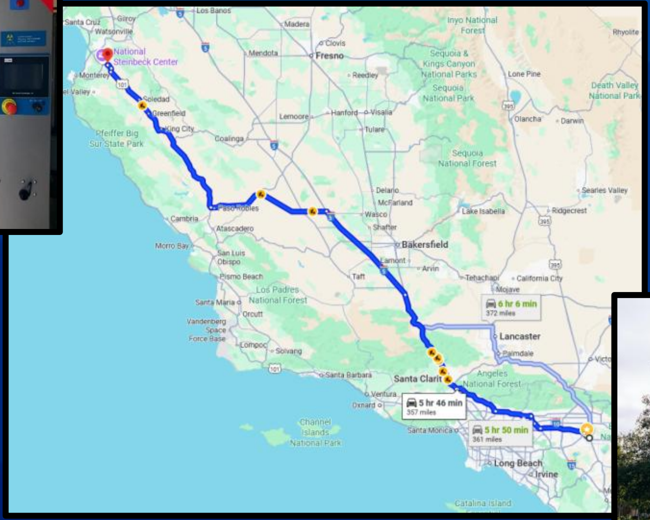
Mass rearing of psyllids

- *C*Las^{-ve} Adult ACP reared in UCR I&Q
- On potted curryleaf plants (*Bergera koenigii*) – not a reservoir for HLB!
- Insectary room ~ 6' x 10', >14 cages
- 200 ACP added to each cage
- At 80°F, yields ~3,000 ACP per cage after 25 days
- >40,000 adult ACP in one month

Preparation of sterile ACP?

- 2-3 day-old virgin adult ACP are aspirated into secure “pharmaceutical” vials – 800 per vial.
- Vials placed inside a cooler @ 6°C and driven to USDA-APHIS, Salinas overnight.
- Irradiated @ 240 Gy or 320 Gy.
- …returned to cooler and driven back to UCR.
- All movement in accordance with CA State Plant Pest Permit # 4033 and ACP remain sealed inside the secure vials throughout!





Sterile releases against "surrogate" wild populations?

- All releases in accordance with CA State Plant Pest Permit # 4033, and vials remain sealed until ready for release inside the cages!
- Field-cages sited at Agricultural Operations, UCR (10'x10'x10' or 12'x12'x12').
- Each cage housed a mature lemon tree [~7 ft high x 7 ft canopy diam.]
- Each cage seeded with 150 wild (non-irradiated) ACP.
- Vials of sterile ACP hung in the canopy and ACP allowed to naturally disperse.

Year 1 – impact of a single sterile release

- Populations initiated by releasing wild and irradiated ACP together
- Experiments conducted in Spring and Summer 2024

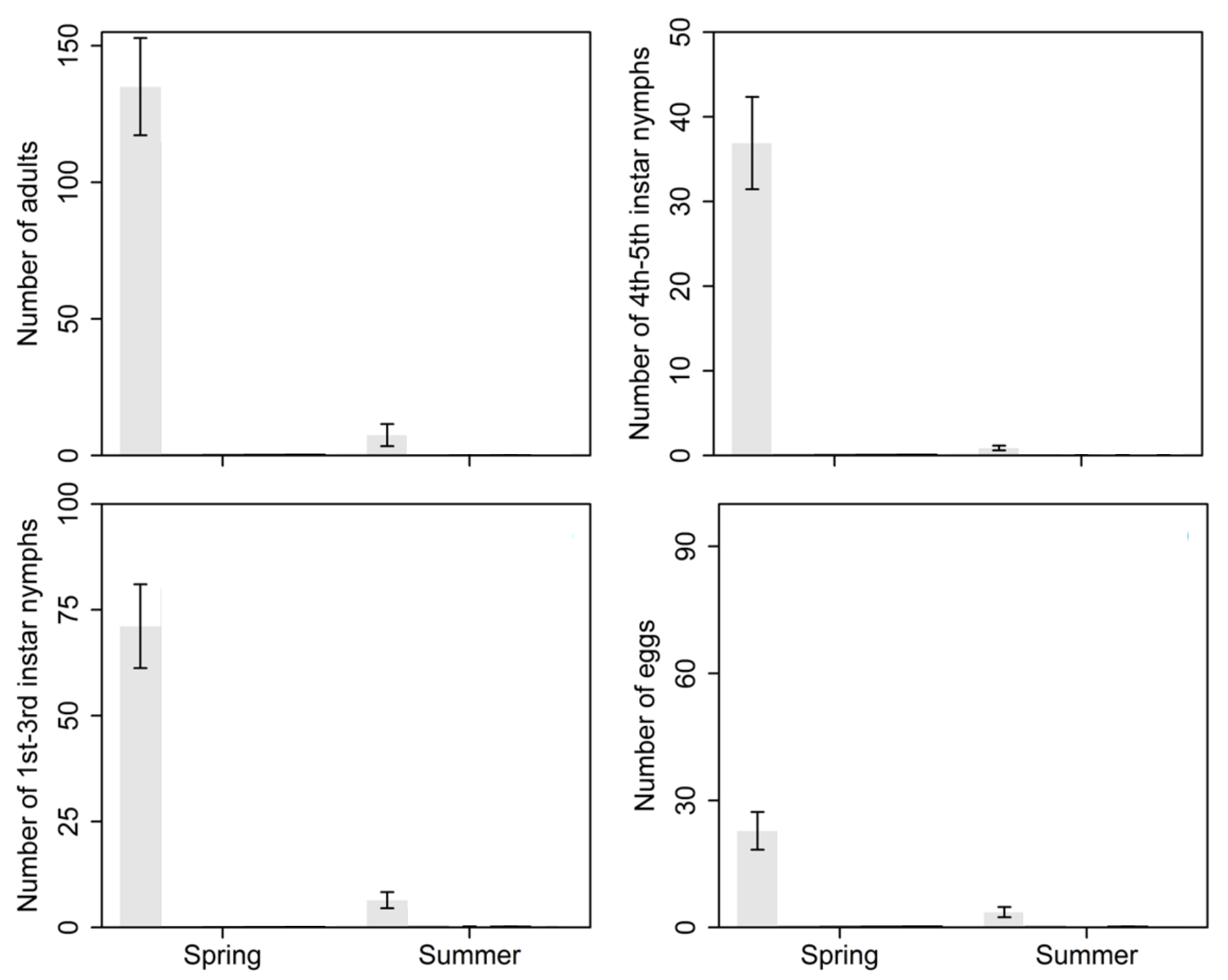
Treatment	Wild ACP	Irradiated ACP	No. of cages
240 Gy, 10:1	150	~1,500	4
240 Gy, 15:1	150	~2,250	4
320 Gy, 10:1	150	~1,500	4
320 Gy, 15:1	150	~2,250	4
Control	150	-	4
Total			20

Population monitoring (Yr 1):

- Degree-day model for ACP (Liu & Tsai 2000) used to predict optimal sampling times for estimating the size of the F1 generation
  - Incorporating temperature data from (CIMIS #44, U.C. Riverside)
- Immature stages (eggs and nymphs) were recorded by destructive sampling of branch tips.
  - Five tips collected from each side of the tree (N, S, E, & W) – 20 total.
  - Flush stage of tip rated from 1-5 (youngest to oldest).
  - Eggs and nymphs counted under a stereo microscope.
  - Nymphal counts split into early- (1^{st}-3^{rd}) and late (4^{th}-5^{th}) instar.
- Adults sampled using yellow panel traps.

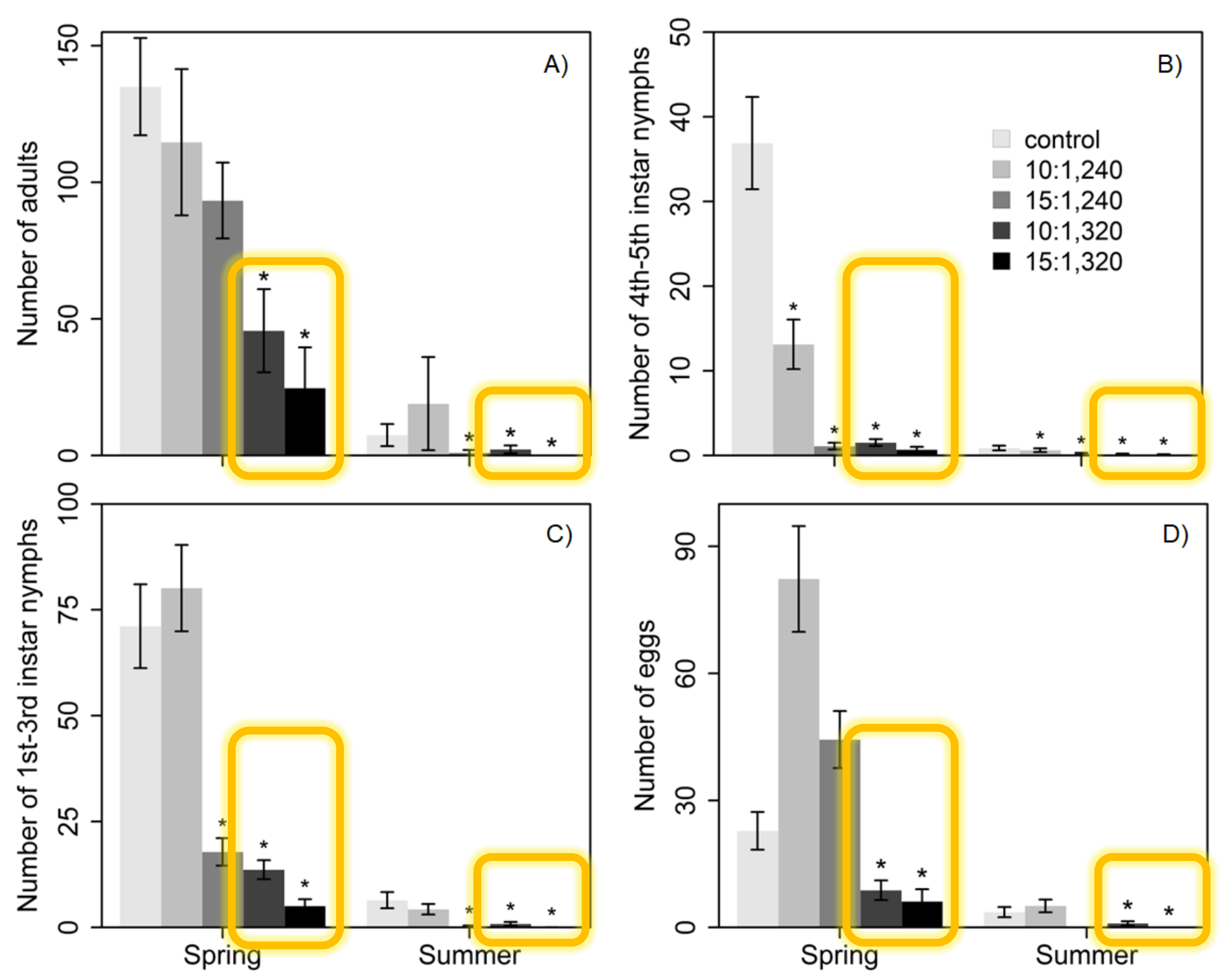
Year 1 – impact of a single sterile release

- But first - growth of the wild ACP without a sterile release?



Year 1 – impact of a single sterile release

- ACP populations lower in the summer, but impact consistent across seasons.
- In general, increasing the radiation dose (from 240 Gy to 320 Gy) showed stronger suppression than increasing the OFR (from 10:1 to 15:1).
- Combination of 320 Gy and 15:1 OFR reduced ACP counts the most compared to the control:
    - A. >80% for adults
    - B. ~98% reduction in late-instar nymphs
    - C. >90% reduction in early-instar nymphs
    - D. ~80% reduction in eggs,



	Eggs			1st-3rd instars			4th-5th instars			adults		
Source	χ^2	df	P	χ^2	df	P	χ^2	df	P	χ^2	df	P
Treatment	38.864	4	<0.0001	60.161	4	<0.0001	57.547	4	<0.0001	31.889	4	<0.0001
Season	201.54	1	<0.0001	301.04	1	<0.0001	137.40	1	<0.0001	78.829	1	<0.0001
Flush	45.812	1	<0.0001	43.105	1	<0.0001	6.662	1	0.0098	--[1]	--	--
Trt*Seasn	--[2]	--	--	--	--	--	--	--	--	11.654	4	0.0201

Ferrater et al. (2026), https://doi.org/10.1093/jee/toag116

Year 2 – impact of multiple sterile releases

- ACP prepared and irradiated as Yr 1 – 320 Gy only
- Populations initiated by releasing wild and irradiated ACP
- Two OFRs [10:1 & 15:1]
- Half the cages only a single sterile release (same as Yr 1)
- Other half, two further sterile releases after 7 & 14 days
- Experiments conducted in Spring and Summer 2025

Photo: Mike Lewis, UCR

Treatment	Wild ACP – Wk1	Irradiated ACP – Wk1	Wk2	Wk3	No. of cages
10:1, single	150	~1,500	-	-	4
15:1, single	150	~2,250	-	-	4
10:1, multiple	150	~1,500	~1,500	~1,500	4
15:1, multiple	150	~2,250	~2,250	~2,250	4
Control	150	-	-	-	4
Total					20

Population monitoring (Yr 2):

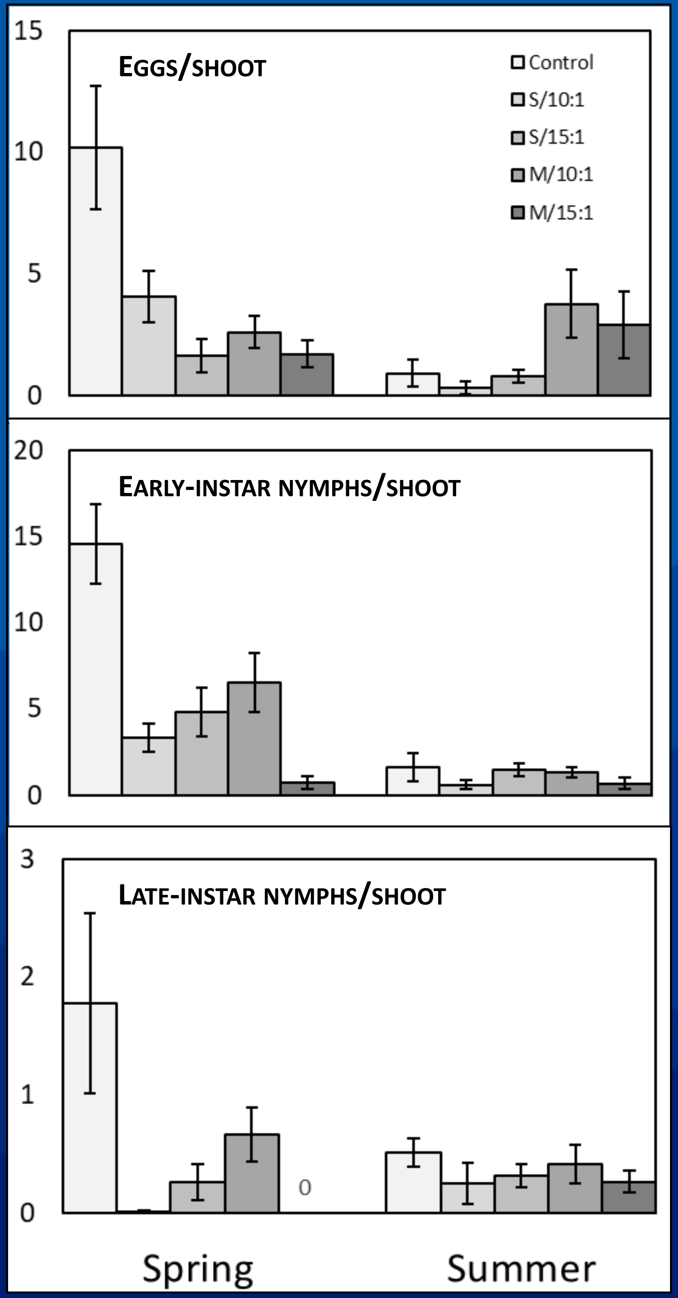
- Degree-day model for ACP (Liu & Tsai 2000) used to predict optimal sampling times for estimating the size of the F1 generation
  - Incorporating temperature data from (CIMIS #44, U.C. Riverside)

- Immature stages (eggs and nymphs) were recorded by destructive sampling of branch tips.
  - Five tips collected from each side of the tree (N, S, E, & W) – 20 total.
  - Flush stage of tip rated from 1-5 (youngest to oldest).
  - Eggs and nymphs counted under a stereo microscope.
  - Nymphal counts split into early- (1^{st}-3^{rd}) and late (4^{th}-5^{th}) instar.

- Adults not sampled at the F1 generation.

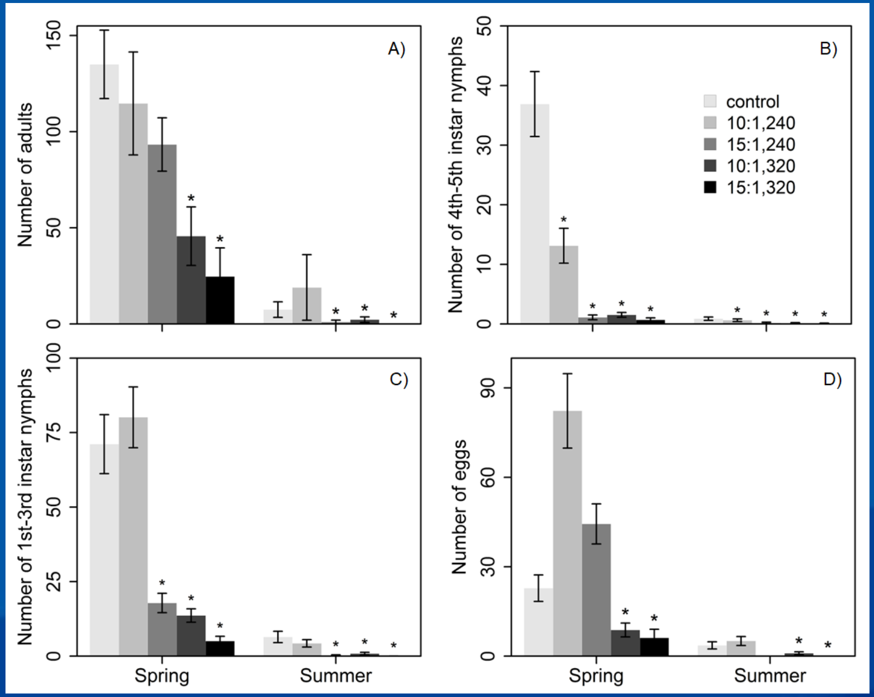
Year 2 – impact of multiple sterile releases

- ACP populations again lower in the summer
- But control cages also >5-fold lower population counts than in Year 1.
- Summer counts particularly low!
- Though overall not statistically significant, sterile releases had the expected impact at least in the spring.
- Largest suppressive effect brought about via multiple spring releases of sterile ACP at 15:1 OFR.



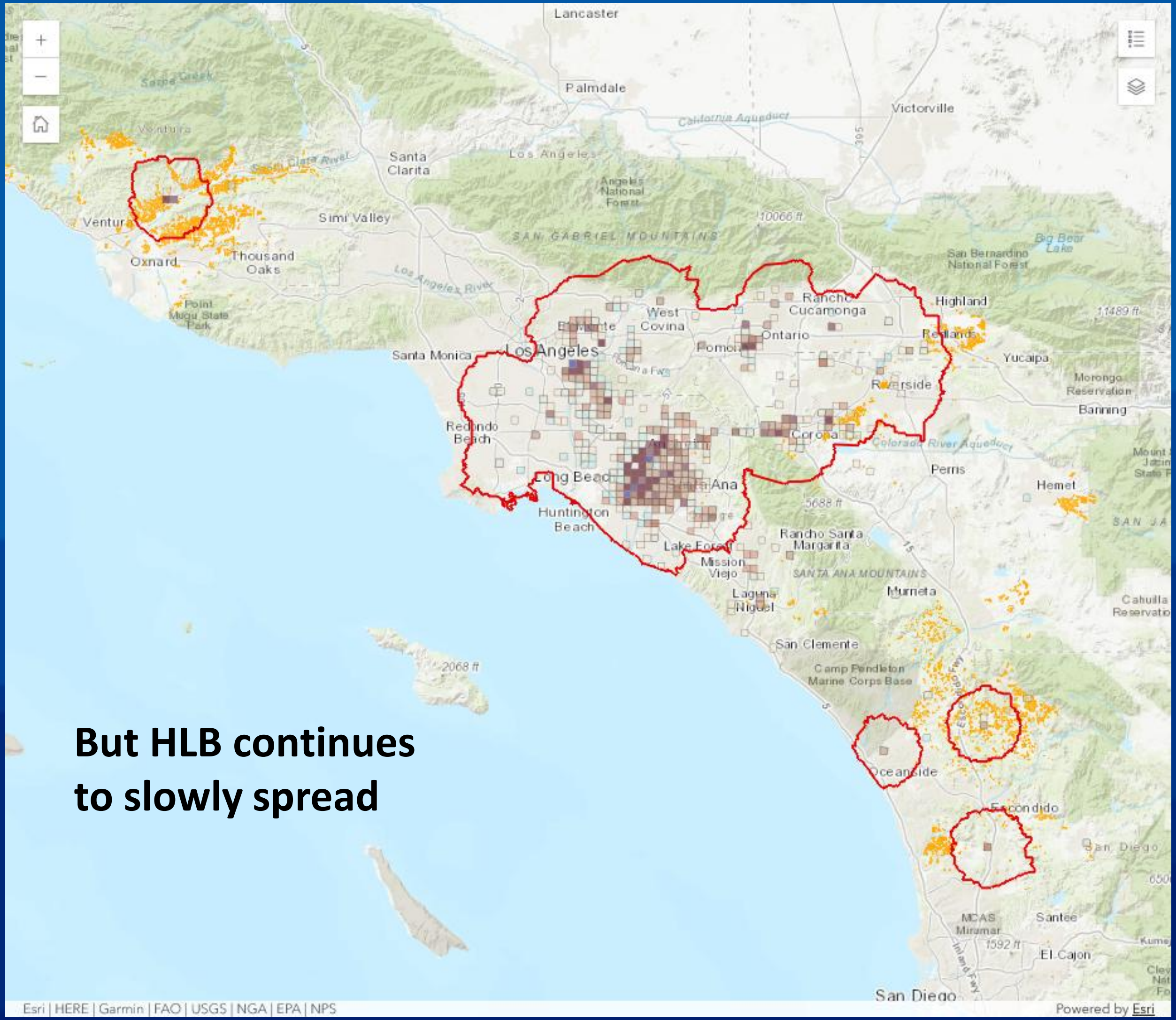
Summary & future directions

- ACP can be mass-reared and sterilized
- With the right combination of dose (320 Gy) and OFR (15:1), the growth of ACP populations on mature citrus trees held within field-cages can be significantly suppressed with the release of sterile psyllids.
- Caged experiments are closed-trials – preventing continued recruitment of wild ACP, and emigration of both sterile and wild ACP from the population.
- We also took steps to exclude natural enemies.
- How will sterile ACP perform in an open environment?



How might SIT be employed?

- Large scale releases are unlikely!
- So, targeted releases to:
  - Suppress/eradicate newly detected adventive populations of ACP.
  - Maintain buffer zones around residential areas close to commercial citrus.



https://ucanr.edu/site/asian-citrus-psyllid-distribution-and-management/distribution-acp-hlb-and-parasitoids

Thank you!

FUNDING:

USDA-APHIS, CHRP: AP21PPQS&T00C148

DPR: 23-PMG-R001

ACKNOWLEDGEMENTS:

Raju Pandey [CRB]

Tom Greene [USDA]

Mya Rodriguez [UCR]

Sandy Priego Solis [UCR]

Sen Miao [UCR]

Nicole Raisola [UCR]

Tammy Dang [UCR]

Greety Wusang [UCR]

Julia Perez [UCR]

Janine Almanzor [UCR Botanic Gardens]

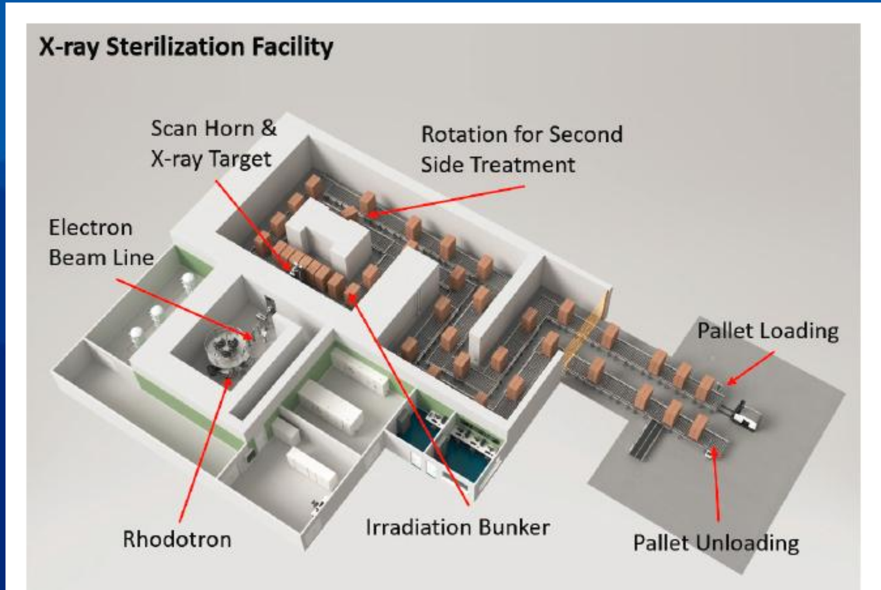
Email: paulrj@ucr.edu

Challenges - infrastructure

- Mass-rearing
  - Investment in rearing facilities/ greenhouse?
  - Can we develop an artificial diet for rearing?

Photo: Farm Progress

- Sterilization
  - Capacity?



Rhodotron® TT1000 x-ray facility. SOURCE: IBA Industrial

Photo: Cal Poly Pomona