Getting the most bang out of insecticides and natural enemies for Asian citrus psyllid management under endemic greening

Lukasz Stelinski

University of Florida, Entomology and Nematology Department, CREC, Lake Alfred, FL

Psyllid infestation reduces tree health with and without HLB—the combo is lethal

HLB +; No ACP

HLB +; Pulsed (monthly) ACP

HLB +; Continuous ACP

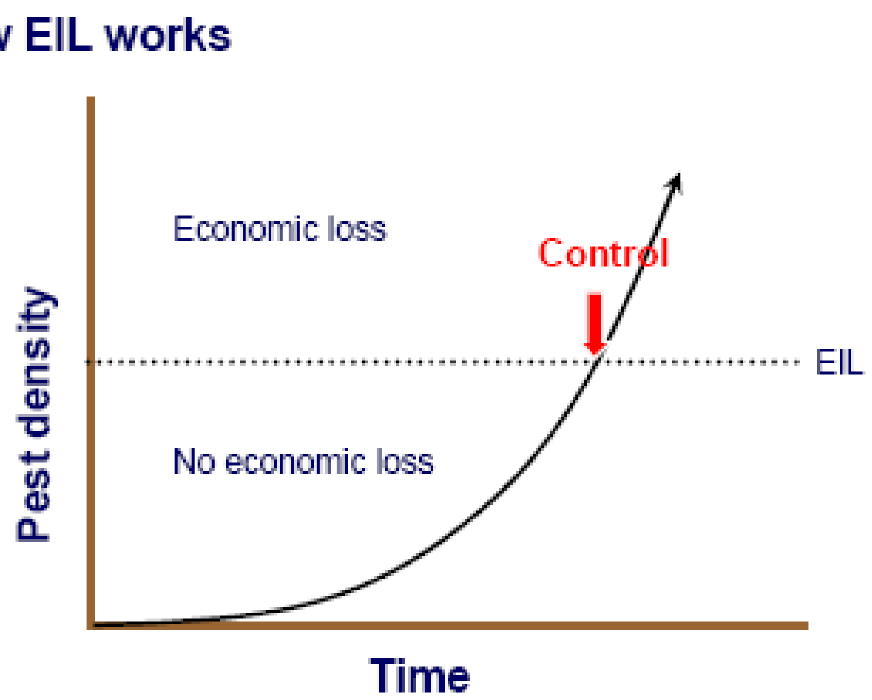
HLB -; No ACP

HLB -; Pulsed (monthly) ACP

HLB -; Continuous ACP

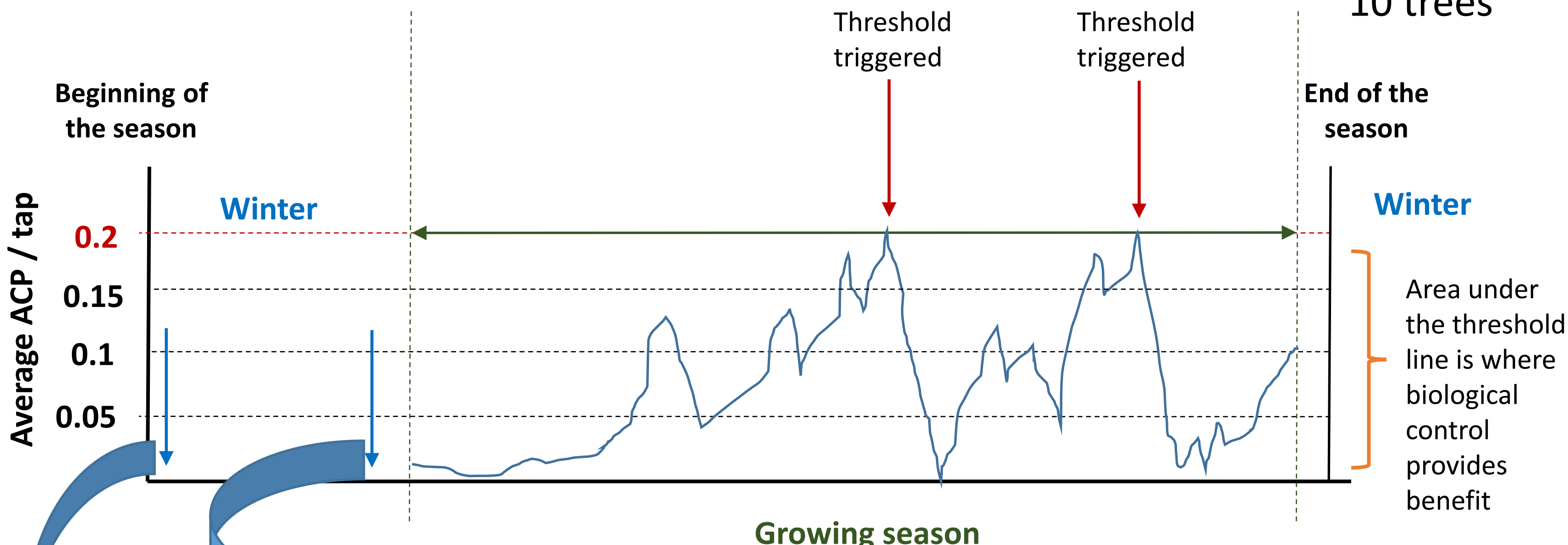
The Economic Injury Level

- Requires regular monitoring
- Known target population that causes economic damage
- Decide whether treatment is necessary after assessing pest populations
- Control measures applied when that known threshold is reached



Hypothetical example of implementing an Economic Injury Level at 0.2 ACP/ tap

Tap sample = Average of 10 trees



Spray on visible flush if/when ACP reappear

Spray at budbreak and before new flush is present

Dormant sprays should achieve 60+ days of low ACP populations

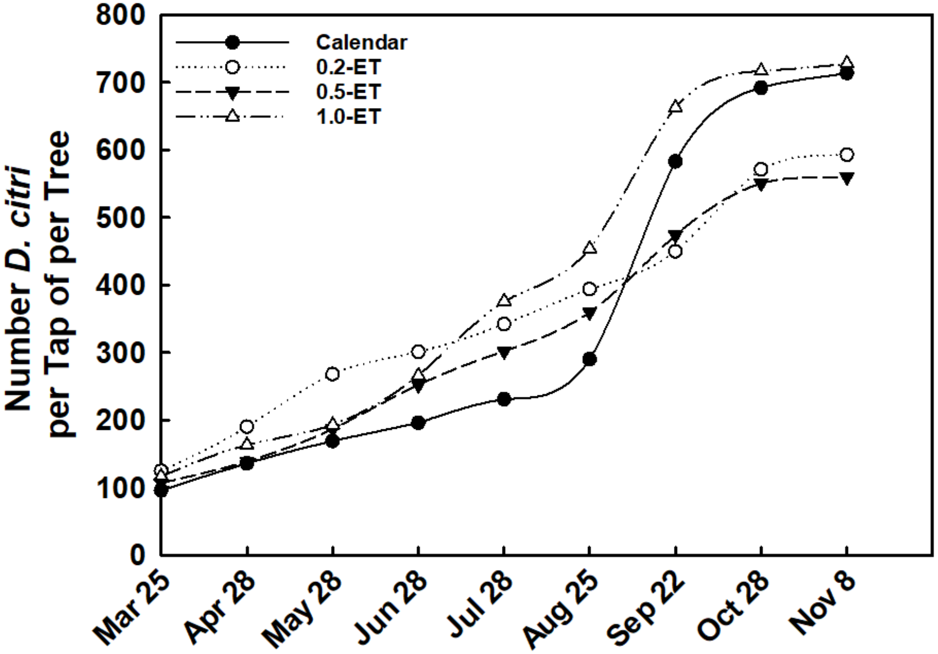
Key Assumptions:

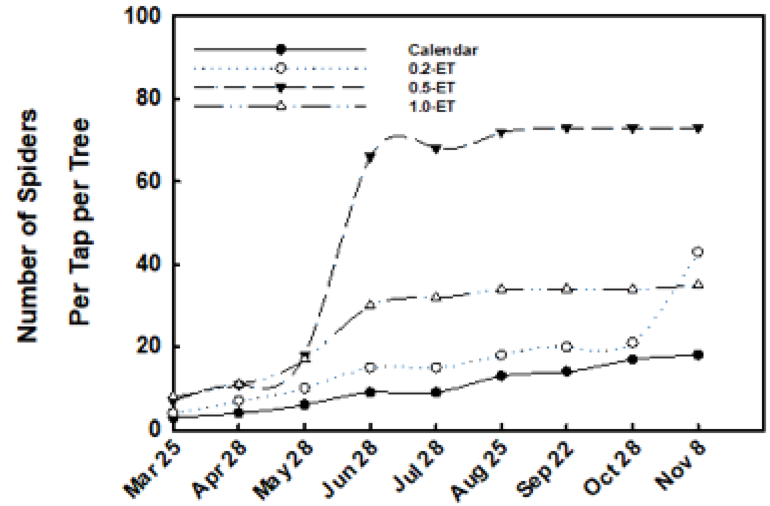
- HLB infection is near 100% and stopping spread is not a goal
- Keeping ACP below the chosen threshold boosts yield via improved tree health

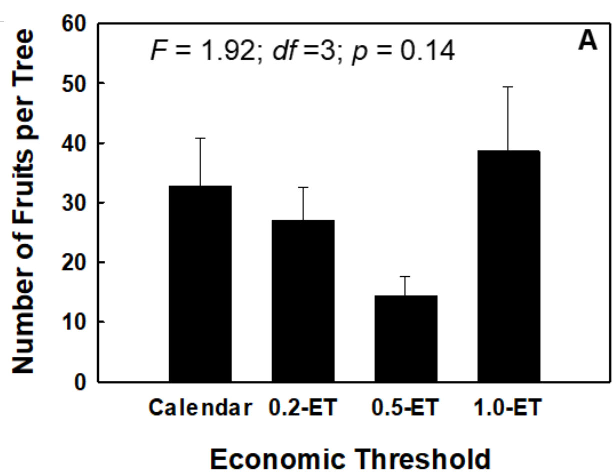
Example 1: Threshold reduced spray frequency from 8 to 3 sprays per year (5-6 yr old tree)

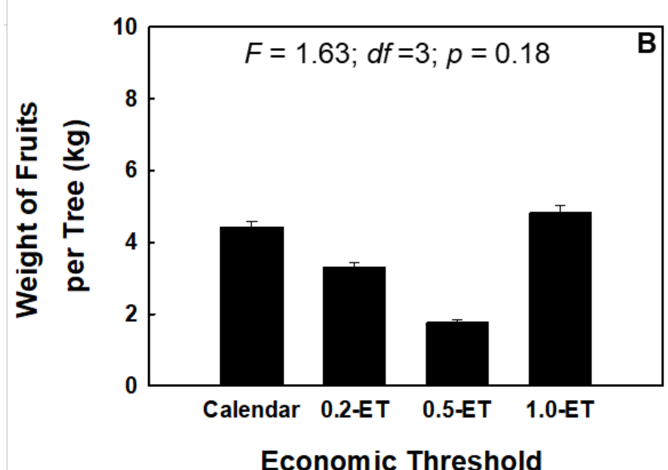
	Threshold		
App Date	0.2 ACP / tap	0.5 ACP / tap	1.0 ACP / tap
May 5, 2020	fenpropathrin (Danitol 2.4EC)	------	------
Jun 9 10, 2020	dimethoate (Dimethoate 4E)	fenpropathrin	------
Jul 7-10, 2020	cyantraniliprole (Exirel)	dimethoate	fenpropathrin
Aug 12, 2020	diflubenuron (Micromite 80WGS)	cyantraniliprole	------
Sep 24, 2020	thiamethoxam (Actara WG)	diflubenzuron	dimethoate
Oct 28, 2020	spinetoram (Delegate WG)	------	------
Dec 18, 2020	abamectin	thiamethoxam	-------

Example 1: Threshold reduced spray frequency no negative impact on psyllid counts or yield









Estimated management costs ($/ha) and yield losses ($/ha) associated with the presence of ACP in Florida citrus.

Management Approach	Initial ACP	No. sprays	K season[a]	Management costs ($/ha)	Estimated Yield loss ($/ha)[b]	Total costs ($/ha)
Calendar	43	8	714	487.22	271.48	758.70
ET-0.2	53	7	593	451.50	206.24	657.74
ET-0.5	35	4	560	229.0	212.79	441.79
ET-1.0	48	3	728	166.92	236.18	403.09

[a] Cumulative number of *D. citri* for the year.

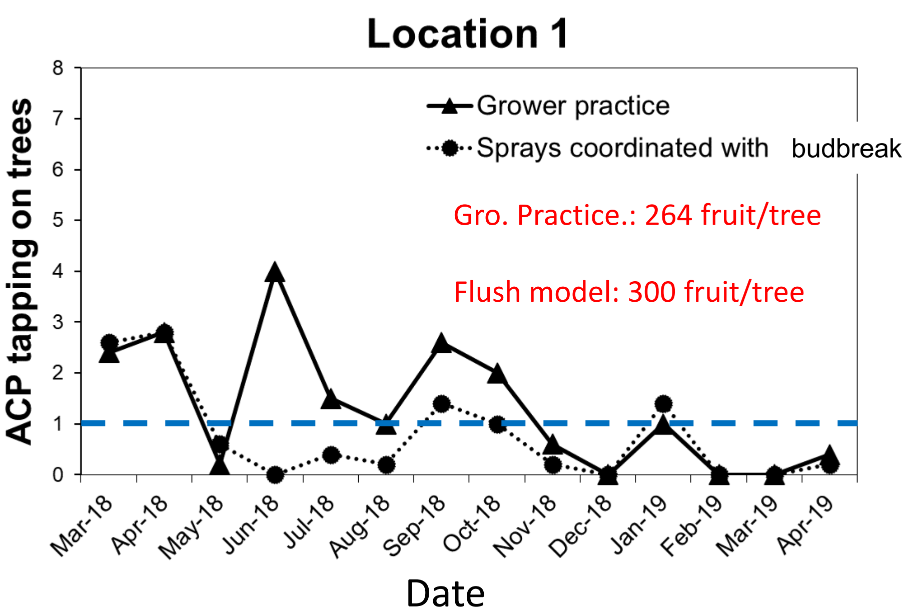
[b] Due to herbivore damage.

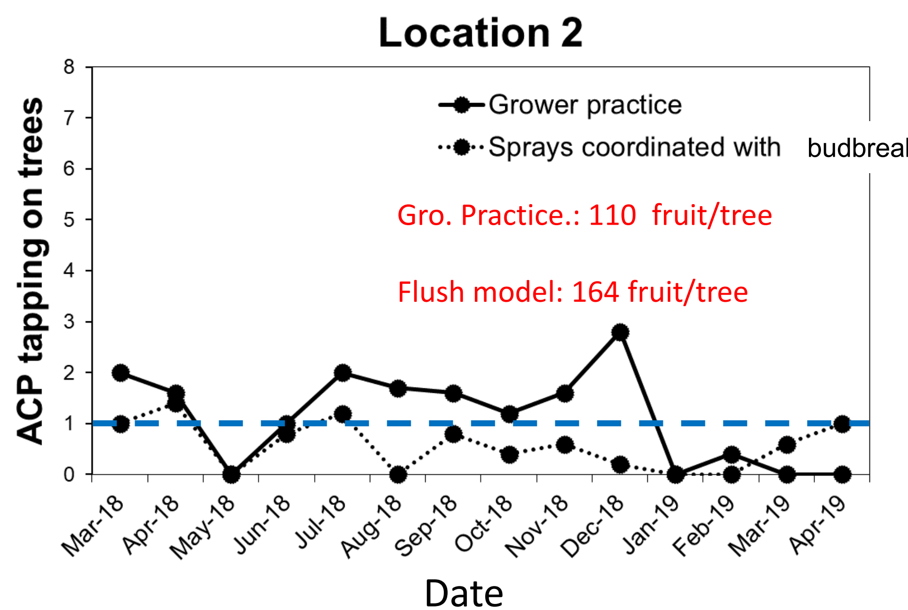
Cost is the monetary value expressed in $/ha associated with the yield loss resulting from the seasonal number of vectors during Kseason and where P is the orange juice price paid at the harvest, expressed in $/kg of solids.

$$\text{Cost} = p \times 2014.5 \times \left(\frac{(3.39 \times Kseason}{1 + \frac{3.39 \times Kseason}{21.8}} \right) / 100$$

Example 2: Integrating tree phenology with EIL

- Timing insecticide applications with bud break resulted in better ACP suppression.
- Maintaining ACP populations below a threshold of 1 ACP / tap was associated with better yield.





-Solid lines indicate calendar sprays (higher ACP)

-Dashed lines indicate use of bud break model to predict flushes (lower ACP)

How to maximize biological control?

I. Ants exclusion experiment

Study site

Treatments

Ants present

Ants absent

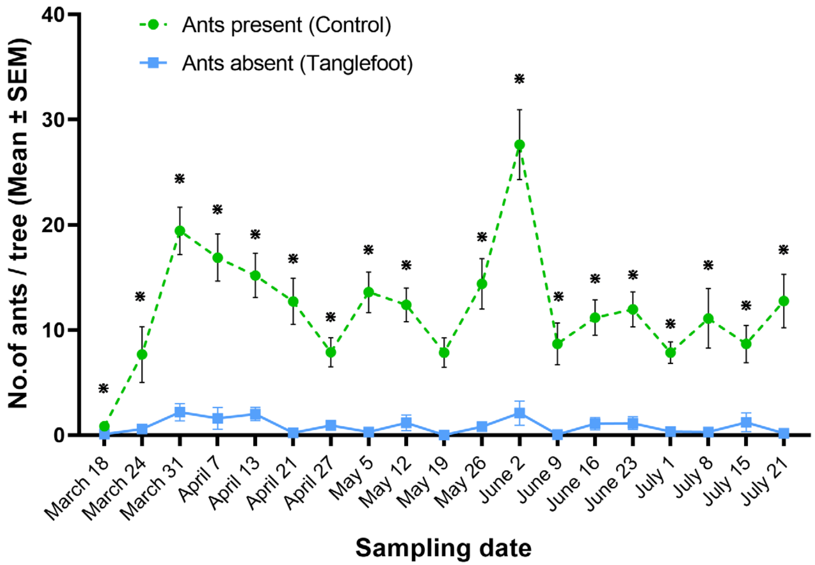
Control

Tangle foot treated trees

- Randomized complete block design with 4 replications
- 12 trees were selected in each plot

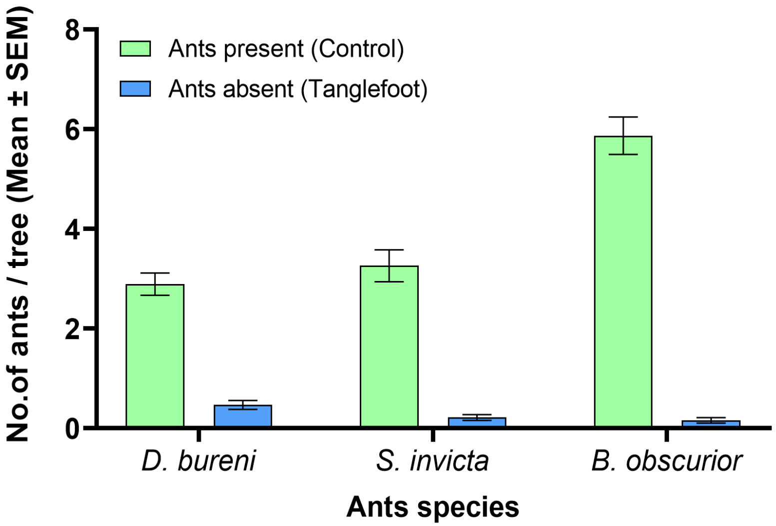
When ants are removed, biological control improves

Ant activity



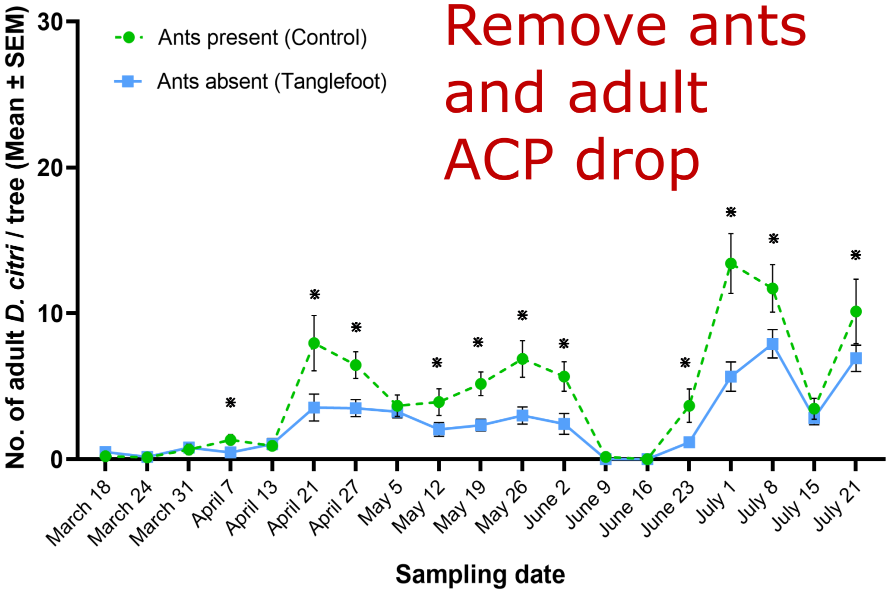
- Mean number of ants observed on Tanglefoot barrier-treated trees was significantly lower than that observed on untreated control trees.

Ant species



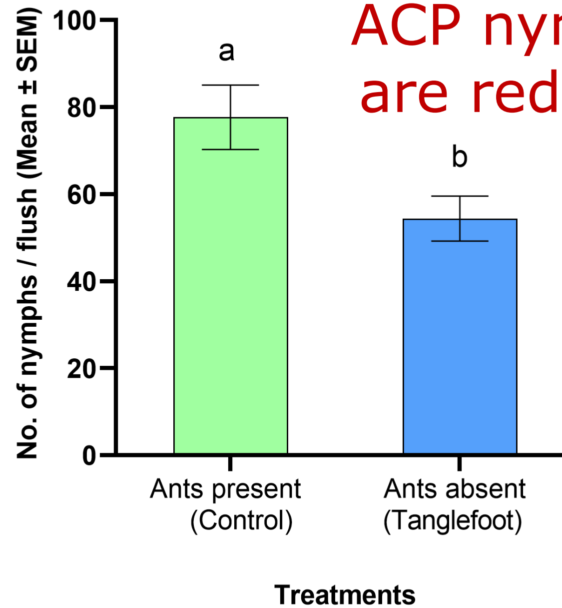
- *Brachymyrmex* obscurior was the most abundant species followed by *Solenopsis invicta*, and *Dorymyrmex bureni* in untreated control trees.

Remove ants and adult ACP drop



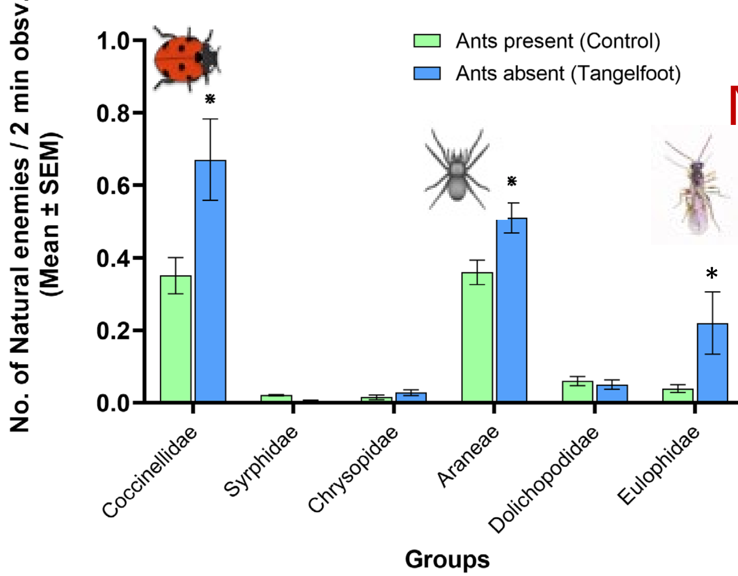
- Tanglefoot-treated trees had significantly fewer adult psyllids than untreated control trees.

ACP nymphs are reduced



- The mean number of ACP nymphs in Tanglefoot-treated trees was significantly lower than in ant-infested trees.

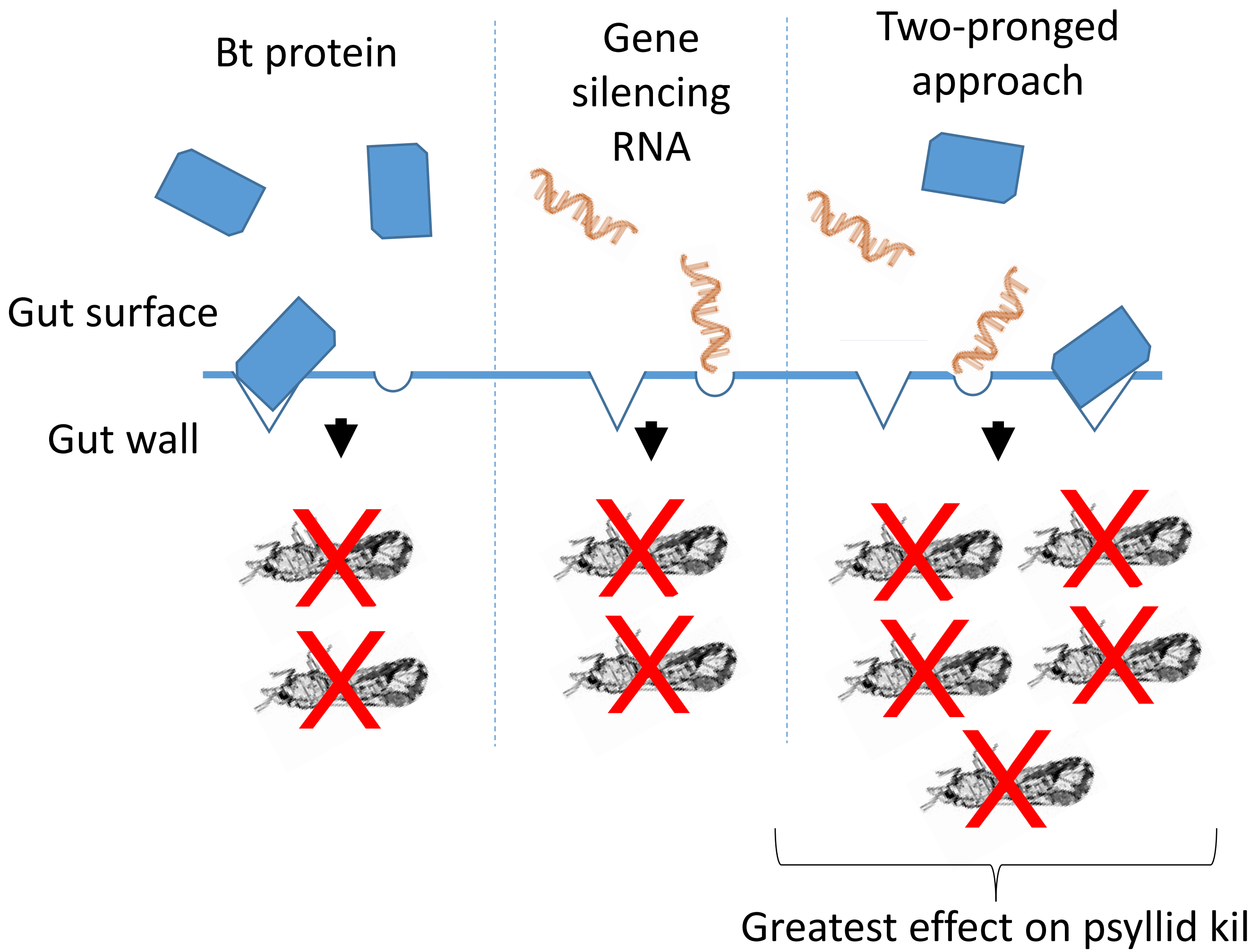
Natural enemy densities increase



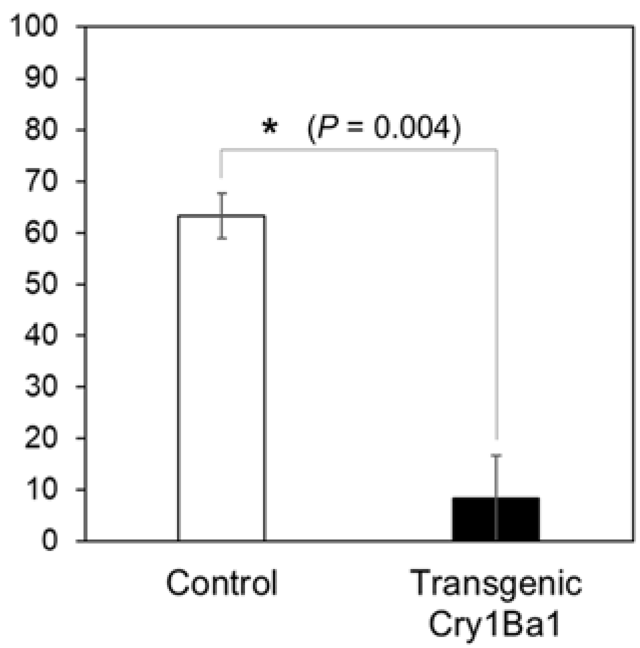
- Lady beetles, spiders, and Tamarixia more abundant in trees without ants

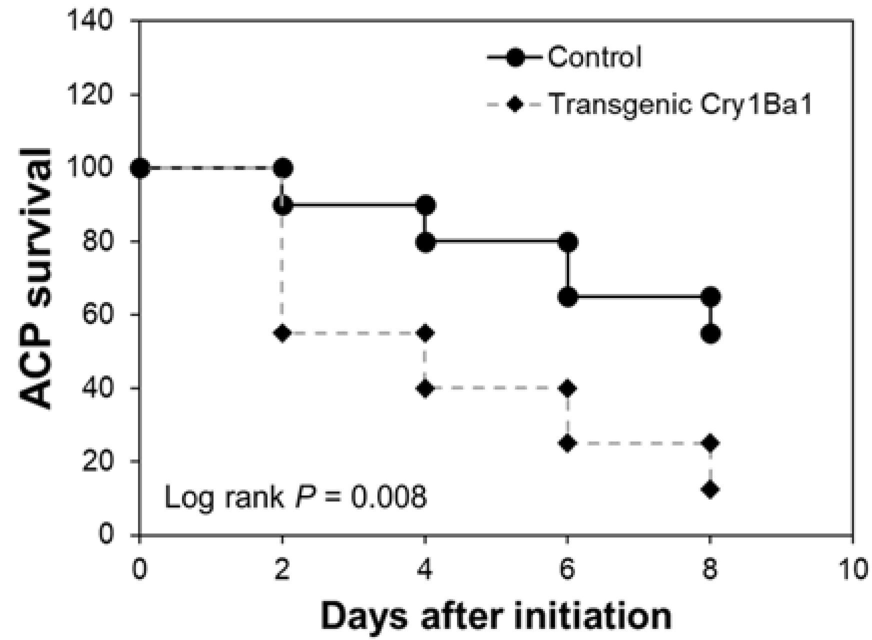
USDA-funded silver bullets Example 1:

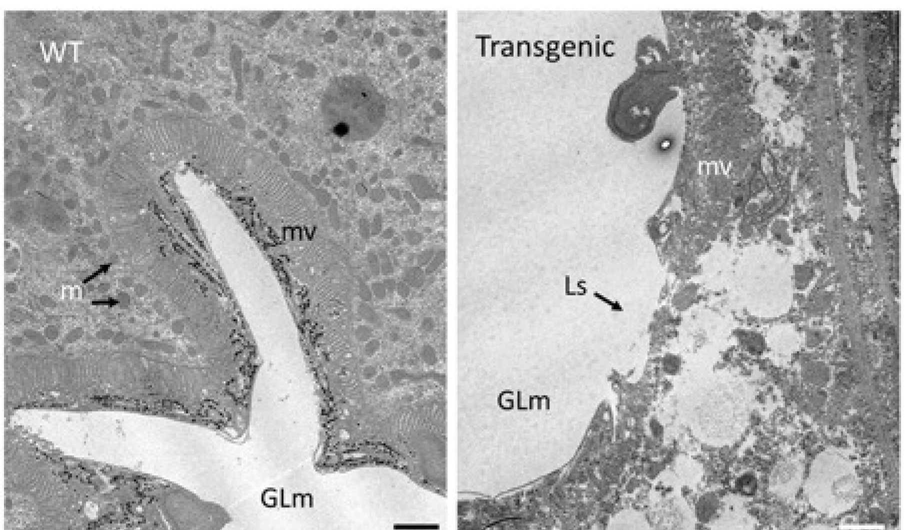
Bt protein + gene silencing RNAs



ACP survival reduced on transgenic plants expressing Cry1Ba1





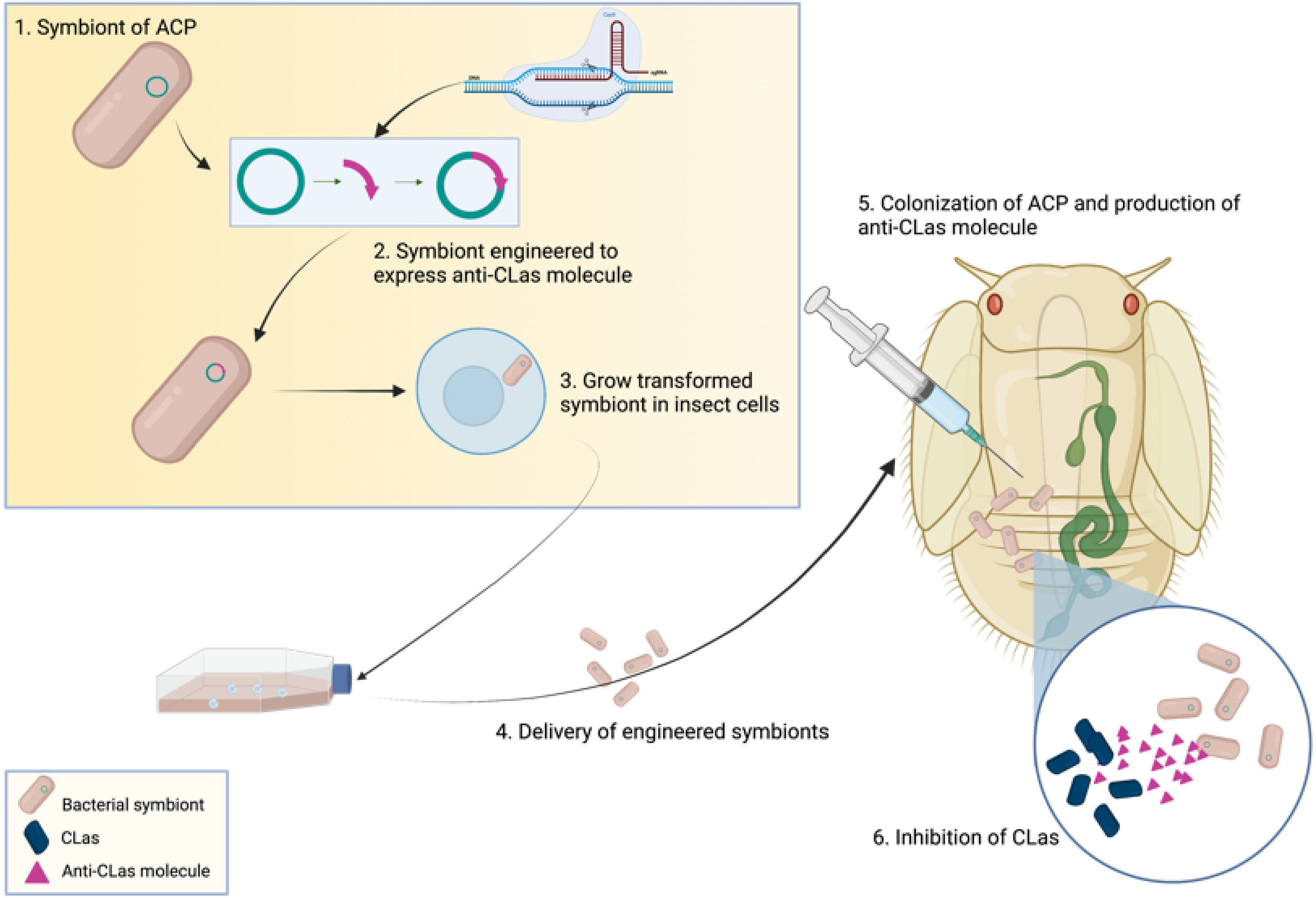


TEM of Cry1Ba1-mediated damage to the gut epithelial tissues of Asian citrus psyllid. The intact microvillar lining of the gut epithelium is evident in ACP fed on WT plants. In contrast, the microvilli of insects fed on Cry1Ba1-expressing *B. koenigii* (Transgenic) were sparse and disrupted with multiple lesions apparent.

Ravanfar et al. 2022. Genetic modification of *Bergera koenigii* for expression of the bacterial pesticidal protein Cry1Ba1. *Frontiers in Plant Science.* 13: 899624.

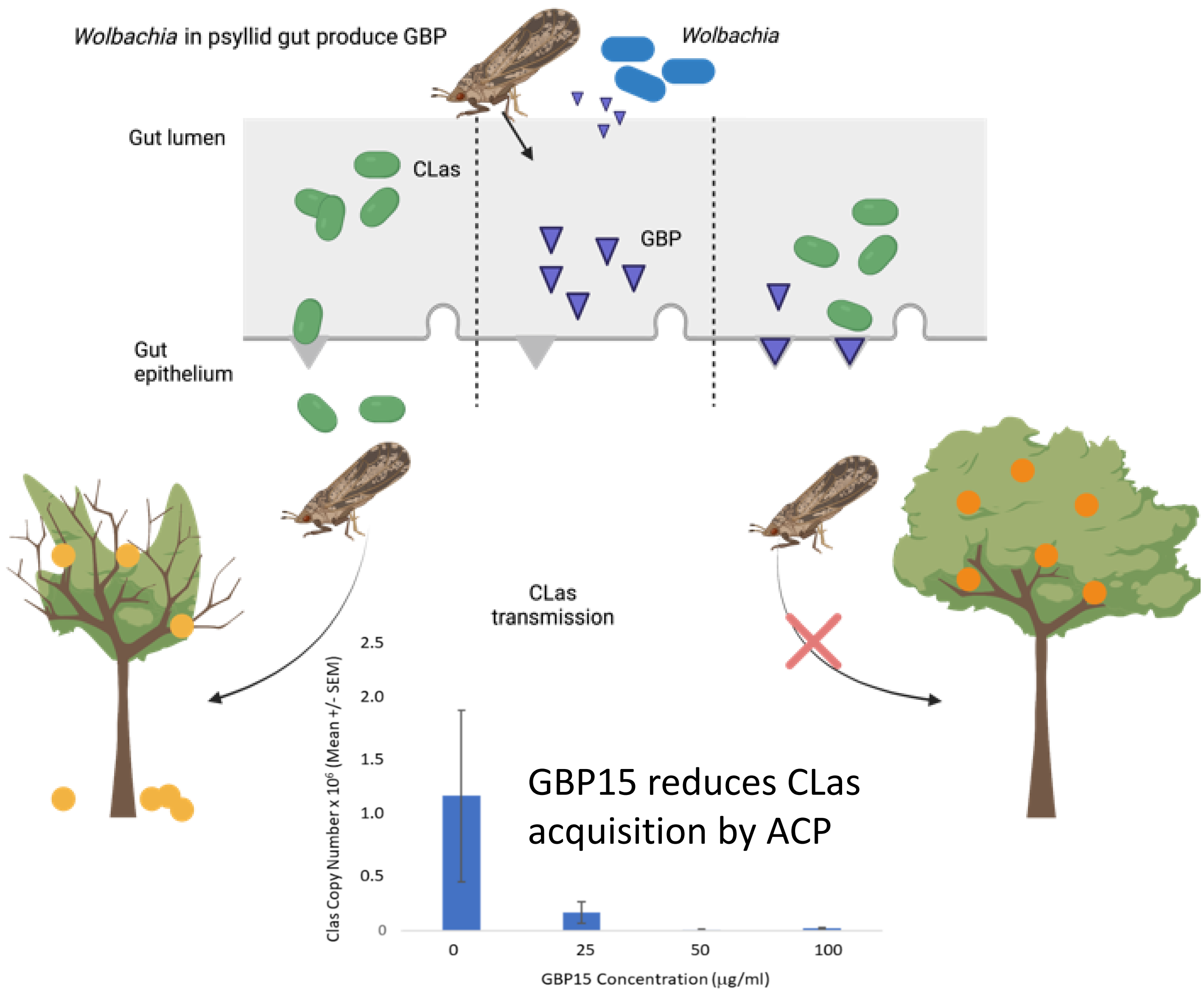
'USDA-funded silver bullets' Example 2:

Reduce transmission by targeting CLas and ACP gut



Pelz-Stelinski et al.. 2019. Genetically modified Wolbachia for biocontrol of insect bacterial disease vectors. US PAT.61094.

Wolbachia as a delivery system for CLas-blocking peptides or silencing RNAs



Managing psyllids while reducing cost

- 0.2 psyllids per tap sample is an effective ballpark threshold in most situations signaling the need to take action (spray)
- Reducing spray frequency from 8 to as few as 3 sprays per year using thresholds had little effect on counts of ACP.
- Management input costs are reduced under economic thresholds (ET-0.5 to ET-1.0) than with monthly calendar-based sprays
- Requires well timed dormant season sprays
- Overall, management savings of more than 100 % occur at highest threshold, which can counter possible yield loss
- Fire ant control improves effect of natural enemies

Funding: Thank you USDA-NIFA and CRDF