What Happened to Citrus Pests Following the Last Major Freeze?:

Xavier Martini, UF/IFAS NFREC

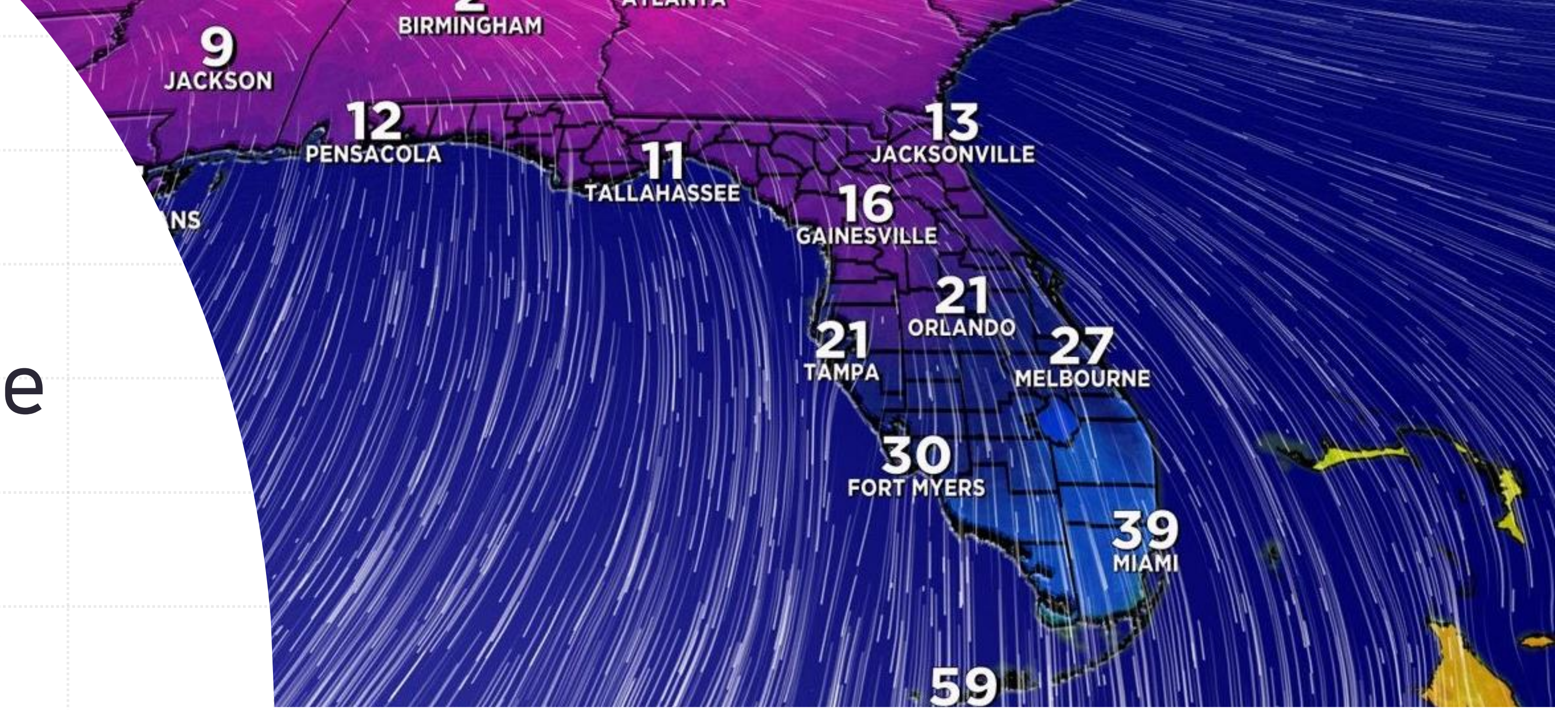
Before we start…

Adult chilli thrips. Photo: Lance Osborne, UF/IFAS

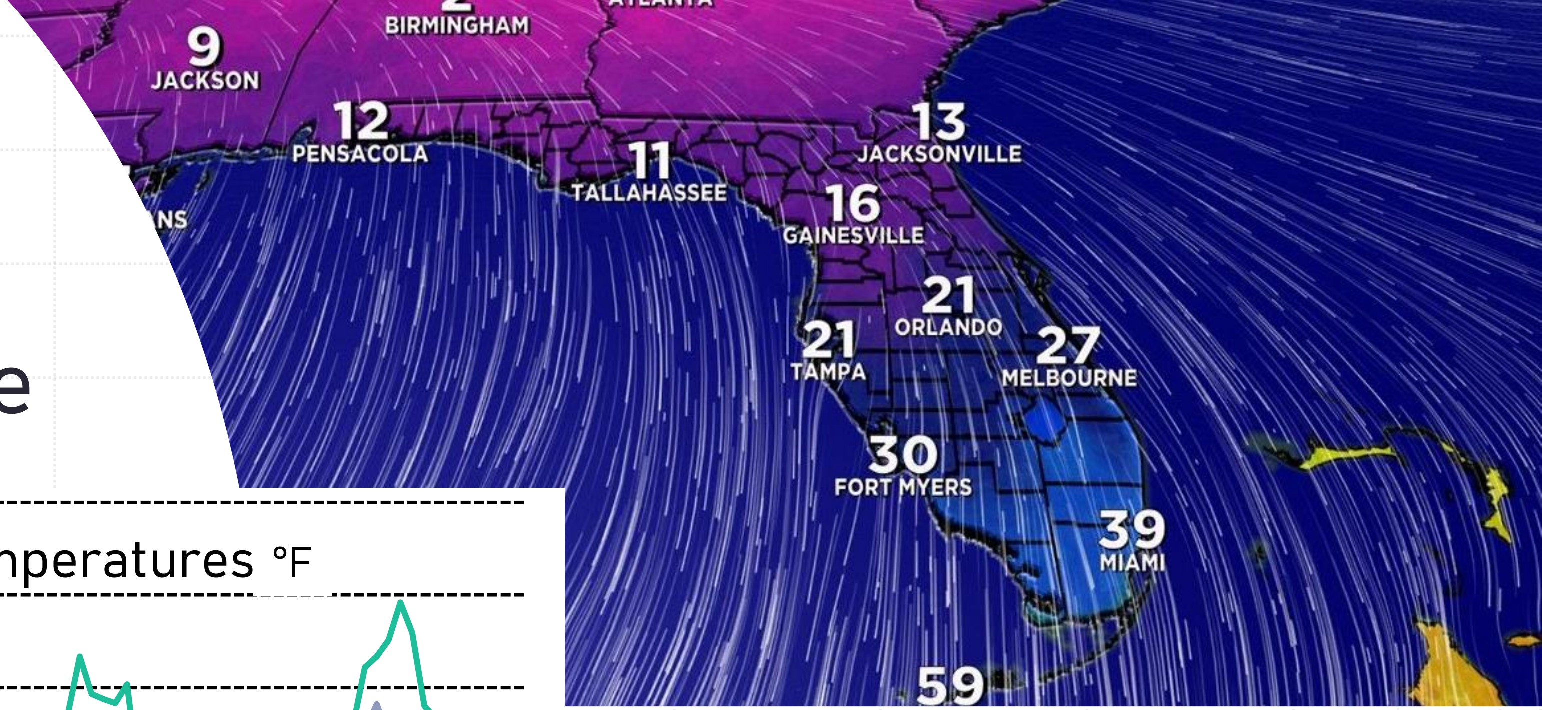
Have you seen these damage on your fruits?

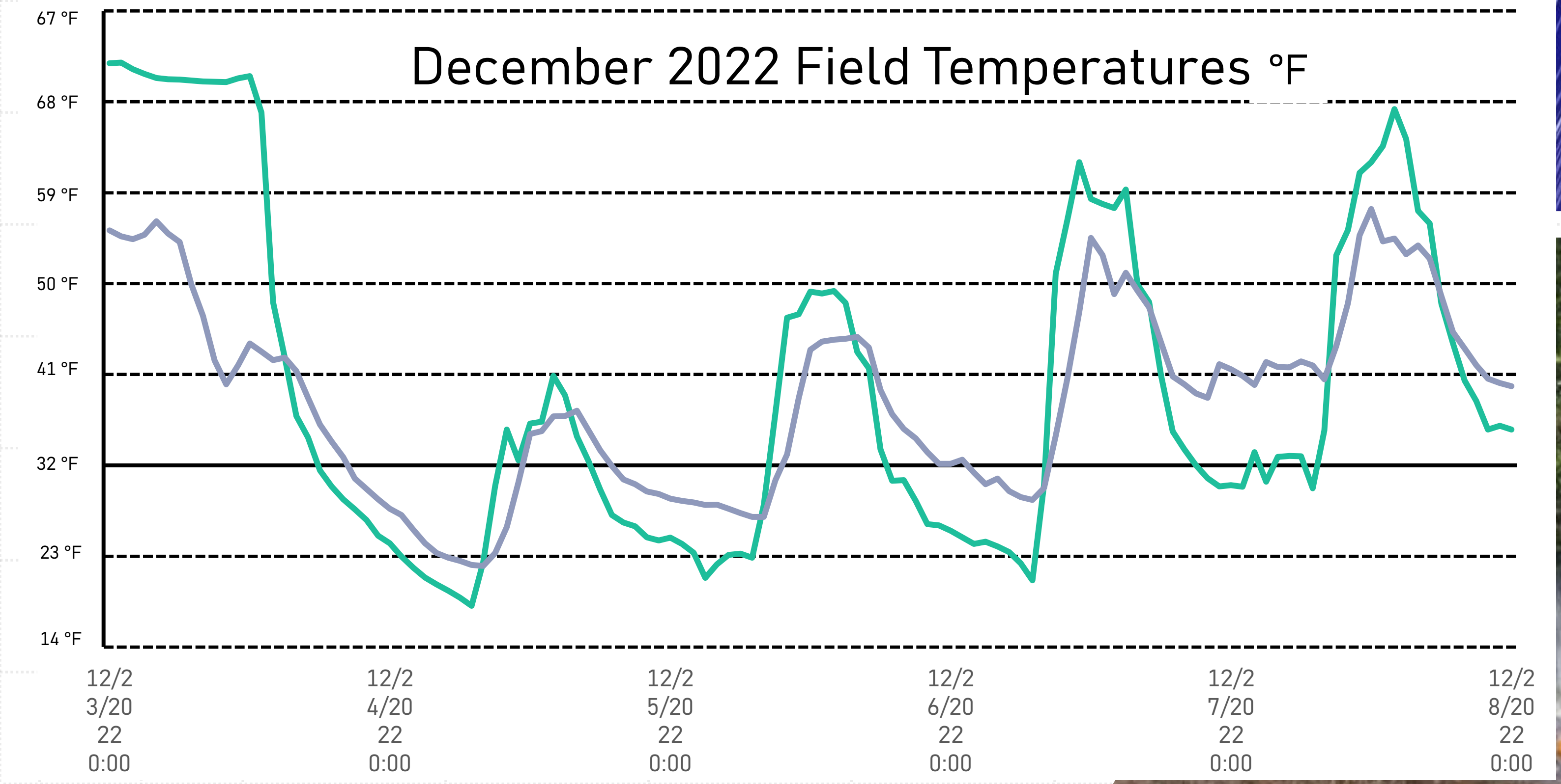
2022 Christmas Freeze

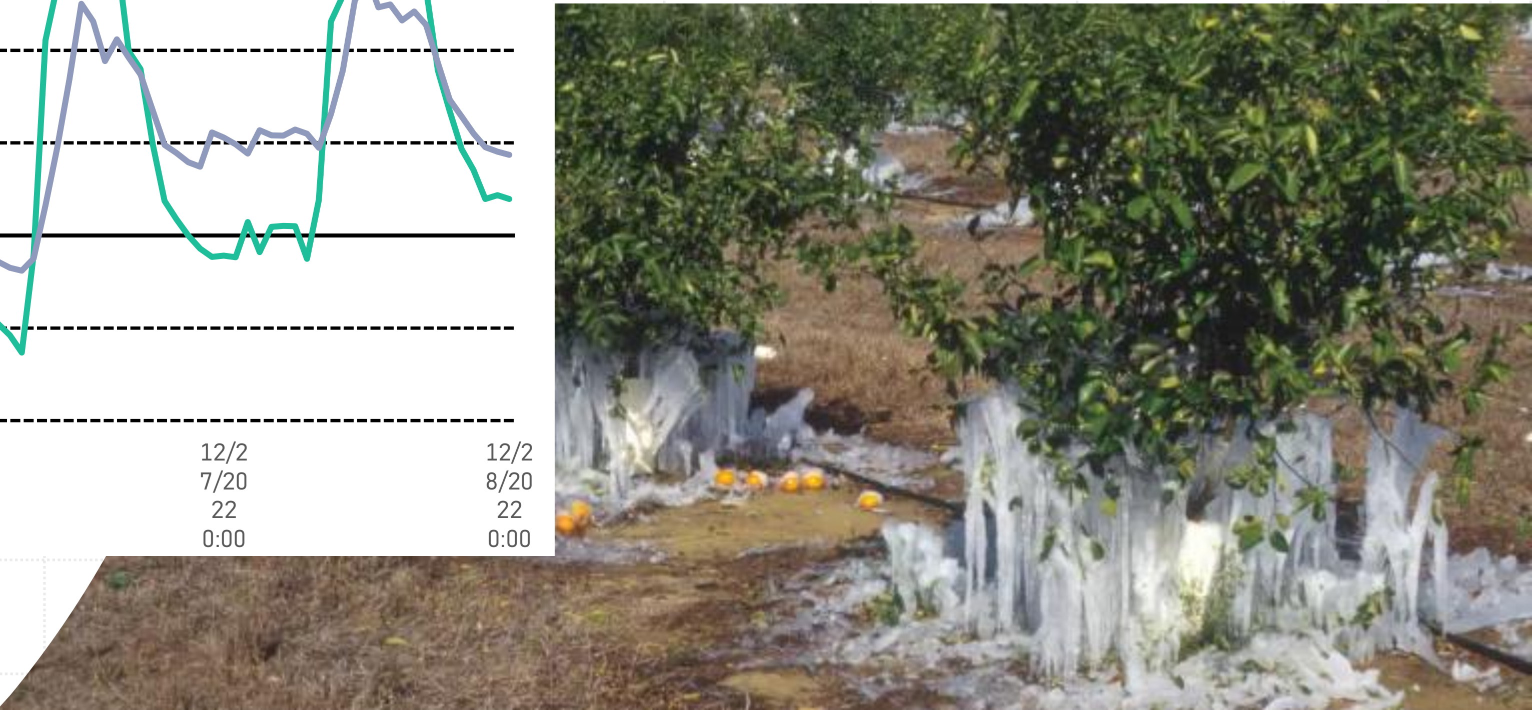
- Extensive freezing temperatures throughout Florida from December 23–27th
- Massive amounts of stress on citrus trees



2022 Christmas Freeze







2022 Christmas Freeze

Insects to look for after the freeze

Pests that may have a step back due to the frost and subsequent defoliation:

- Citrus whiteflies
- Scale insects restricted to leaves
- Rust mites

THE EFFECTS OF THE FREEZE OF FEBRUARY 2-4, 1917 ON THE INSECT PESTS AND MITES ON CITRUS.*

By W. W. YOTHERS, Bureau of Entomology,
Orlando, Florida

WEATHER CONDITIONS AND TEMPERATURES

For more than five weeks prior to February 1st, the weather had been very warm. Many days the temperature reached 85° F., at Orlando, Florida, and on February 1st it reached 86° F., and it was a very sultry, calm day. Between 6 and 8 o'clock p. m., about half an inch of rain fell and there was more or less rain the entire night. The rain was followed immediately by a heavy wind from the northwest, which continued until late Saturday afternoon. It was quite calm, however, Saturday night.

The following minimum temperatures of localities, where examinations were made to determine the conditions of pests, were taken from the U. S. Weather Bureau:

Putnam County, Crescent City	19°F.
Volusia County, DeLand	15°F.
Marion County, Ocala	18°F.
Lake County, Eustis	20°F.
Orange County, Orlando	22°F.
Polk County, Winter Haven	25°F.
Polk County, Frostproof	27°F.
Pinellas County, Pinellas Park	27°F.

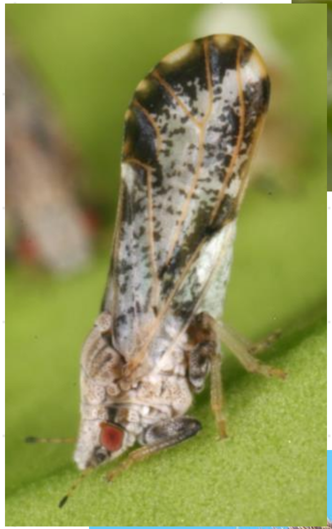
Insects to look for after the freeze

Insects that damage young flush and may take advantage of the frost:

- Citrus leafminers (might be impacted by defoliation)
- Aphids
- Asian citrus psyllid (might be impacted by defoliation and by cold)

Insects that do not rely on leaf for survival may benefit from stressed trees:

- Ambrosia beetles
- Some scale insects



Insects to look for after the freeze

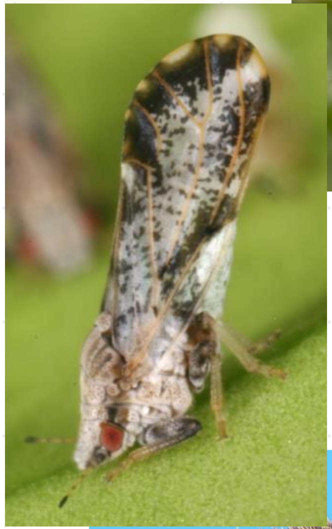
2023 pest monitoring survey:

3 fields:

- NFREC
- Monticello
- Quincy

Residential areas (for Asian citrus psyllids)

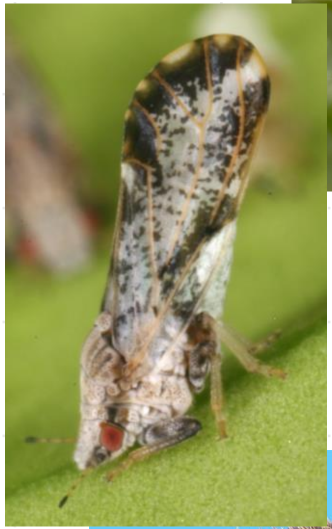
Monitoring from March to November



Insects to look for after the freeze

2023 pest monitoring survey:

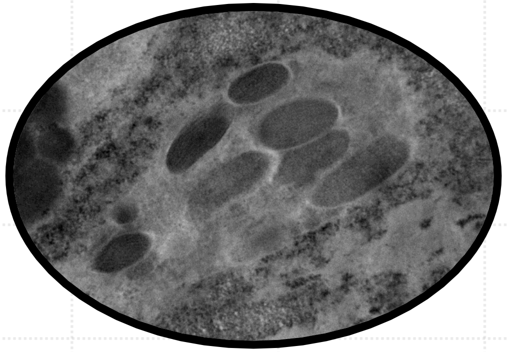
- Asian citrus psyllid
- Citrus whiteflies
- Ambrosia beetles
- California red scale
- Citrus whiteflies



The Asian citrus psyllid

- *Diaphorina citri*, the Asian citrus psyllid. First found in Florida June 1998

- Vector of *Candidatus* Liberibacter asiaticus (CLas) pathogen responsible for Huanglongbing (HLB)



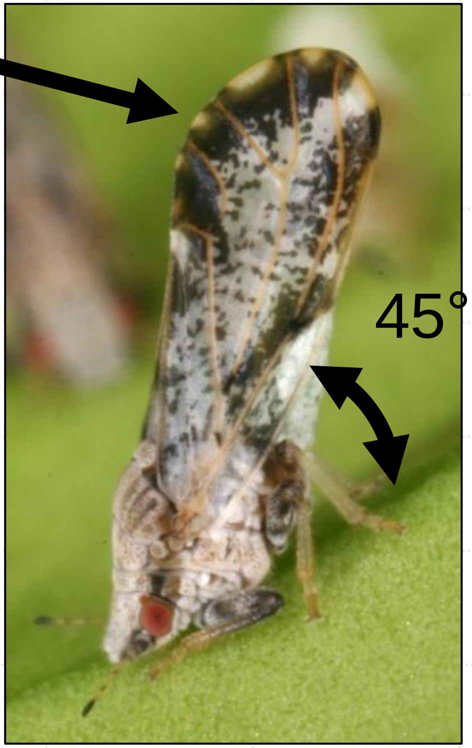
Candidatus Liberibacter asiaticus

Uninfected

The Asian citrus psyllid

- Adults jump when approached
- They sit in a vertical position with abdomen up in the air

Black coloration at the end of the wings



1/10 to 1/6 inches

- Nymphs are always found on new emerging leaves.
- Can be confused with scale insects, but scale insects do not move and do not produce white honeydew.

Flat yellow body

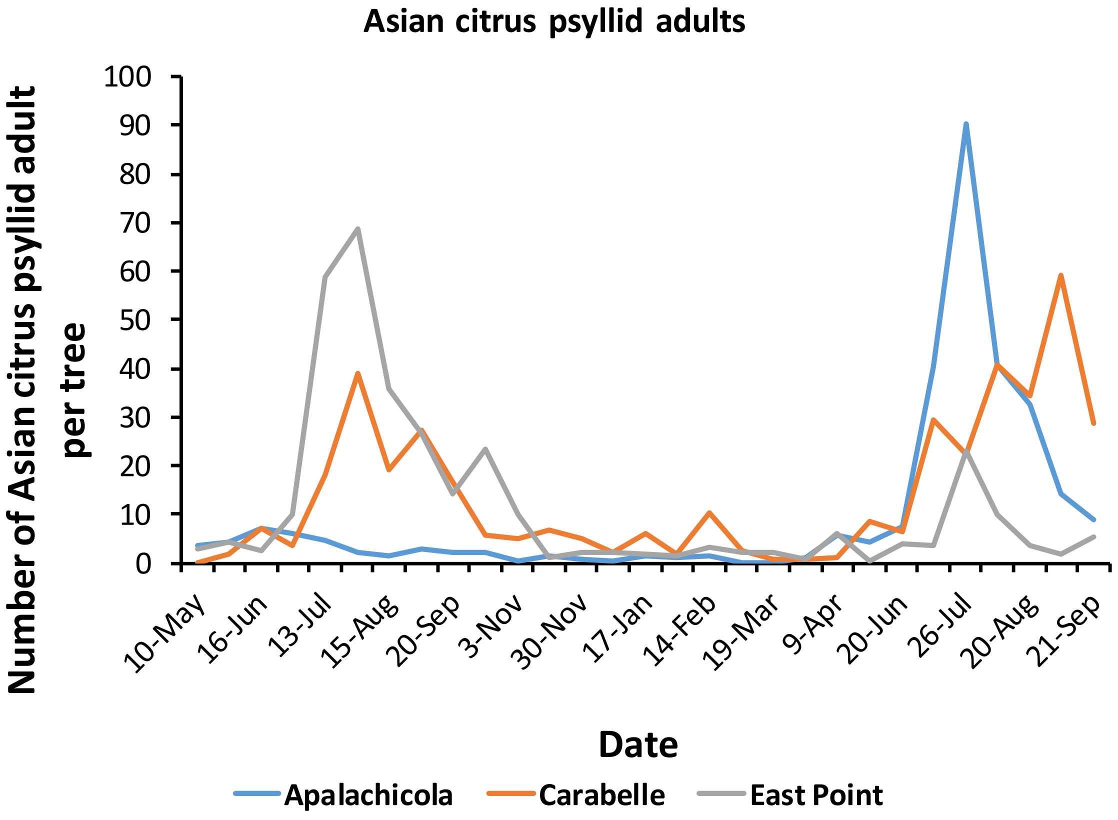
White Honeydew

Leaf distortion

Citrus Greening Disease in North Florida

- Cold hardy satsuma acreage increasing in North Florida, AL, and GA
- Satsumas account for largest citrus expansion in North Florida
- Peak Production is in mid-November
- Peak psyllid population in June-November
- California citrus industry expanding into colder regions
  - Sacramento and San Francisco
  - Faces similar psyllid challenges

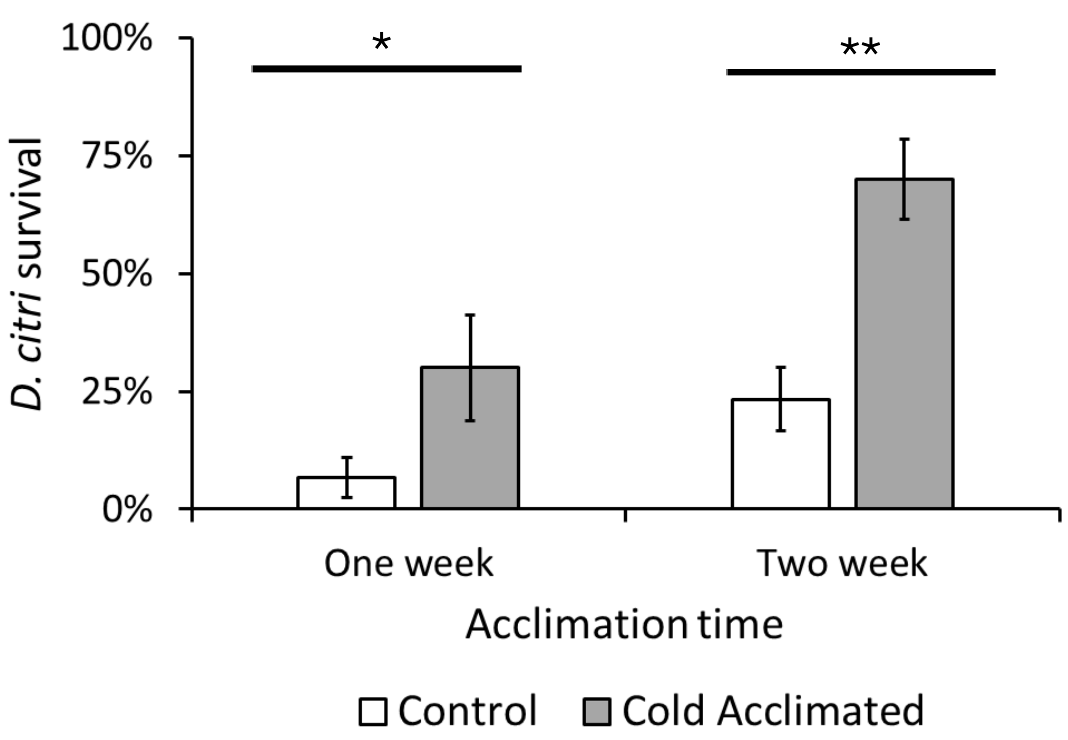
(Martini, X., et al. 2018)



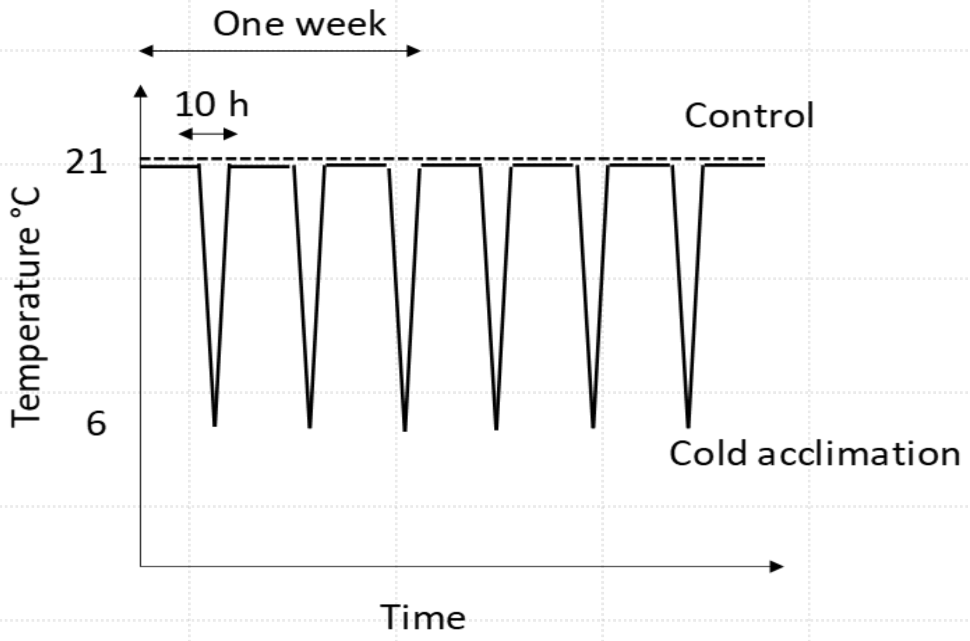
Population dynamic of Asian citrus psyllids in North Florida (Martini, X., et al. 2022)


Female: G/B
Female: W/Y
Male: G/B
Male: W/Y
Fisherbrand
-2.5°C
Control
Temperature Drop

Cold acclimation experiment



Intermittent acclimation



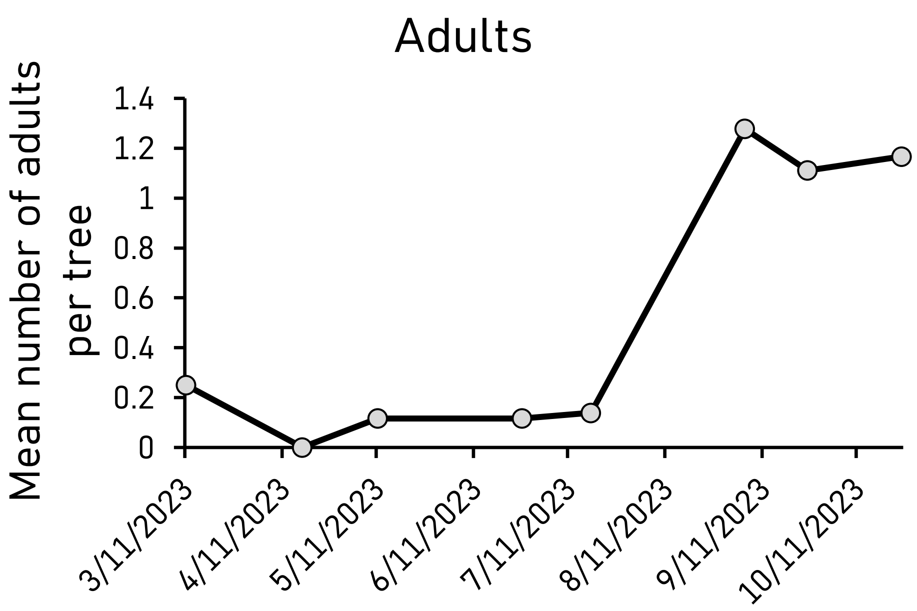
Intermittent acclimation

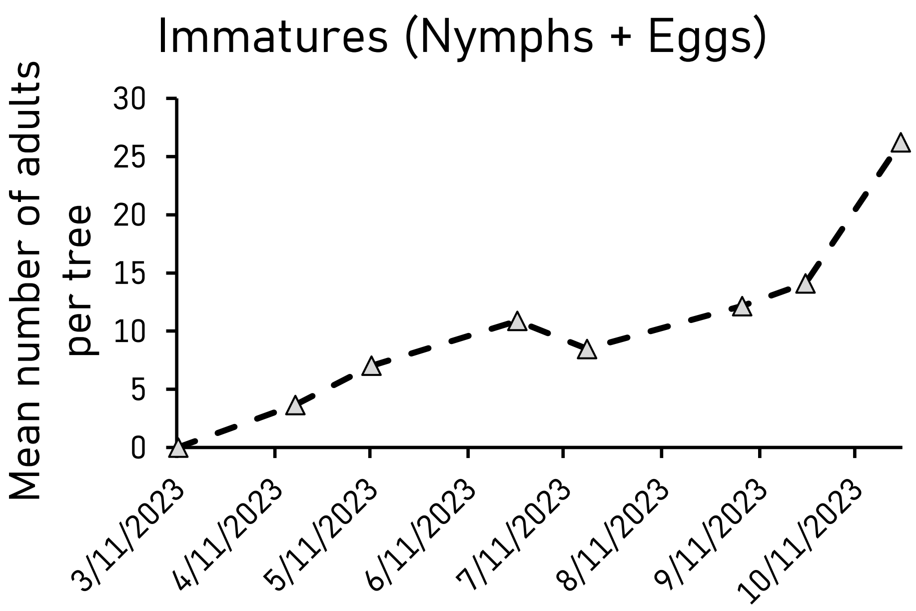
- Observed significant increase in survival rate when temperatures were decreased for intermittent acclimation experiment.
- Survival of treatment group is significant in both week 1 and 2 but does increase after 2nd week.

Field observation during freeze

- 6 sites scouted for psyllids prior to freeze
  - Apalachicola (3), Bristol, Carrabelle, Eastpoint
  - 31 psyllids were isolated for observation in Apalachicola and Bristol

- December 22, 2022:
- 4 consecutive days of freezing temperatures
- January 4, 2023:
  - No psyllids in Bristol survived
  - Only one psyllid (out of 6, 16.6% survivorship) in Apalachicola survived



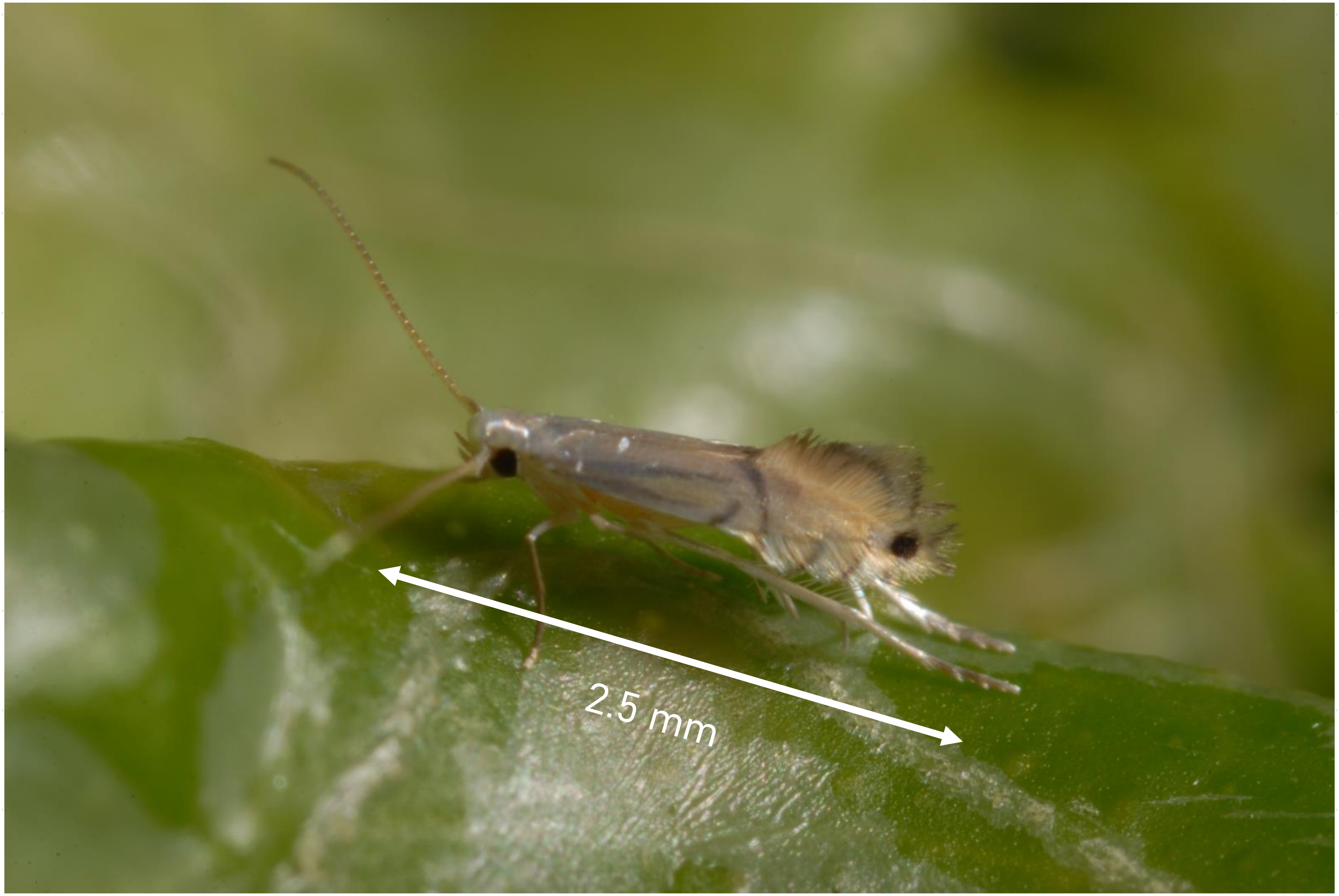


- Despite freezing temperatures for 4 days, adult psyllid population returned to Bristol by April 2023 continues to rise in other sites

- Nymphs and eggs population progressed in Bristol, with an additional site recently found with immatures as well.

Psyllids were found in >80% of the sites surveyed

Citrus Leafminer



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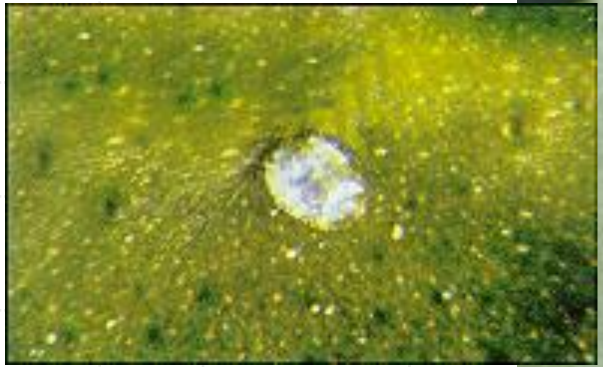
Citrus Leafminer



Transparent and ovoid-shaped egg of citrus leafminer.

- **Adults are active diurnally and in the evenings**
- **Leaf mines are usually on the ventral leaf surface**

- Damage heaviest during flush
- Direct damage greatest to young trees
- Reduced photosynthesis, tree growth
- Mines provide entry for pathogens

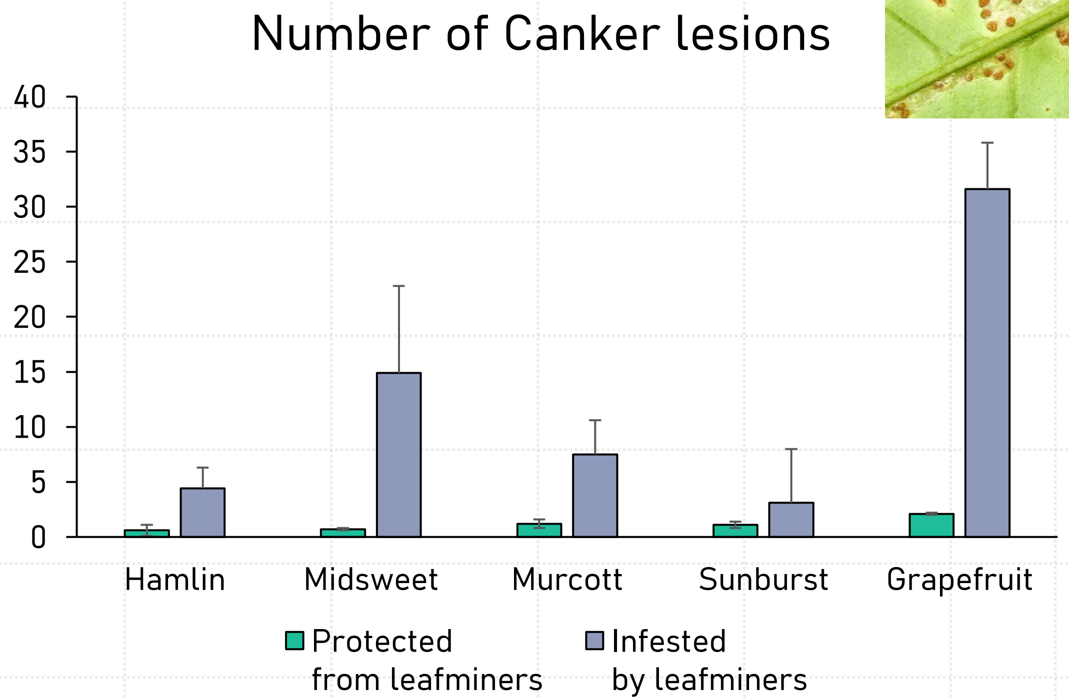
Association of injury with canker

Citrus canker without leafminer lesion

Citrus canker with leafminer lesion

More leaf mines = More Canker

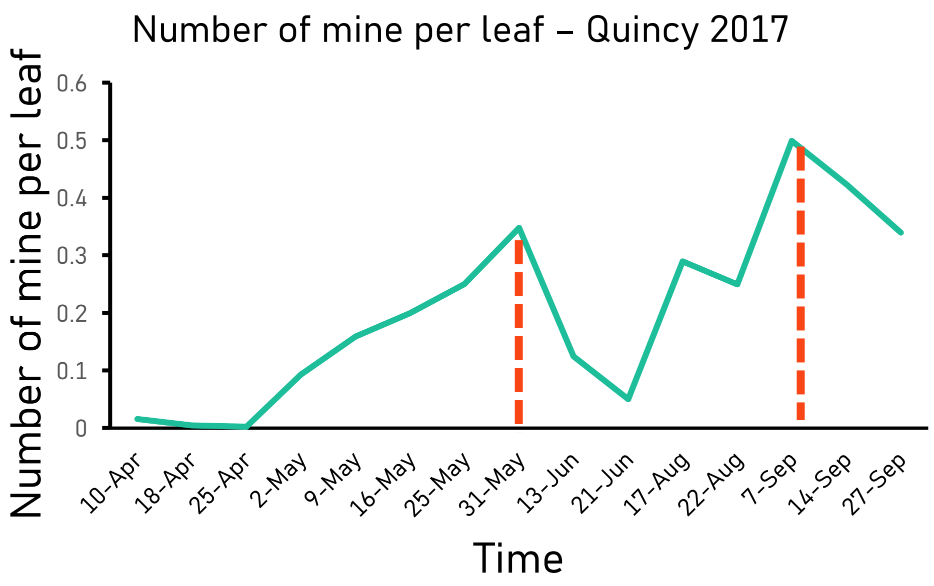
- **Damage heaviest during flush**
- **Direct damage greatest to young trees**
- **Reduce photosynthesis and tree growth**
- **Mines provide entry for pathogens**

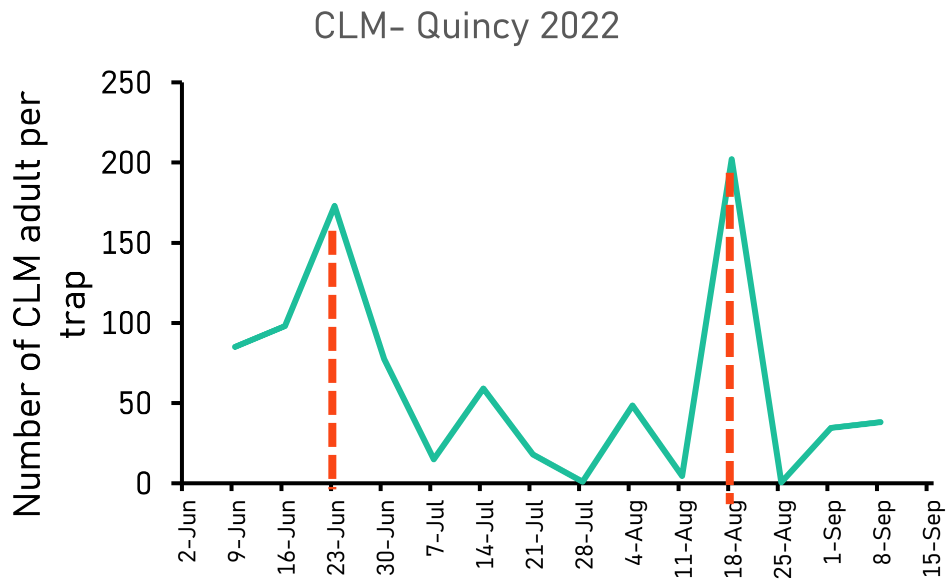


Hall, D. G., Gottwald, T. R., & Bock, C. H. (2010). Exacerbation of citrus canker by citrus leafminer Phyllocnistis citrella in Florida. *Florida Entomologist*, *93*(4), 558-566.

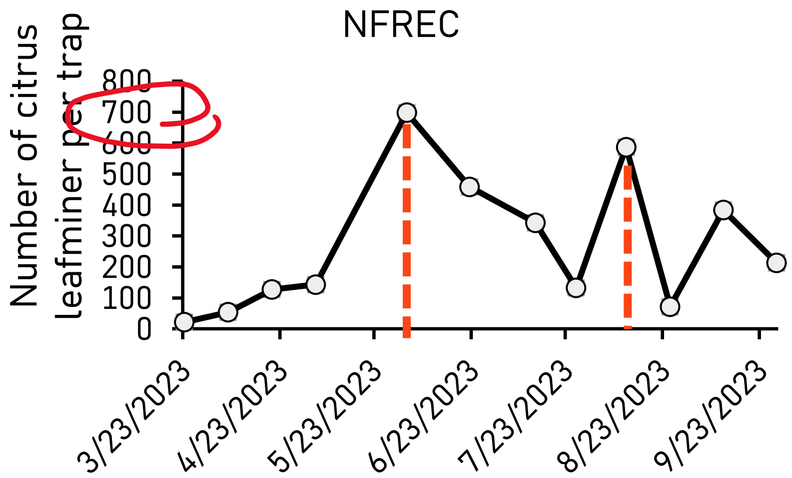
Phenology

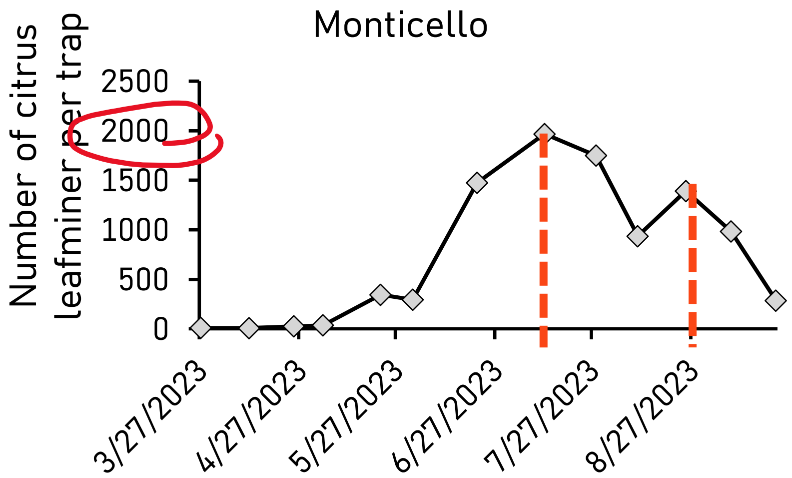
- Population peaks of CLM follow flush cycle.
- Usually, 2 per year
- However, timing can vary

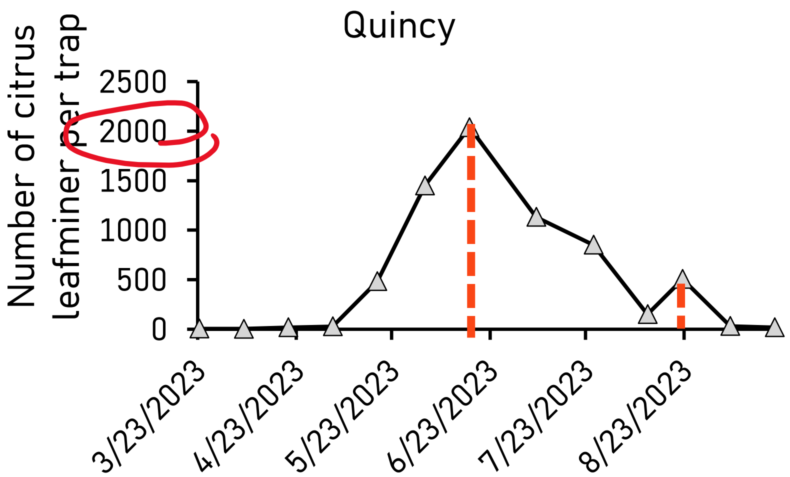




2023 post freeze trapping





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Citrus Leafminer Toolbox

Soil applied neonicotinoid (soil drench) – Mode of Action class 4A

- Clothianidin (Belay 50 WDG)
- Imidacloprid (Admire Pro)
- Thiamethoxam (Platinium)

Soil applied diamides - Mode of Action class 28

- Cyantraniliprole (Verimark)

- Soil drenches are best applied using an applicator metered to deliver 8–10 oz of formulated drench solution per tree.
- Drench applications should be applied directly at the soil-rootstock interface.

Citrus Leafminer Toolbox

Foliar applications

- Spinetoram (Delegate) and Spinosad (Entrust) – MOA class 5
- Abamectin (Agri-Mek) - MOA class 6
- Difubenzuron (Micromite) - MOA class 15
- Methoxyfenozide (Intrepid) - MOA class 18
- Cyantraniliprole (Exirel) – MOA class 28 - if not used in soil application
- Volian Flexi (Thiamethoxam (MOA 4A) + Chlorantraniliprole (MOA 28)), only for bearing tree.
- Agri Flex (Thiamethoxam (MOA 4A) + Abamectin (MOA 6))

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Nonbearing trees

- Effectively controlled in young trees by **systemic insecticides** (neonicotinoides or diamides).
- Soil applications of neonicotinoids should be made about 2 weeks prior to leaf expansion.
- Applications of neonicotinoids should be timed to avoid rain events within 24 hours.
- The appearance of leafminers in young flush of these trees is an indication that residual effects have worn off.
- Foliar applications of products effective against CLM may follow when flush is about halfway extended to kill the maximum number of larvae.

Nonbearing trees

Timing of soil applications of systemic neonicotinoids and cyantraniliprole (Verimark) for small, non-bearing trees

- Soil-applied systemic insecticides are a good option
- These can be applied before leaf flush (10-14 d) because it takes time for the concentration of insecticide to build up
- The duration of control with these (up to 8 week) is often longer than with foliar sprays

Bearing trees

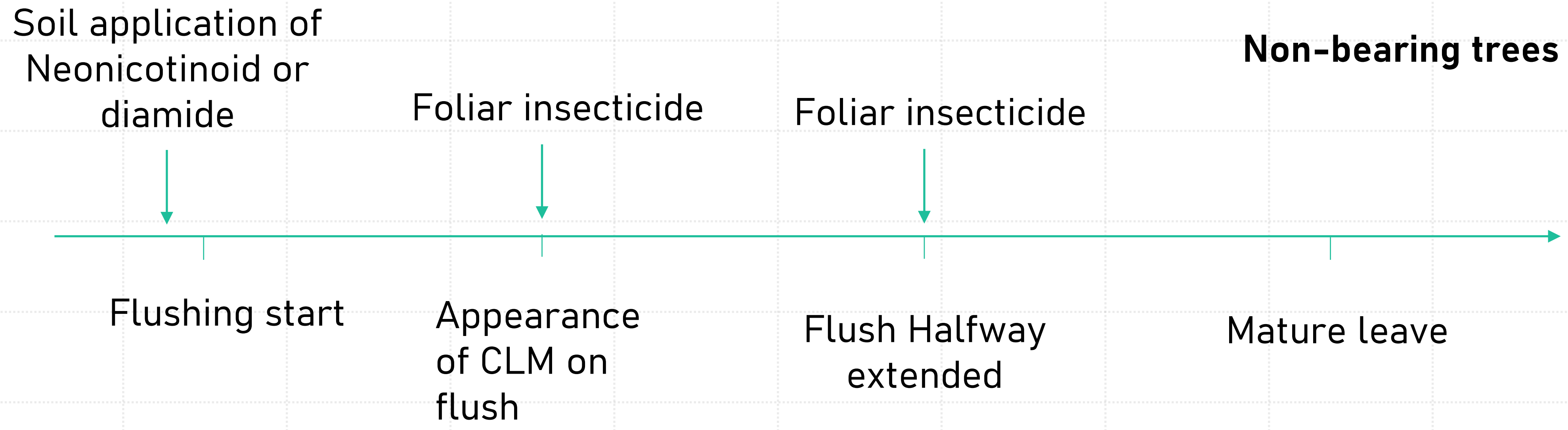
- In the absence of canker, moderate leafminer damage is acceptable on bearing trees, unless they recover from heavy defoliation.

- Since leafminers affect only developing leaves, coverage of peripheral leaves in the canopy with foliar pesticides is enough.

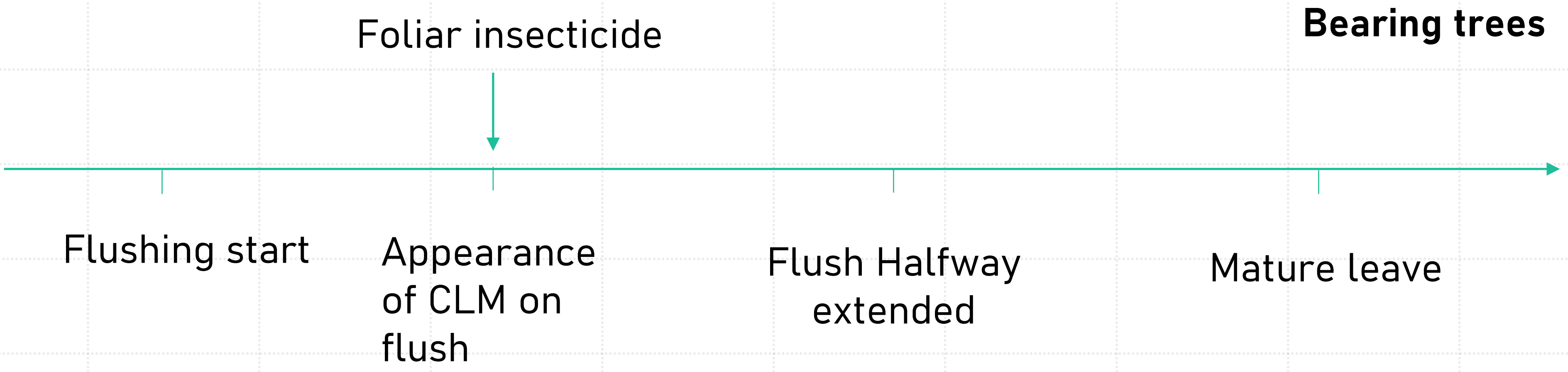
- Foliar sprays are directed against the larvae and should be timed to coincide with the appearance of the first visible leaf mines.

- Foliar applications do not control CLM adults.

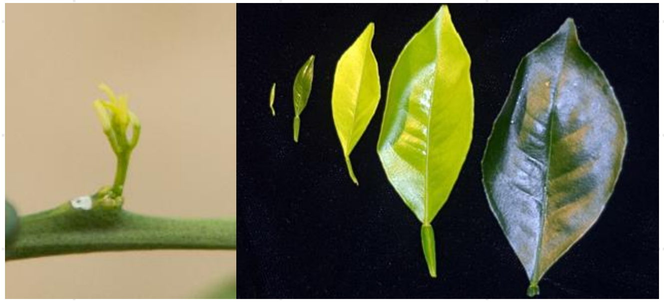
- Pheromone traps are also available commercially to help monitor CLM population trends.



Do not use neonicotinoids or diamide in spray if you already used them in soil application



Timing of foliar application for leafminer control



Days 0 Budbreak

5 First feather leaf 1st egg laid

10 1st larva hatch

13 days from general budbreak is earliest time for application

15 last feather leaf

20 Last egg laid

18 days window

25 First leaf expended

Last larva feeding

Last potential date for leafminer application is 31 days after budbreak

30

Last leaf expended

35

What are Ambrosia Beetles

- Specialized bark beetles; classified as a wood-boring insect
- Play a central role in the nutrient cycling of forest ecosystems
- Derived group of Ips and Dendroctonus beetles
  - Evolved with symbiont fungi to invade the nutrient poor xylem
  - Adults and larvae feed on this symbiotic “ ambrosia” fungus
  - Dependent on the presence of this fungus
  - “Fungus farming” and sibling breeding has evolved separately

Infection cycle

Mature Ambrosia beetle females emerge after mating:

- Seek a susceptible tree as a new host
- Attracted to volatile odors produced by tree
- Female creates new gallery in tree xylem to cultivate fungus and oviposit

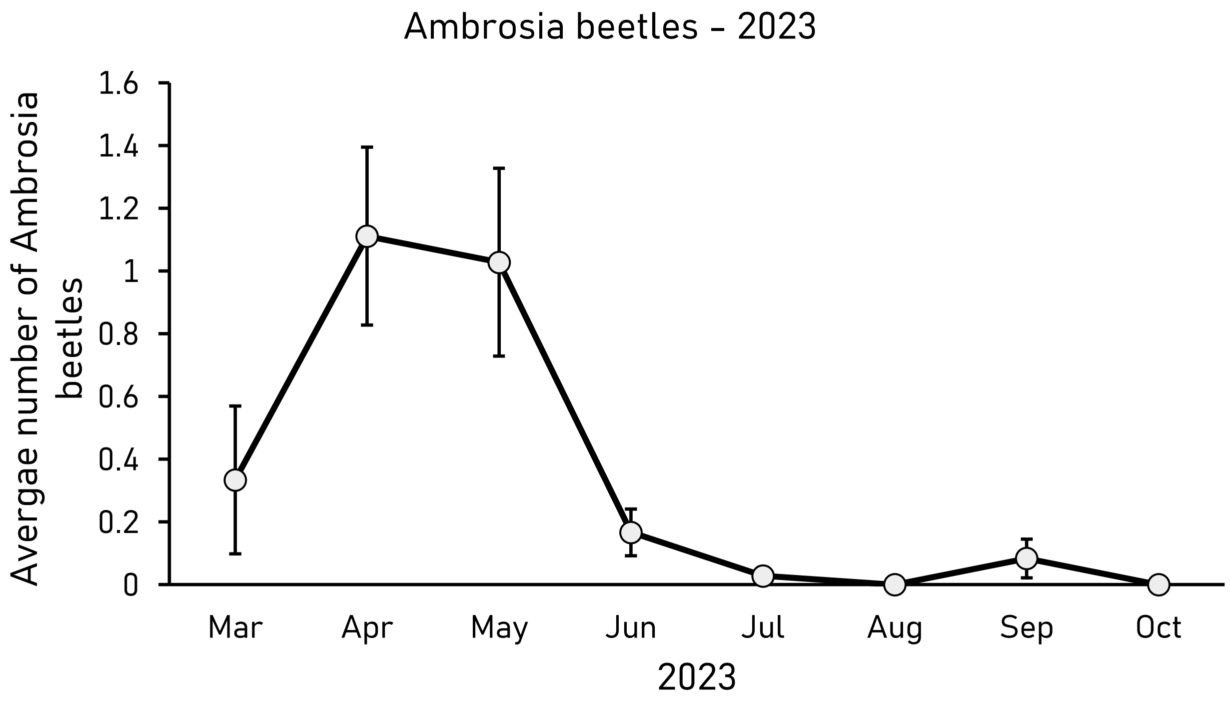
Most Ambrosia Beetles attack weak trees

- Extreme freezes or over pruning can stress trees

Declining & dying trees encourage more attacks

- Other beetle spp. (increased ethanol release)
- Ambrosia beetle population increase


Ambrosia Beetle Collected on Citrus

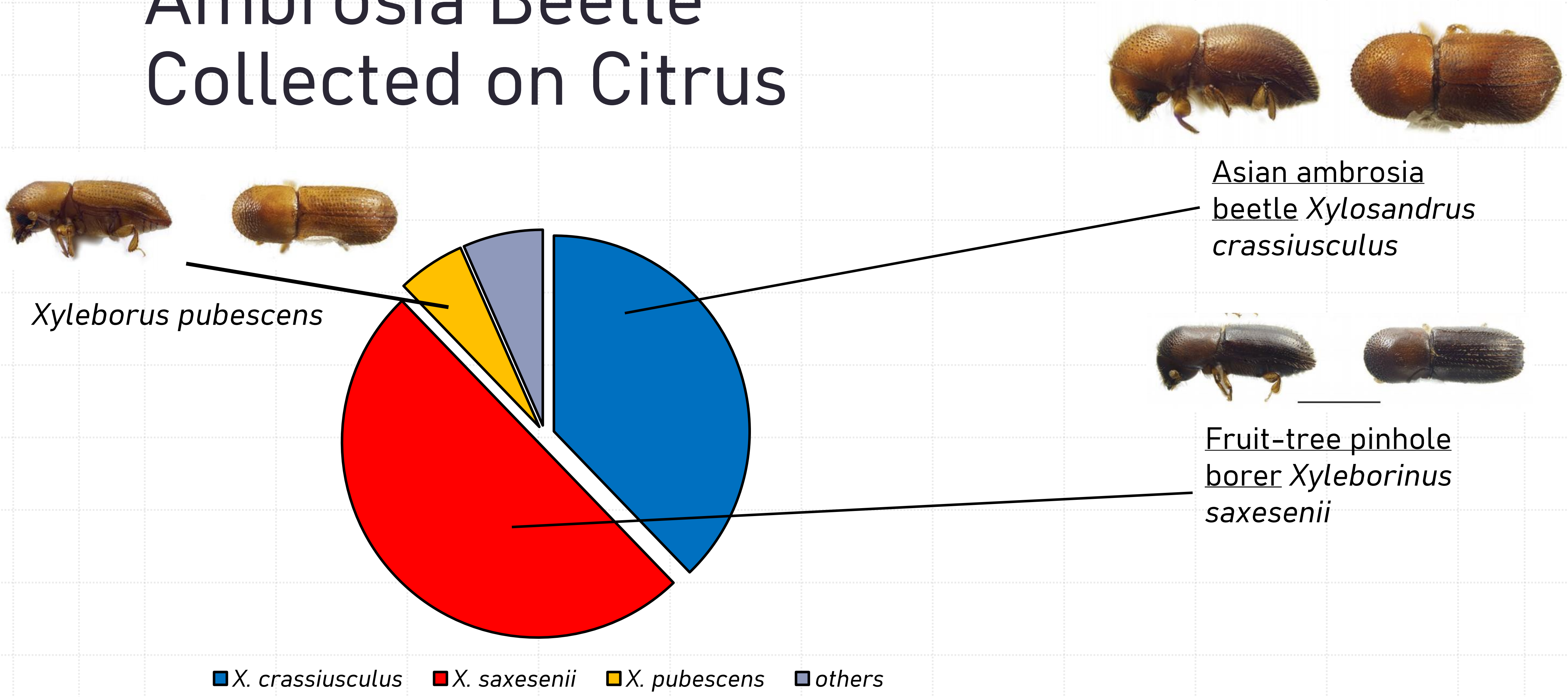


Asian ambrosia beetle

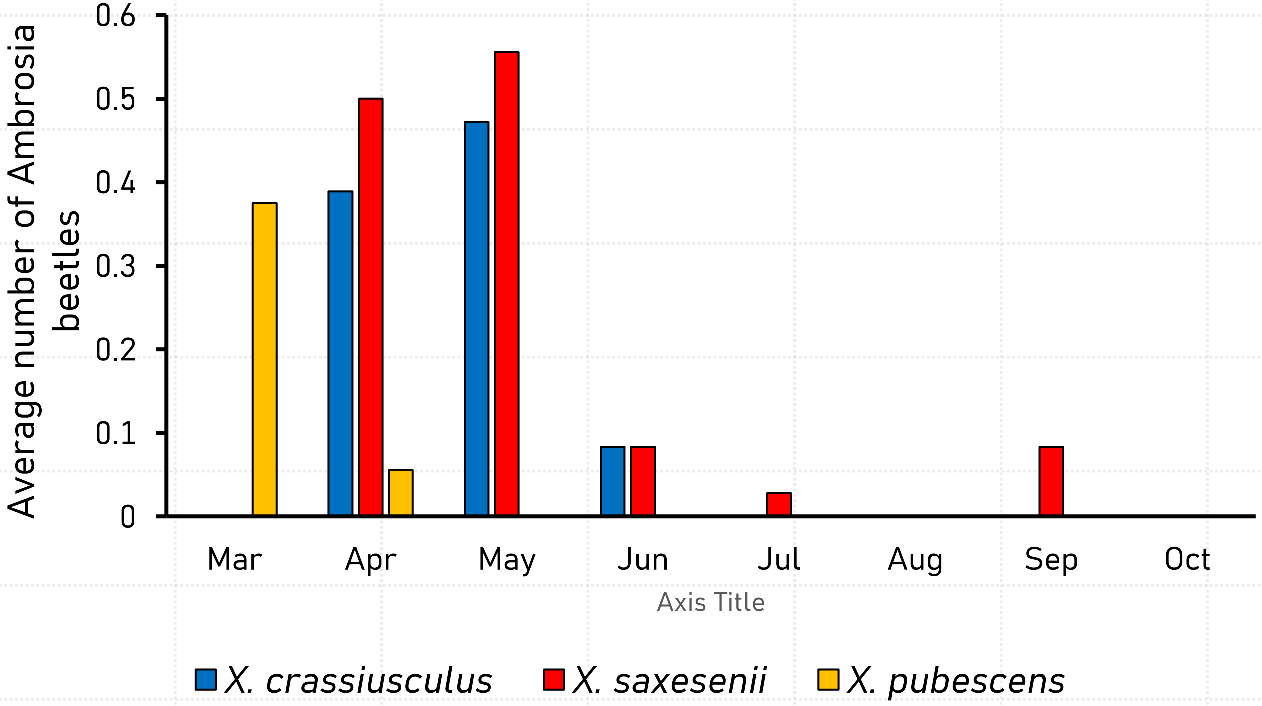
Fruit-tree pinhole borer

Xyleborus pubescens

Ambrosia Beetle Collected on Citrus



Ambrosia Beetle Collected on Citrus

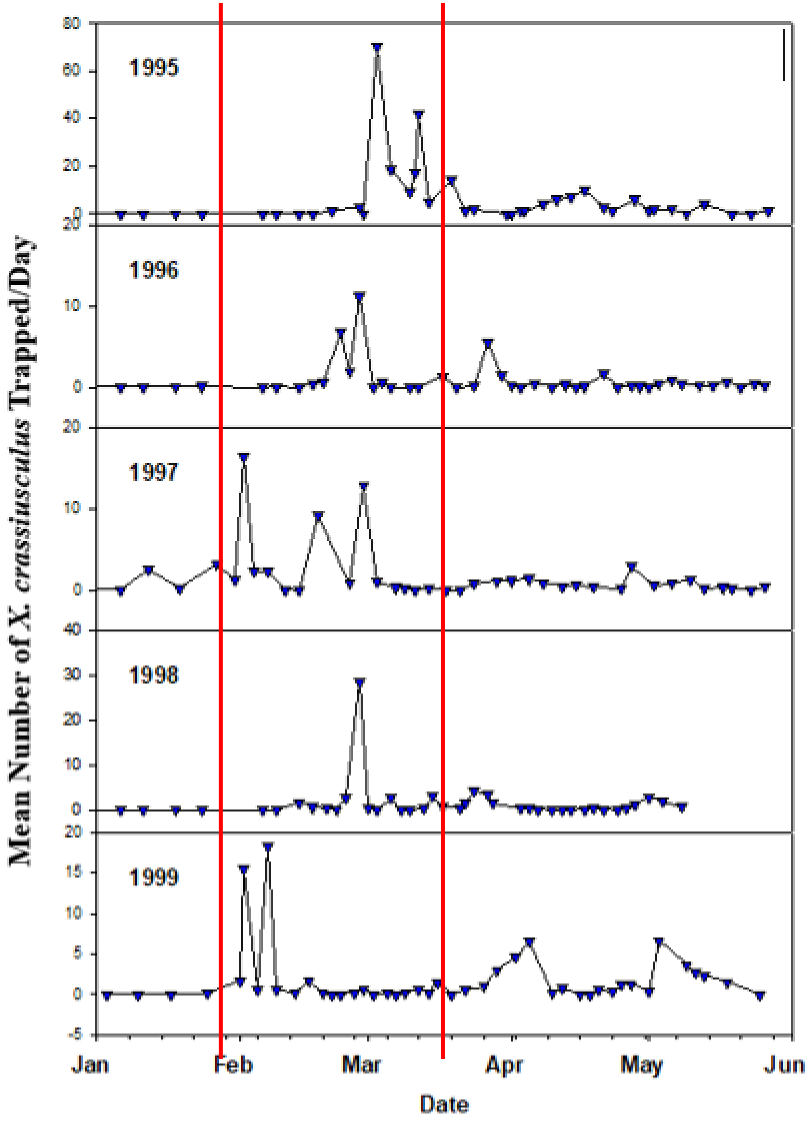


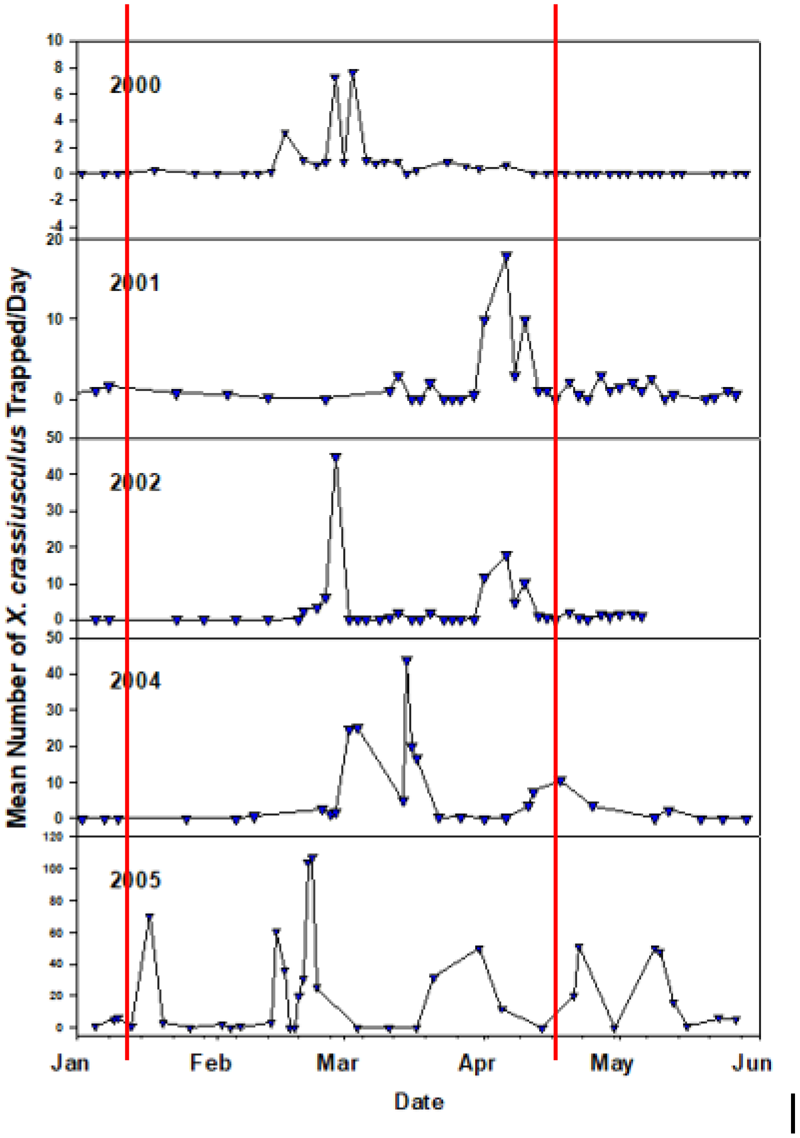
Asian ambrosia beetle *Xylosandrus crassiusculus*

Fruit-tree pinhole borer *Xyleborinus saxesenii*

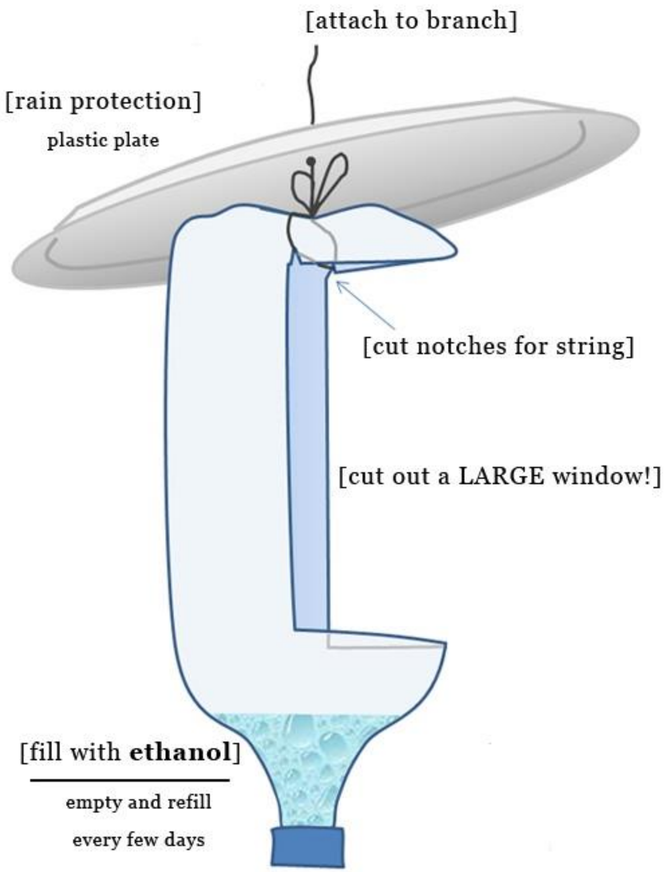
Xyleborus pubescens

Ambrosia Beetle emergence over time in N. Florida





Monitoring



Bottle trap

Looking for frass tubes

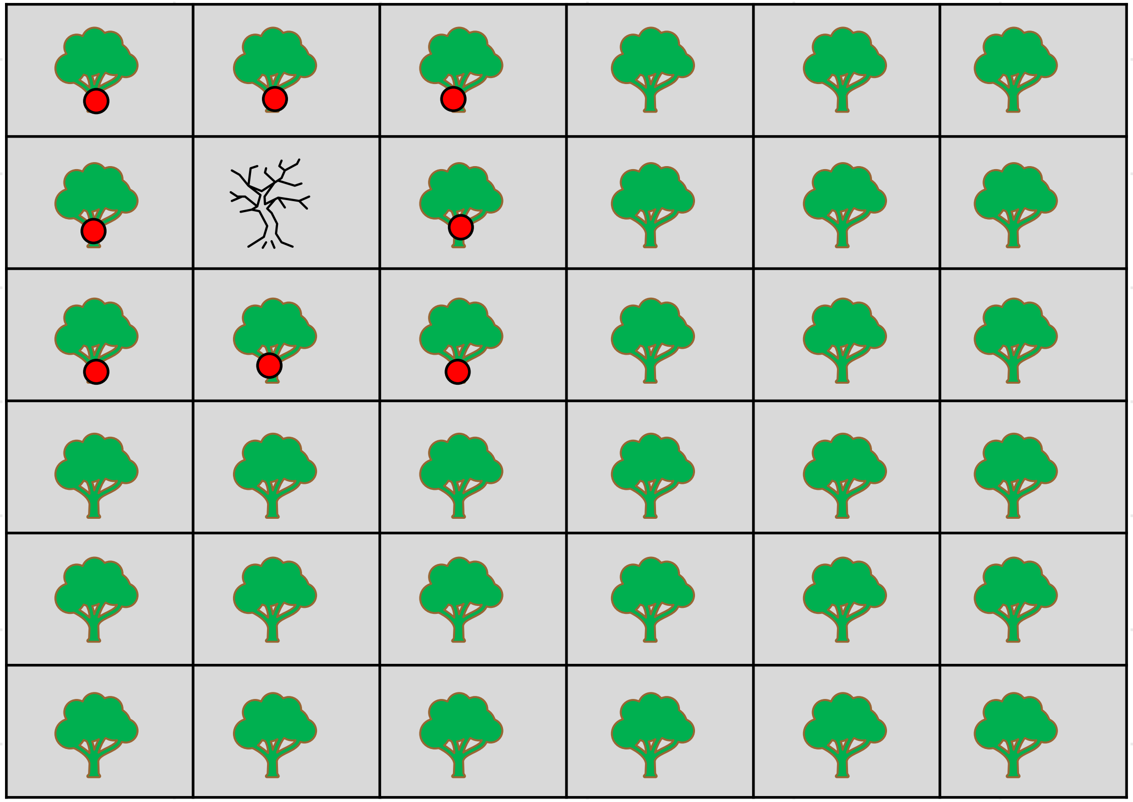
Control methods

- Remove any trees that has been killed by ambrosia beetles

- Use verbenone in pouches (one per tree) or SPLAT® directly applied on the trunk of citrus trees (4 dollops per tree)

- Spray of pyrethroids on the base of trees also provide a repellent effect

Control methods

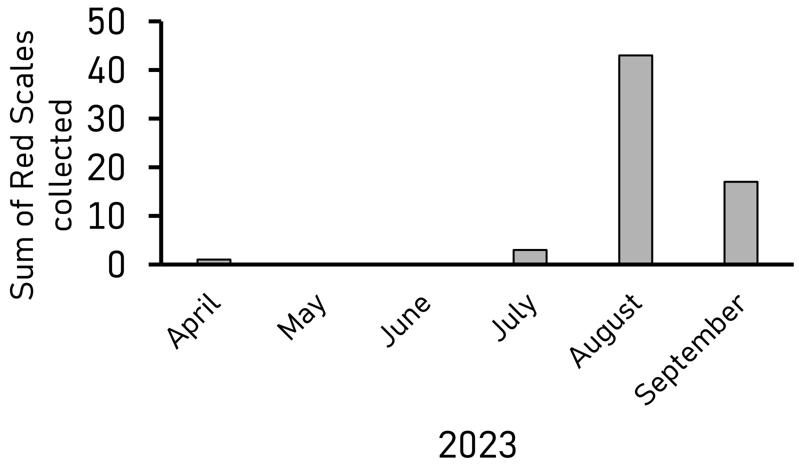


Only treat with verbenone or pyrethroids the trees next to the infested one.

Ambrosia beetles are poor flyer and usually do not disperse fast

Other pests

Red scales – Rare – 64 in 6 months

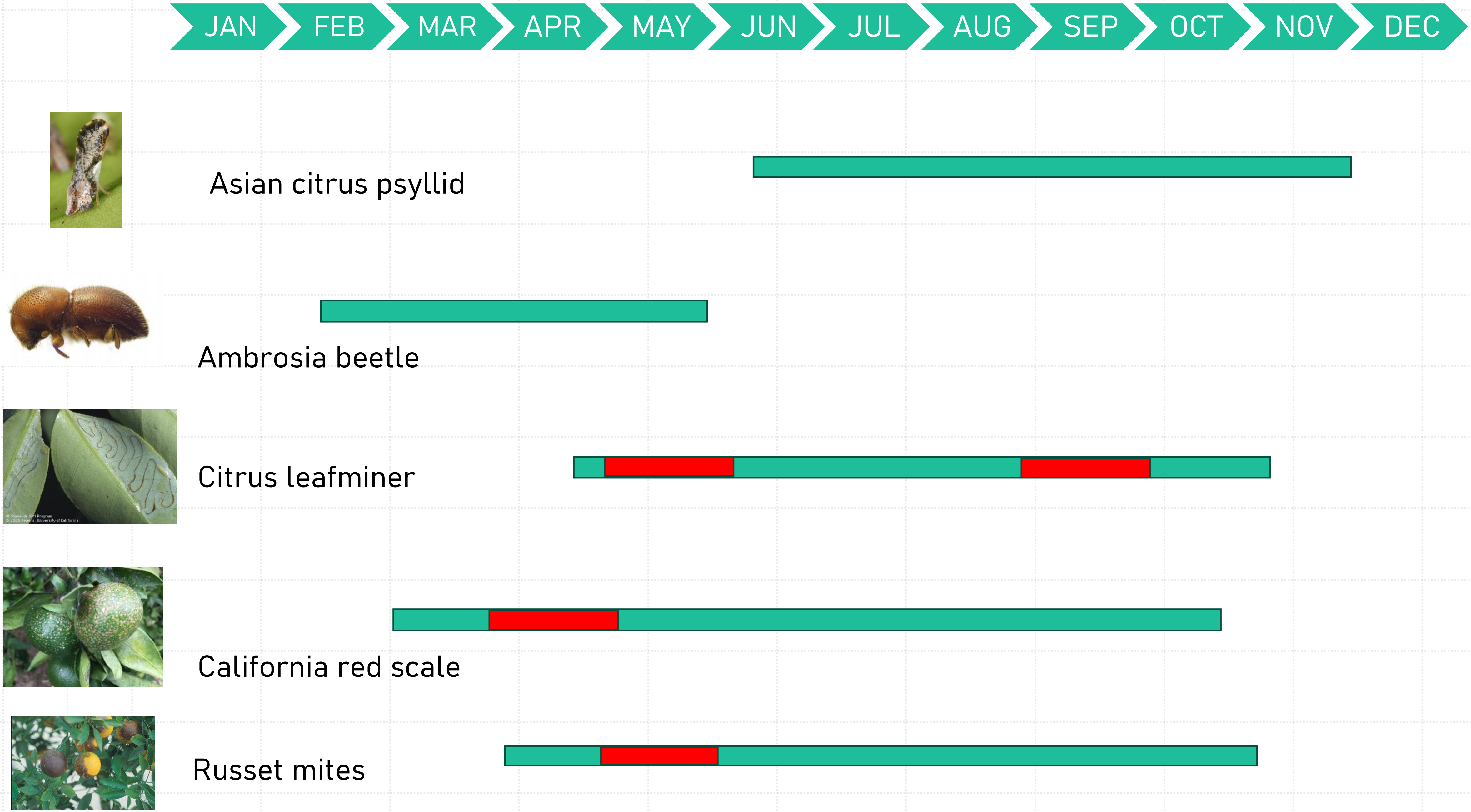


Other pests

Peach aphids – only found in March in low density

Other pests

- Citrus whitefly– absent


JAN
FEB
MAR
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DEC
Asian citrus psyllid
Ambrosia beetle
Citrus leafminer
California red scale
Russet mites

Acknowledgments

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- Derrick Conover (PhD)
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- Romain Exilien (PhD)
- Kathi Malfa (MS)
- Hellenah Kunga (MS)
- Thomson Paris (Postdoc)
- Daniel Crook
- Adnise Christophe
- Keith Johnson

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