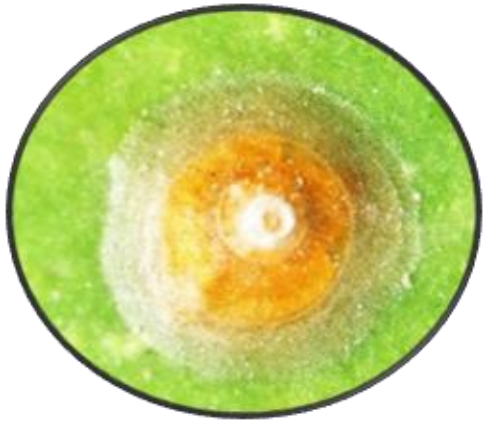
Integrated management of *Aonidiella aurantii* and *Planococcus citri*



Sandipa Gautam, Ph.D.

Area Citrus IPM Advisor

UCANR, UCIPM Statewide Program Operations

Seminaro Manejo Integrado De Plagas Emergentes En Citricos

March 25, 2026

UC IPM

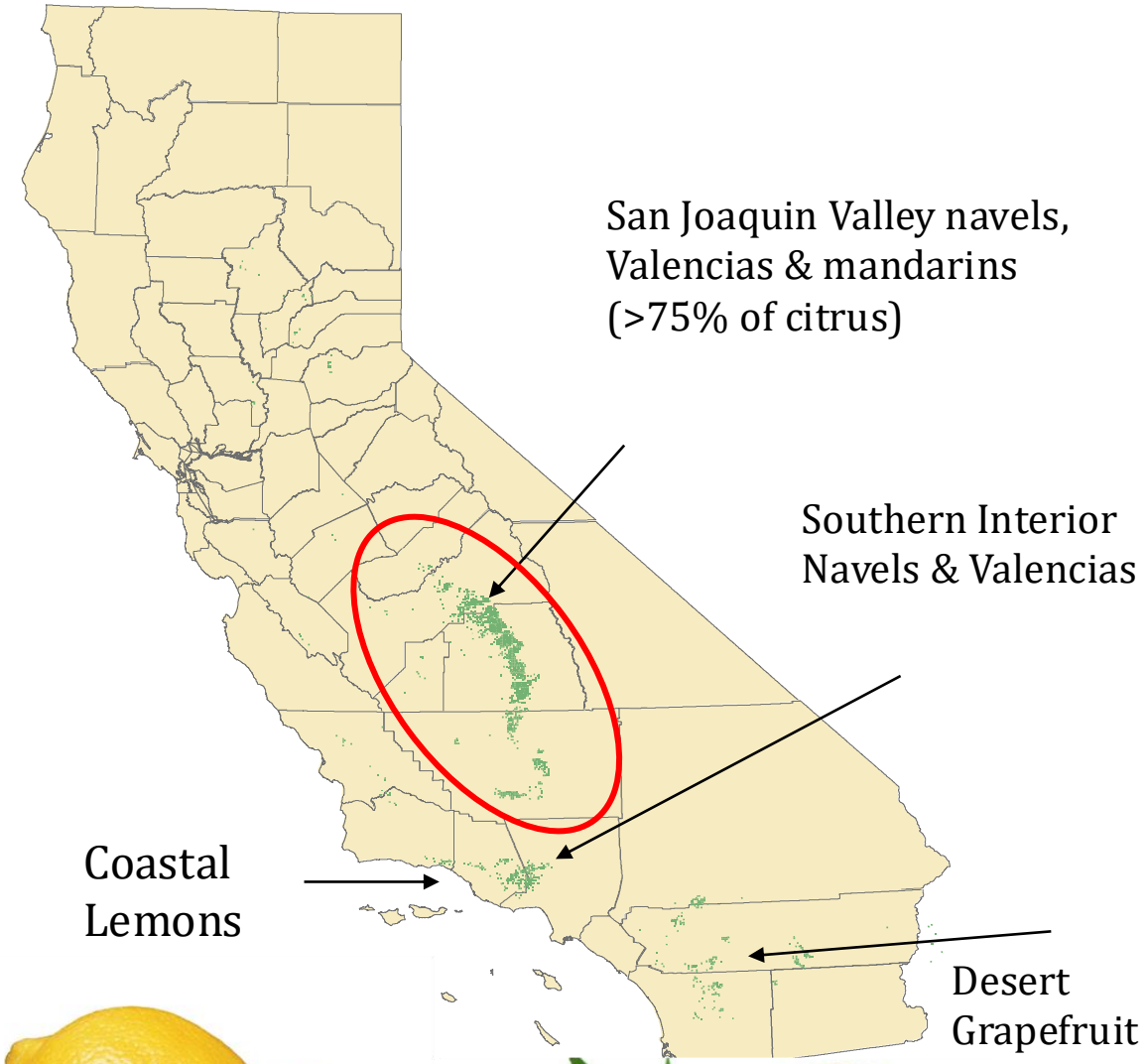
UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

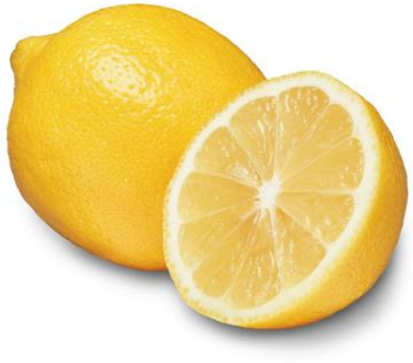
Outline

- Background
- California red scale IPM
    - Biology and Monitoring
    - Current Management Practices and Challenges
- Citrus mealybug IPM
    - Biology Monitoring
    - Current Management Practices and Challenges

California Citrus

- Four distinct citrus growing regions
- 268,376 acres citrus in CA (108,608 hectares)
- Orange (navel/Valencia), lemon, grapefruit, mandarin, lime
- $3.4 billion farm gate value; economic impact on California's economy: $7.1 billion





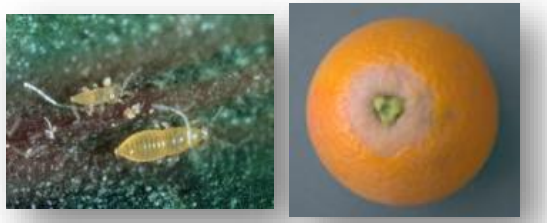
Citrus Pest Management Navels & Mandarins

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Cosmetic damage

Citrus Red Mite, *Panonychus citri*

Citrus Thrips, *Scirtothrips citri*



Forktailed Bush Katydid, *Scuddaria furcata*

Citrus cutworm, *Egira curialis*

Yield damage

California red scale, *Aonidiella aurantii*

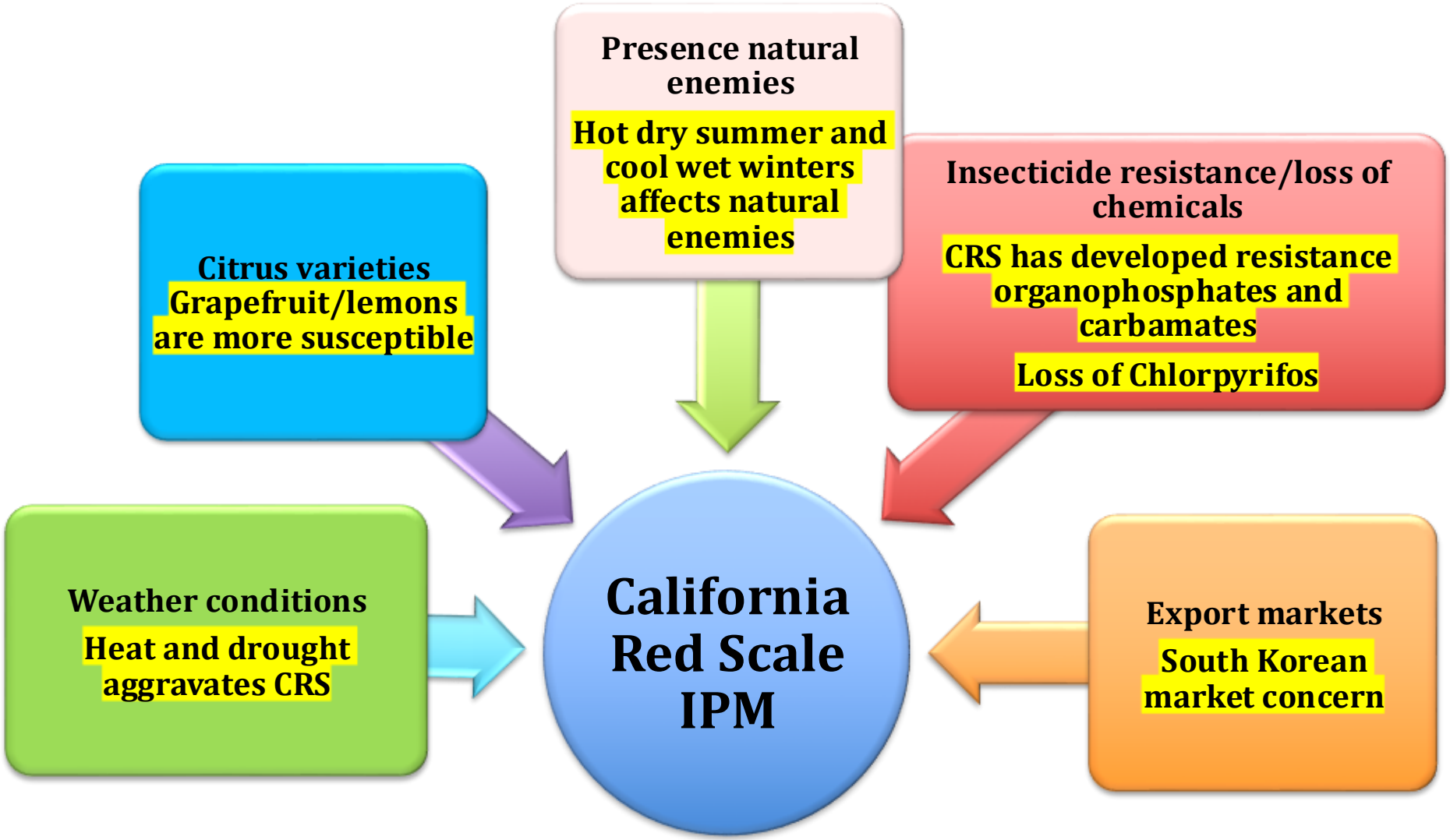
Citrus mealybug, *Planococcus citri*

California Red Scale

Aonidiella aurantii

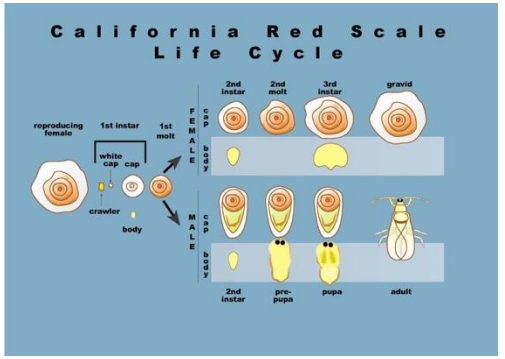
- Sap-sucking insect
- Attacks all parts of trees including fruit
- Downgrading of fruit and yield loss
- Export issue in Korea

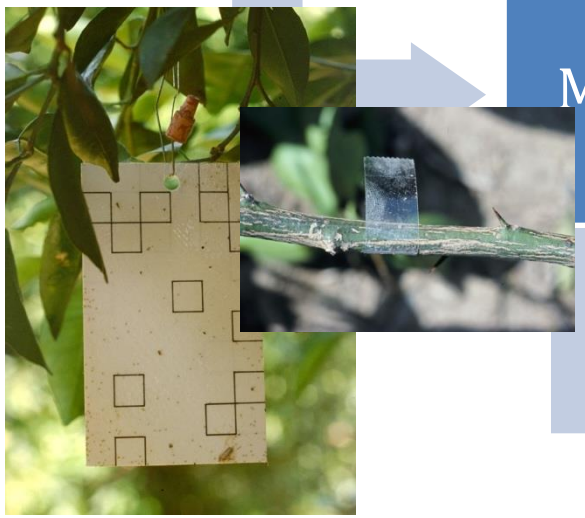
Pest management program shifts/evolves along with the factors influencing it.



California Red Scale IPM

Biology and Seasonal phenology



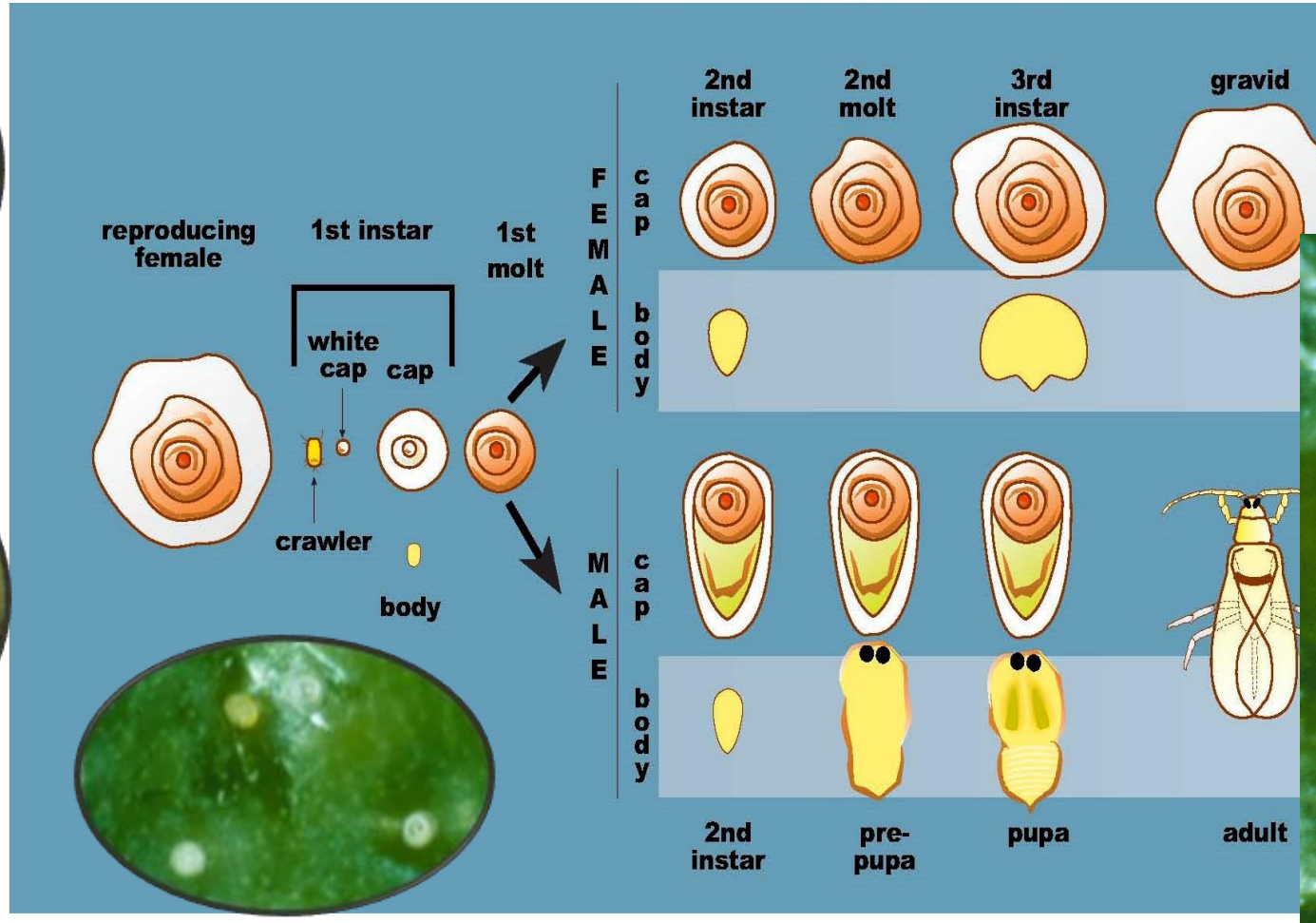


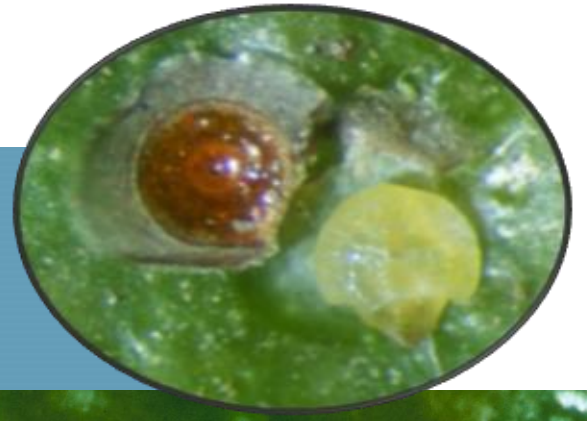
Monitoring

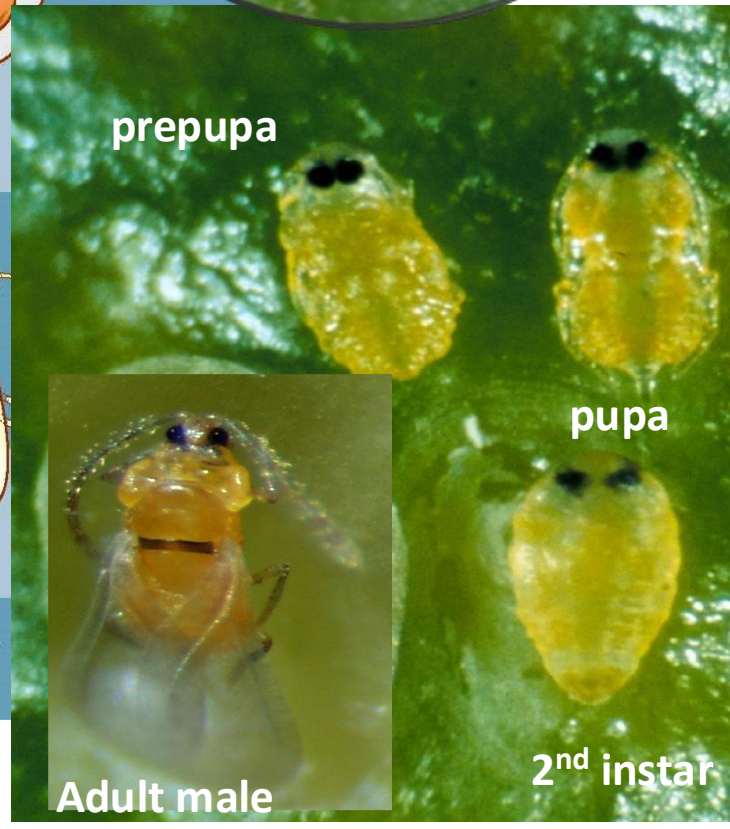
California red scale management

University of California
Agriculture and Natural Resources

California red scale biology and life cycle

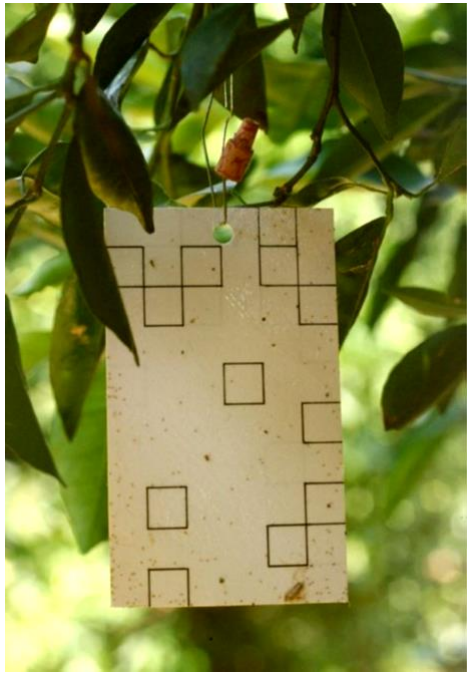






Warmer weather in the last decade has affected seasonal phenology of CRS.

CRS Male Flight 2001 to 2023						
Year	Biofix	F1	F2	F3	F4	Total degree days
2001	3/20	6/5	7/31	8/30	10/22	4696
2002	3/21	6/12	7/24	9/6	No Gen 4	4292
2003	3/12	6/14	7/25	9/2	10/26	4596
2004	3/15	6/3	7/18	8/28	11/23	4433
2005	3/22	6/12	7/21	8/26	No Gen 4	4201
2006	4/11	6/17	7/23	9/2	No Gen 4	4179
2007	3/14	6/10	7/22	8/31	12/5	4412
2008	3/17	6/17	7/26	9/5	11/19	4448
2009	3/23	6/10	7/23	9/1	11/27	4429
2010	3/30	6/28	8/7	9/26	No Gen 4	4008
2011	4/1	6/27	8/8	9/20	No Gen 4	4073
2012	4/6	6/16	7/30	9/7	11/21	4499
2013	3/15	6/4	7/15	8/25	10/29	4609
2014	3/10	6/4	7/12	8/23	10/9	4959
2015	3/2	6/2	7/8	8/21	10/9	4866
2016	2/24	5/31	7/11	8/21	10/15	4766
2017	3/15	6/4	7/15	8/16	9/26	5174
2018	3/13	6/4	7/19	8/19	10/4	4991
2019	3/19	6/6	7/13	8/24	9/30	4838
2020	2/28	5/30	7/11	8/18	9/25	5137
2021	3/19	6/3	7/16	8/14	9/25	5064
2022	3/4	6/3	7/26	8/19	9/27	5136
2023	4/11	6/15	8/22	9/2	11/8	



Coolest

Warmest

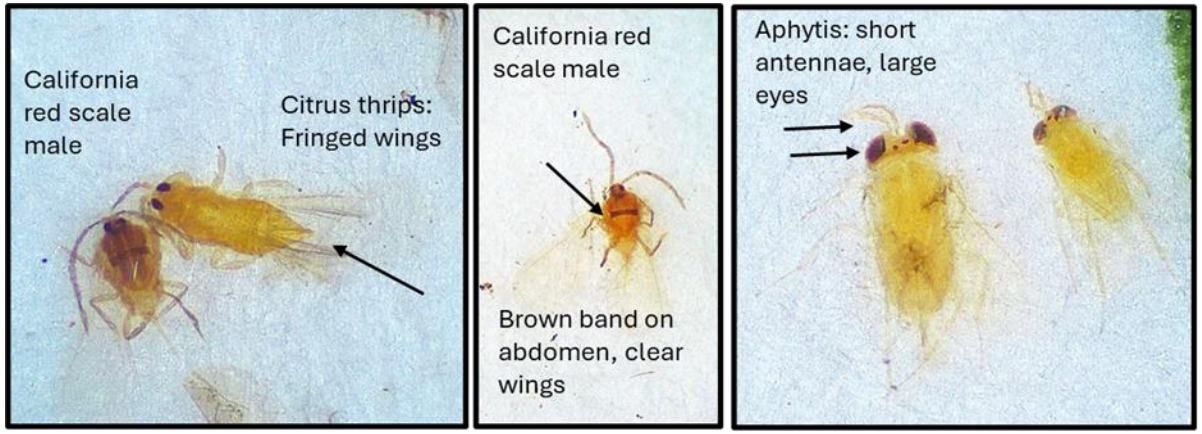
Year with 5th generation crawlers
4950 degree days after the biofix

Six out of 10 years in the last decade had an extra generation (incomplete).

Monitor male flights using a pheromone card and use the degree day model to predict successive generations.

- Pheromone cards to watch populations at the beginning of the season as early as February 15 (replace cards every week)
- Observe cards to identify a male CRS.
- Identify a biofix (first consistent male flight of the new season)
- Use the degree-day model to predict successive generations.
- Degree day unit/day = Daily temp. average – Lower developmental threshold of CRS, i.e., 53°F
- 550 DD needed from the flight to the next generation crawler emergence.
- Or place pheromone traps out during the 4th flight to decide which orchards to spray next year.

4th generation flight is an important event in CRS IPM. Helps estimate the control and prepare for next season.
The threshold can be different based on the pest management program.



Using pheromone cards to monitor CRS?

- Cards **overestimate** scale numbers in *Aphytis*-release orchards, because *Aphytis* prefers to parasitize female scales and the male scale numbers can be very high when the female numbers are low.
- Cards **underestimate** red scale numbers when insect growth regulators or mating disruption are used because the males are more sensitive to these treatments than the females. In mating disruption situations: a threshold of 50 scales per flight is helpful in determining if mating disruption is effective.
- Cards are **not reliable** predictors of fruit infestation in orchards where spirotetramat (Movento) or imidacloprid (Admire) are used because these insecticides do not kill scale on the woody trunk or branches. Thus, while the number of scales can increase on these surfaces and, the trap cards are heavily infested, fruit can still be relatively free of scales.

California red scale management choices – UCIPM Guidelines

Management choices	Efficacy	Selectivity	Spectrum
Mating disruption (Checkmate CRS)	Moderate: Effectiveness varies	Nontoxic	Narrow: CRS
Aphytis melinus	Moderate: effectiveness varies	Nontoxic	Narrow: CRS
Oils (415, omni)	Moderate: short residual	Short term effect on all arthropods	Broad: most pests
Esteem (Pyriproxyfen)	Moderate: Emerging resistance issues	Toxic to beetles	Narrow: CRS
Centaur (Buprofezin)	Moderate	Toxic to beetles	Interm: CRS, Citricola
Movento (Spirotetramat)	Moderate: Doesn't control scale on wood	Toxic to predatory mites	Interm: CRS, ACP
Sevin (Carbaryl)	Moderate: Resistance issues	Toxic to most natural enemies	Broad; CRS, Citricola scale, FRB

More options for CRS mating disruption?

Rate: 180/acre; 1 per tree.

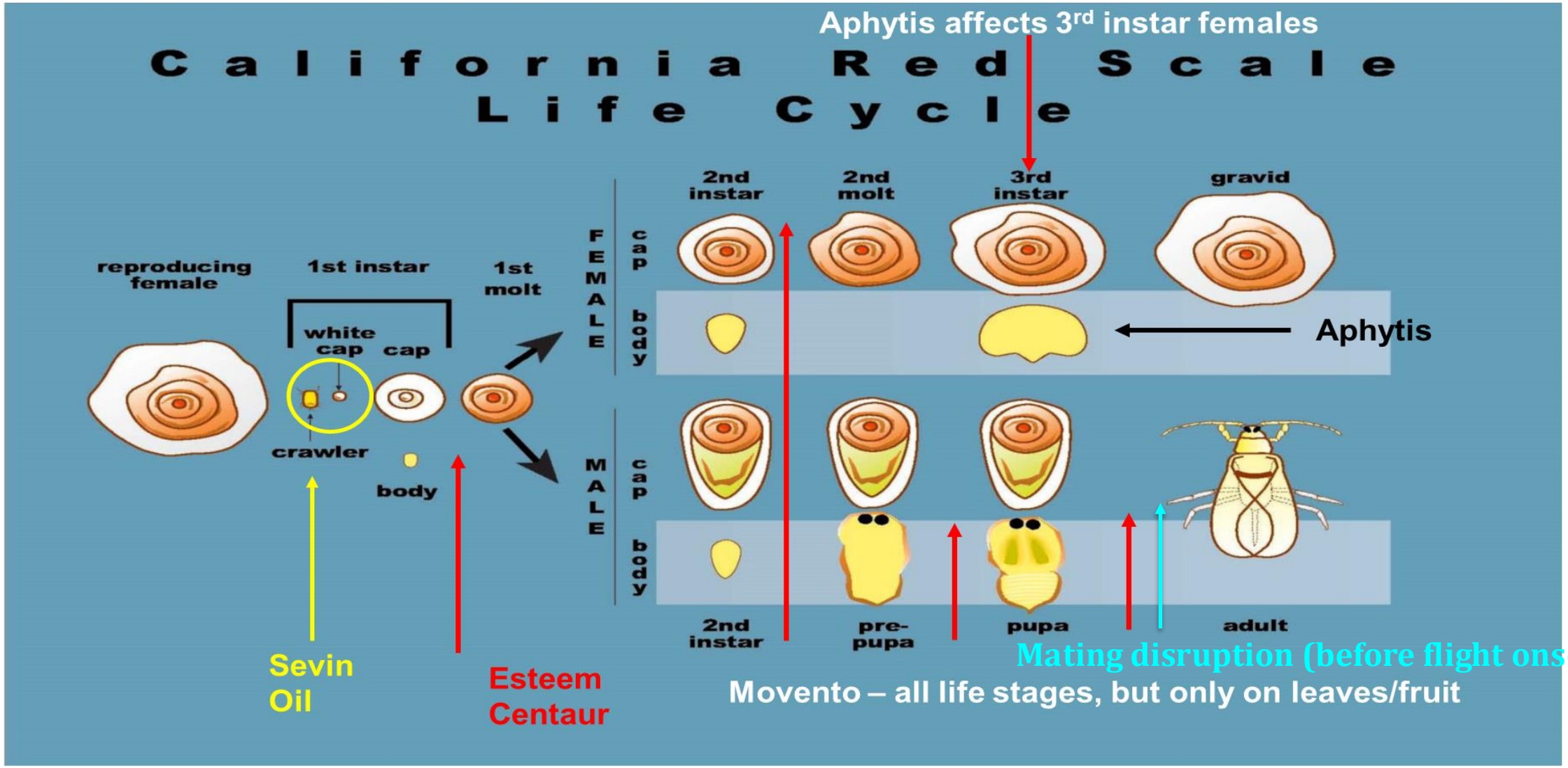
CIDETRAK® CRS MESO Registered

Semios

Aphytis Pesticide Selectivity

	MOA	Parasites	Predatory mites	Predatory beetles
OPS and Carb	1a,b	Rate dependent	Resistant	resistant
Pyrethroids	3	Toxic	Toxic	Toxic
Admire Pro, Assail, Actara (Neonicotinoids)	4a	Toxic	Toxic	Toxic
Sivanto (flupyradifurone)	4d	Toxic	Soft	Egg production
Esteem (Pyriproxifen)	7c	Soft	Soft	Toxic
Entrust/Success (Spinosad)	5	Soft	Soft	Soft
Delegate (Spinetoram)	5	Toxic	Soft	Egg production
Agri-Mek (Avermectin)	6	Soft	Toxic	Soft
Micromite (Diflubenzuron)	15	Soft	Soft	?
Centaur/Applaud (Buprofezin)	16	Soft	Soft	Toxic
Fujimite, Nexter (Fenpyroximate)	21a	Toxic	Toxic	Egg production
Movento (Spirotetramat)	23	Soft	Toxic	Soft
Exirel (Cyantraniprole)	28	Soft	Soft	Egg production

How to use life cycle for making pest management choices?



All management choices should target first or second generation.

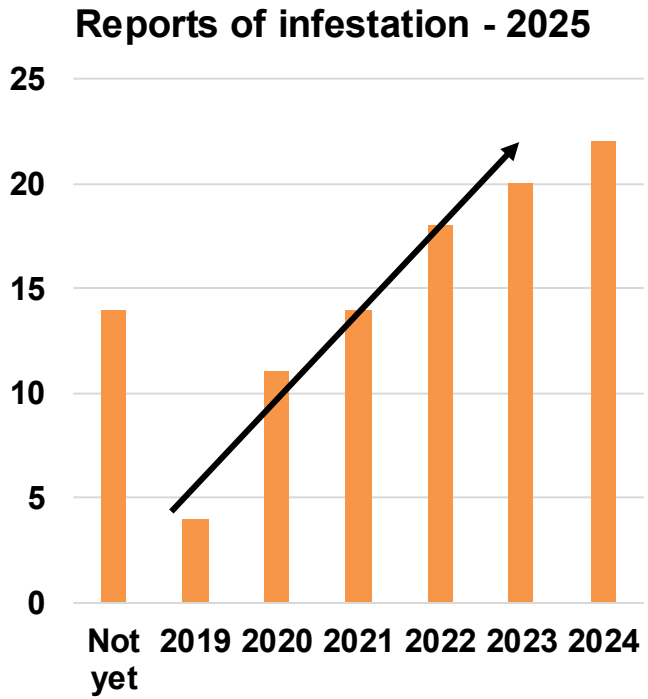
Best Management Practices: California Red Scale

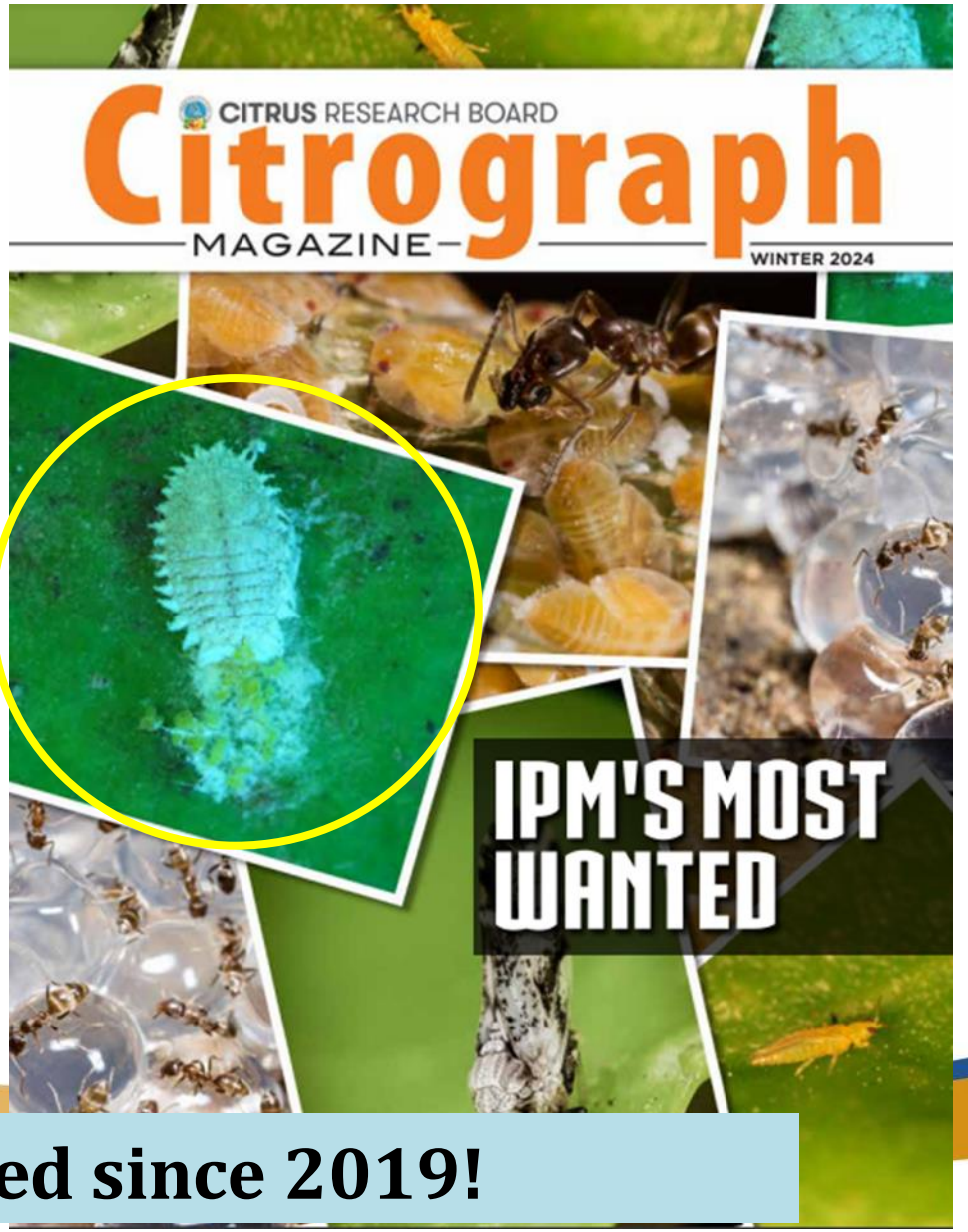
- Weather affects populations, monitor and predict next life event
- Treatment Timing: Target early generations (1st and 2nd)
  - Mating disruption: Prior to the beginning first or second-generation male flight
  - *Aphytis*: Biweekly in spring and early fall
  - Insecticides: Treat generations 1 or 2 when the scale population is uniform in stage (exception is spirotetramat, which seems to work in fall)
  - Use the selective insecticides that allow natural enemies to survive when you can
- Rotate products to avoid resistance
- Good coverage: 750-1500 gpa/acre (7000-15000 l/ha) (spirotetramat 250 gpa/acre)
- Drive slowly! < 1.5 mph (2.4 kph)
- Postharvest options include: Phosphine fumigation ~48 hours; pressure wash @300 psi; ethyl formate

Outline

- Background
- California red scale IPM
  - Biology and Monitoring
  - Current Management Practices and Challenges
- Citrus mealybug IPM
  - Biology Monitoring
  - Current Management Practices and Challenges

Citrus mealybug





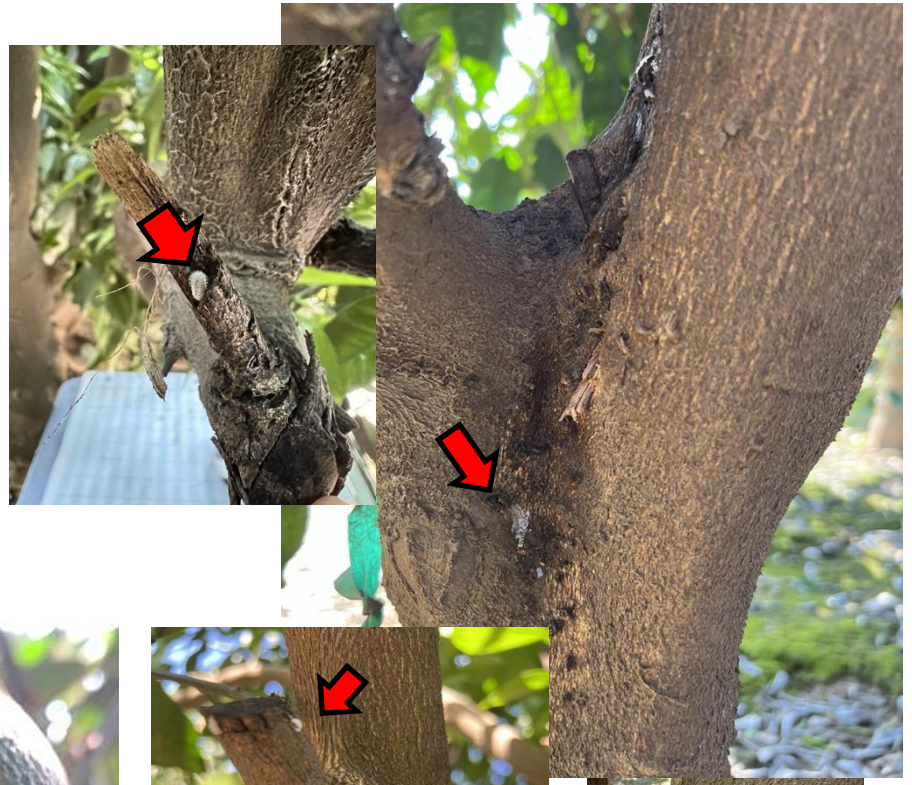
Concerns about mealybug as a pest increased since 2019!

How to identify a mealybug?

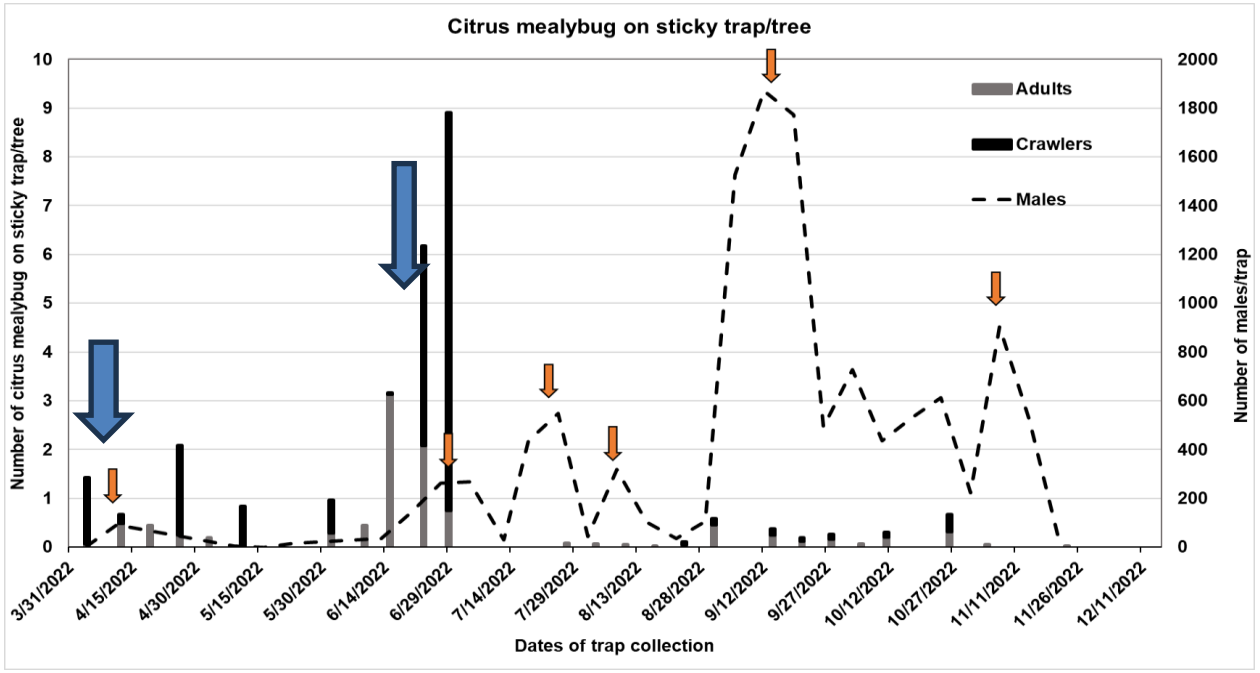
- Soft, oval, flat, clearly segmented body
- A vertical line runs through the middle of the body – dusted in flour appearance
- A pair of setae at each segment of the body
- Immatures and adults have similar appearance, all life stages can be present at any time
- Males have wings, narrower and smaller than females (4-5 mm in length)
- Two wings with minimal venation, hairy antennae
- Tail filaments clearly visible

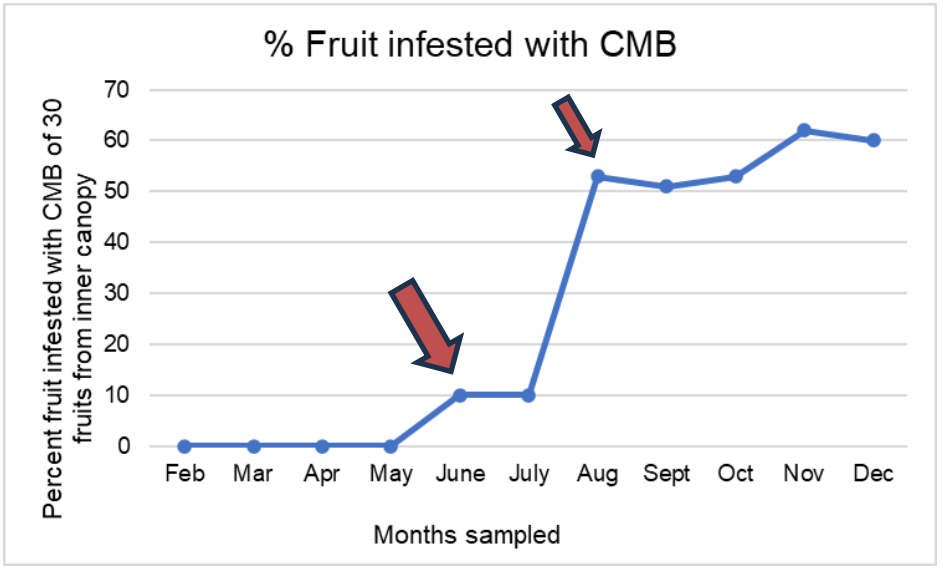
Mealybug infestations are hard to control, because…

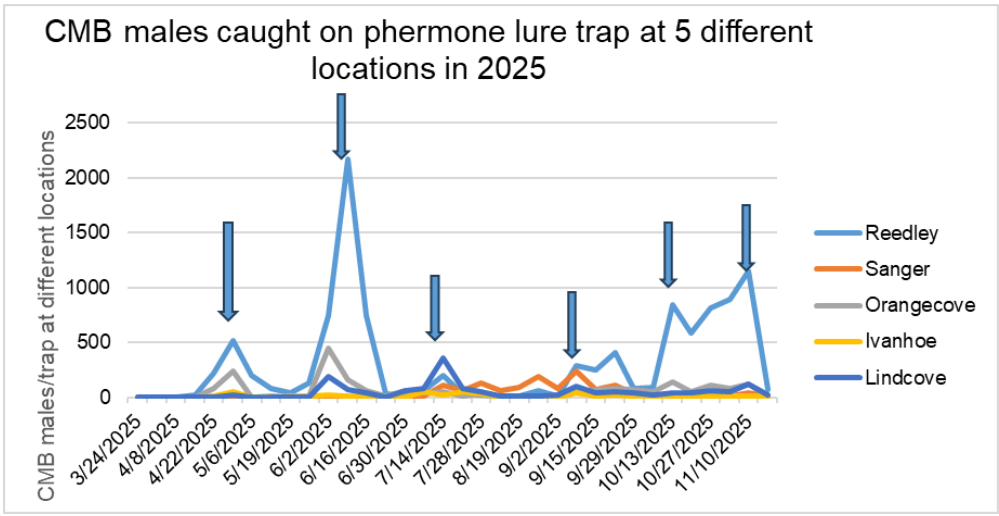
- Low populations are hard to detect, especially early in the season.
- Frequent overlapping generations, and eggs are protected within egg sac
- The hydrophobic waxy body covering of adults repels hydrophilic (water-loving) insecticides.



Knowing what's happening with the population helps with monitoring and management decisions.



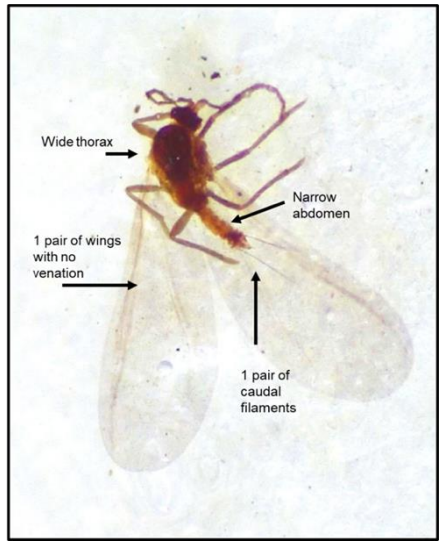




- Crawlers hatch from overwintering eggs began late March. **First male flight in spring (late March/April).**
- First generation crawlers emerged in early May. Second generation crawlers by mid June.
  By July, CMB moved to fruit. Less caught on the sticky traps.

Monitoring for citrus mealybug in orchards

- Males can be monitored using a pheromone lure. Place a pheromone lure before March 15 and replace weekly. Change lure every 5 weeks.
- Presence of males on the card indicates infestation, check hot spots, and treat if needed.

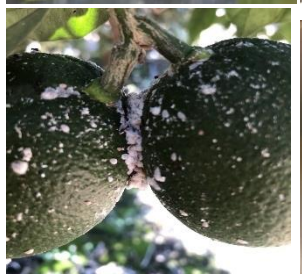


For adults/crawlers and egg sacs

- Scouting monitoring is season-dependent!
- Mealybugs move to the carbohydrate sink.
- Season begins in late March with crawlers hatching from the overwintering site. These crawlers either feed on the fruit (if fruit is present) or move to flush. Check inner canopy suckers.

Because mealybugs move, scouting monitoring is season-dependent!

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb



Mature Fruit:
Between clusters
Navel or calyx end

Leaves: egg hatch and crawlers move to flush from overwintering sites

Young Fruit and Mature Fruit: Between clusters, navel or calyx end

Overwintering population on leaves trunk, cracks/crevices of inner branches

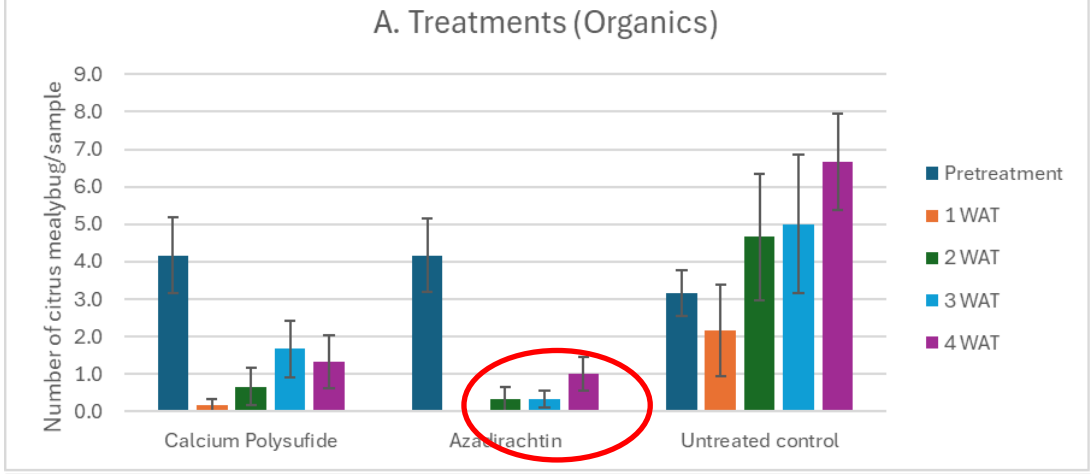
- **January to March** – Overwinter in protected areas. Check inside the tree canopy, fruit (if present) or leaves (with signs of sooty mold) for overwintering adults, egg sacs, and crawlers.
- **April to June** – crawlers emerge and start moving into new flush or fruit. Egg masses, crawlers on the trunk, and inner branches.
- **July to December** – CMB feed and multiply on fruit. Overlapping generations can be present.

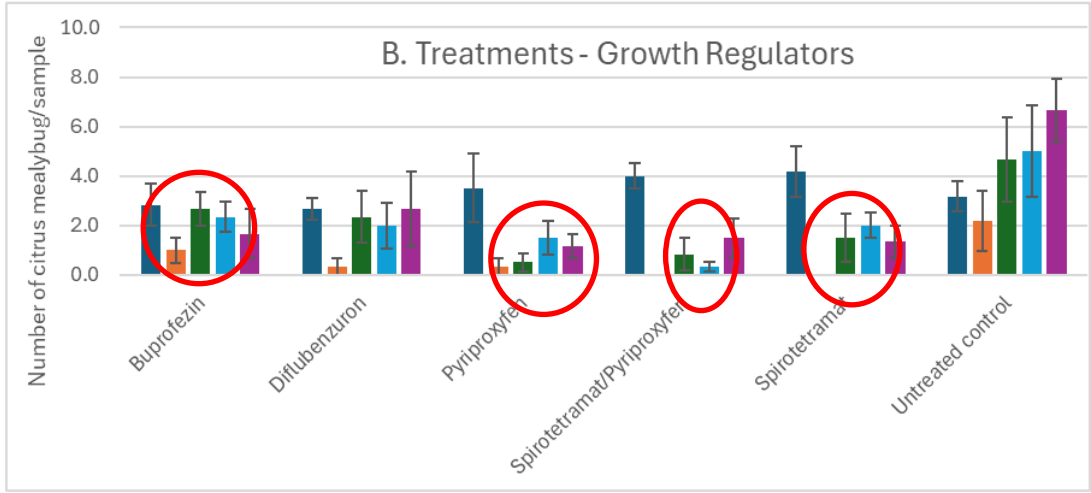
Chemical control – 2022

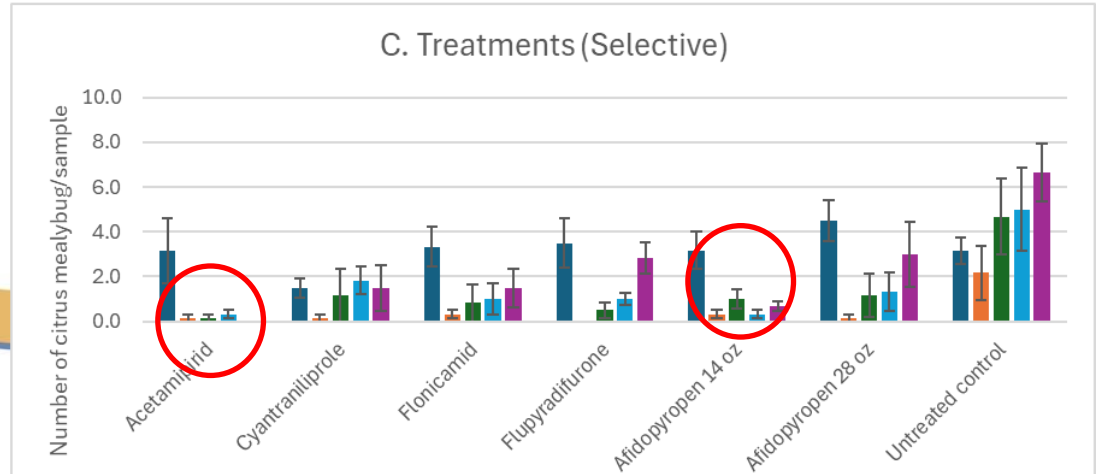
- Treatments:
  - Organics: Calcium polysulfide, Azadirachtin
  - Growth regulators: Buprofezin, Diflubenzuron, Pyriproxyfen, Spirotetramat
  - Selective: Acetamipirid, Cyantraniprole, Flonicamid, Afidopyropen
- Single tree application, six replications
- All products were applied with 0.5% oil and surfactant.
- Applications made on March 29, targeting 1st generation crawler population.

All treatments reduced mealybug density. Some products worked better than others, but mealybug came back in two weeks!

University of Californ
Agriculture and Natural Resources

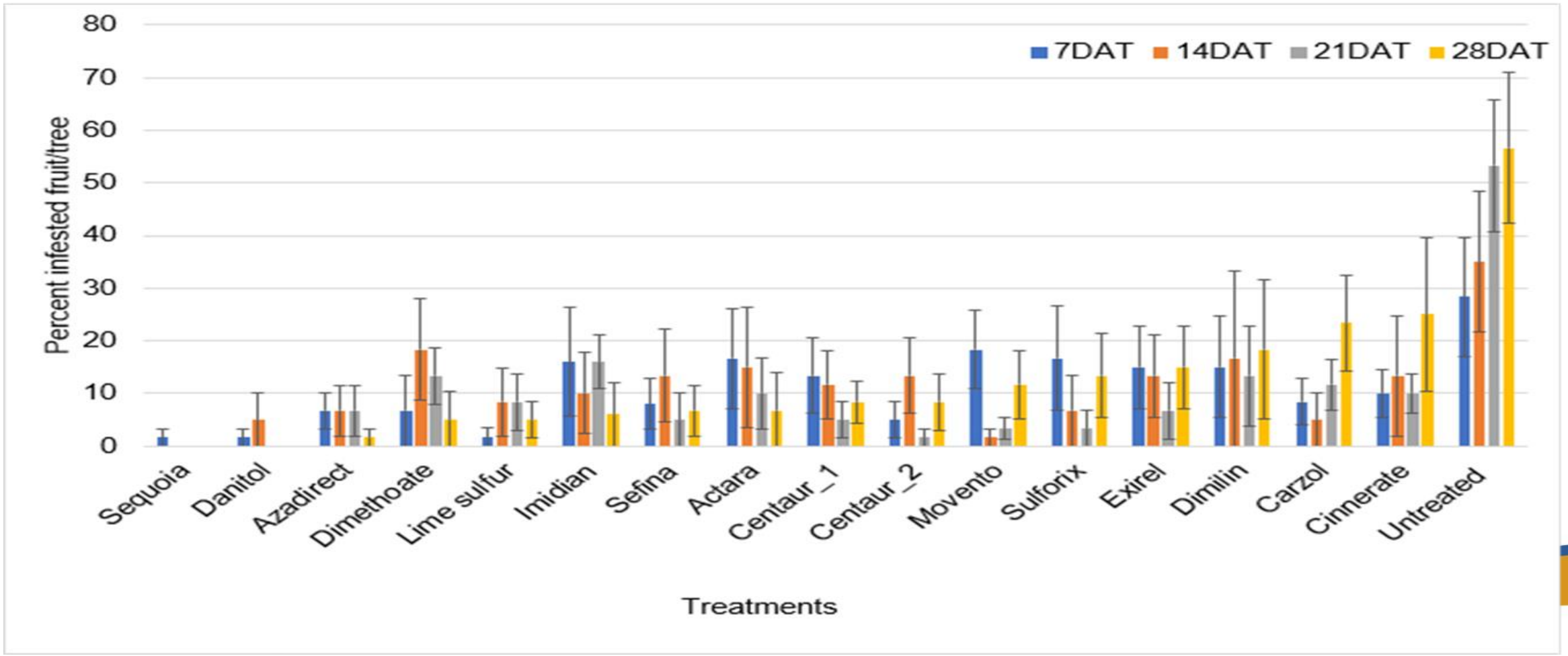




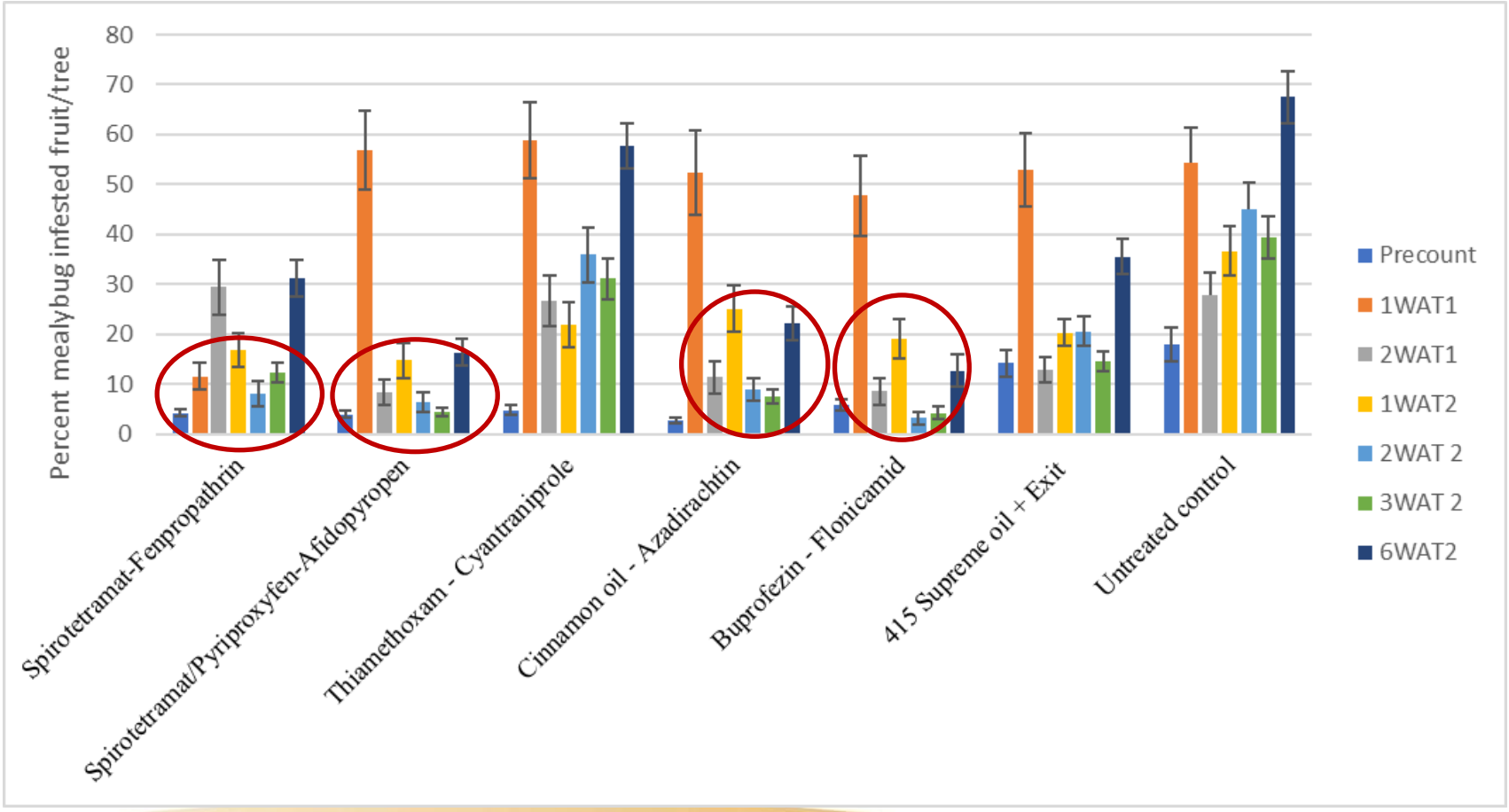


Before

Overall, treatments reduced the percent infested fruit after one application. Second application within 10-14 days is needed.



First application – July 7, 2023
Second application, Aug 3, 2023
Final evaluation on November, close to harvest.



- We observed high fruit drop in the untreated control.
- Natural enemies were active in this orchard.
- Untreated had high number of mealybugs on fruit compared to all treatments.

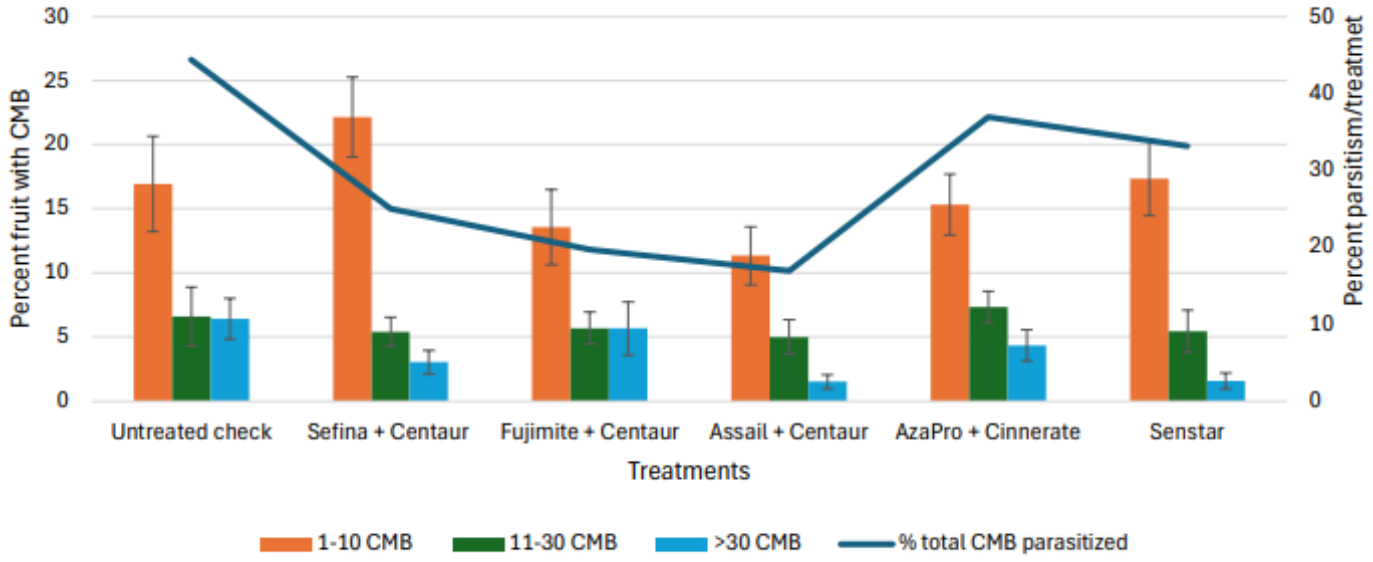


Figure 5. Percent fruit infested with citrus mealybug (CMB), total number of CMB per fruit (all life stages), percentage parasitism across insecticide treatments at five weeks after treatment. Bars represent infestation severity classes (1–10, 11–30, and >30 CMB per fruit), and line shows percent of parasitized mealybugs (3rd instar and adult females).

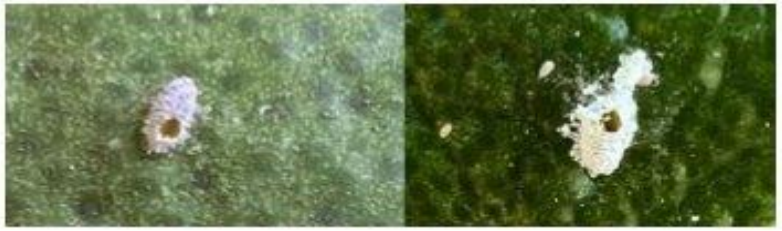
Natural enemies contribute significantly to control mealybug. Activity is enhanced in late summer/fall.

Check if natural enemies are present in your orchard.

Signs of parasitism to look for in a citrus orchard.

Note mealybugs with a black spot visible, mealybugs with a hardened body and lack of wax are early signs of parasitism

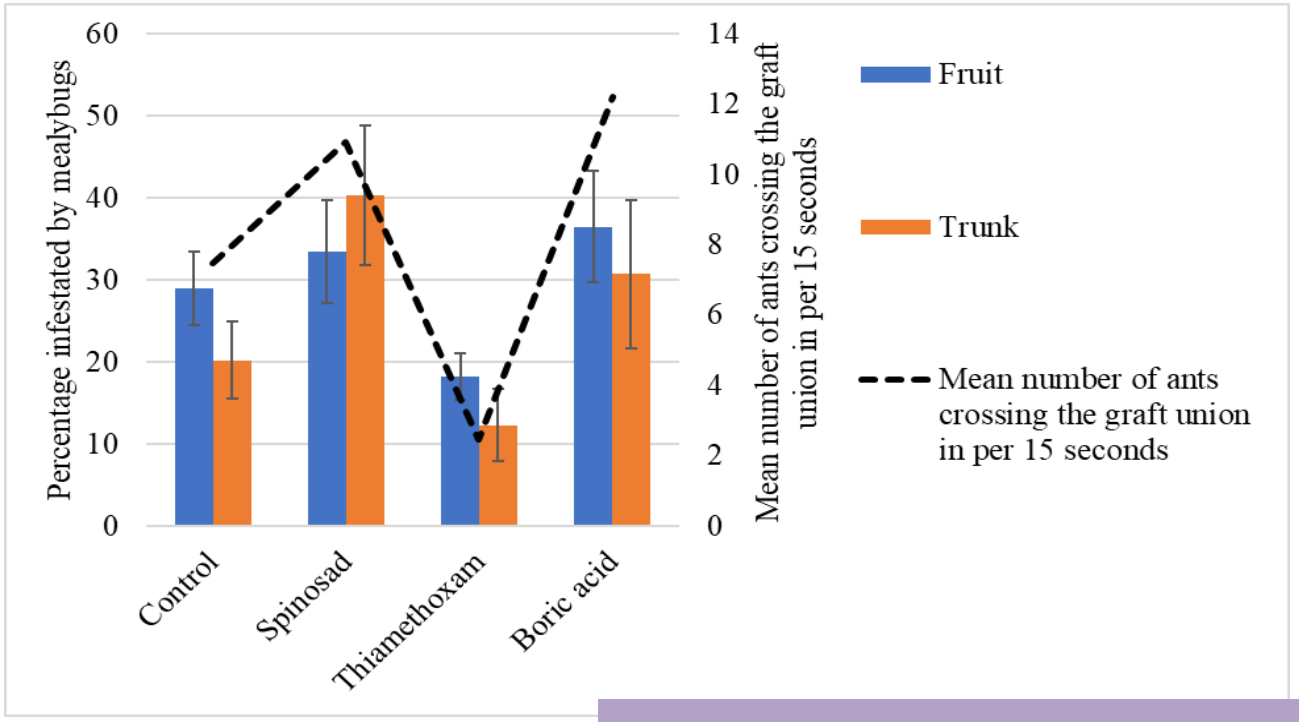
Note, mealybugs without waxy filaments and parasitoid pupae

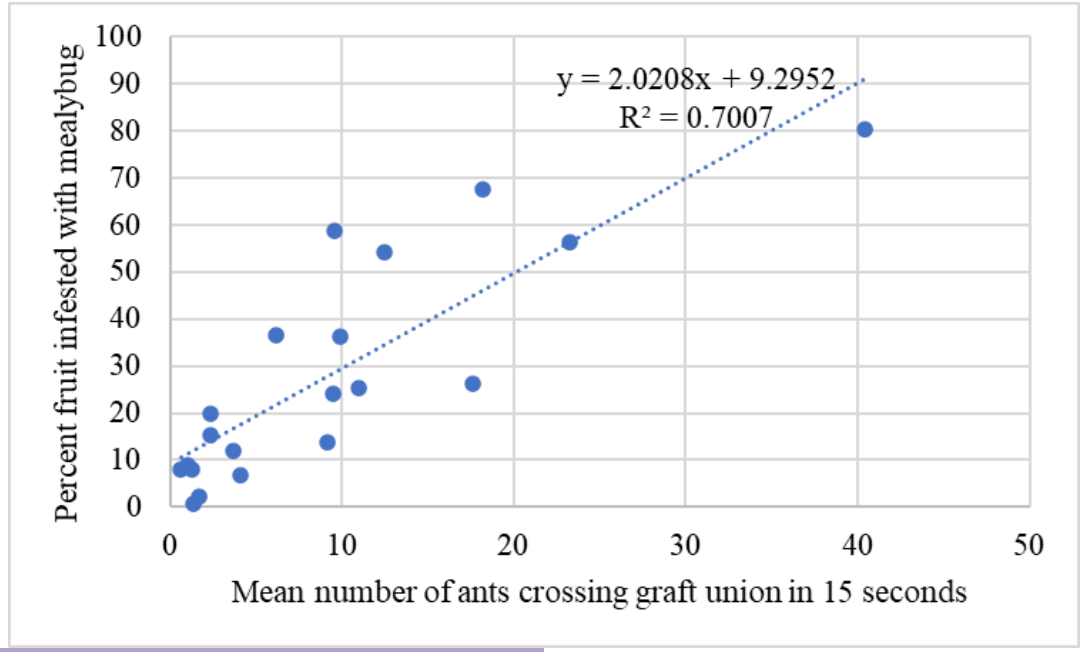


Exit hole left behind by a parasitoid

Natural enemies in action

Ants protect mealybug from natural enemies. Manage ants to control sap sucking pests.





2023 trials showed that mealybug population pressure was reduced in blocks with ant control.

BMPs for CMB management

- Mealybug activity starts in early spring (March) when crawlers from overwintering females start moving to new flush.
- Scouting is season dependent. Spring: overwintering eggs/adults, early summer: on young flush; summer/fall: fruit. Monitor males using pheromone lure/trap.
- For management, target first generation crawlers in April, and second-generation crawlers in late June/early July.
- Tank mix or two insecticide applications may be necessary. IGR with other insecticides provides the best control. Organic option – Azadirachtin + Cinnamon oil. Rotate products to avoid resistance development. Drive slowly ~1.5mph.
- Choose products that are safer to natural enemies.
- Manage ants for better mealybug control.

Acknowledgements

- Sanjeev Dhungana
- Ping Gu
- Lauren Vuicich
- Jovani Belman

- Growers
- Pest Control Advisors
- Agro chemical companies