

# Vinegar flies in CA strawberries: Species Identification & insecticide resistance monitoring



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# BACKGROUND – SPOTTED WING DROSOPHILA

- SWD is an invasive vinegar fly, arrived in CA in 2008 from SE Asia
- First found in strawberry & caneberry fields in Watsonville
- Severe economic pest of raspberries, blackberries, blueberries & cherries
- Females have serrated ovipositor used to lay eggs into firm, still-ripening fruit



# BACKGROUND – STRAWBERRY SUSCEPTIBILITY

- Fresh market strawberries may be protected from SWD by cultural practices & chemical controls
  - Short harvest intervals
  - spinosad & malathion
- Strawberries for processing are allowed to ripen in the field & insecticide applications stop
- Can lead to vinegar fly infestation & rejected shipments if detected
  - Impact of SWD unknown

# RESEARCH GOALS

- 1) Assess ripe & overripe processing fruit for larval infestation
- 2) Determine the relative abundance of species causing infestation at each developmental stage

Studies to be replicated in 3 main CA growing regions: Oxnard, Santa Maria & Watsonville



# METHODS

- Collect at least 40 ripe and 20 overripe strawberries from 3-4 field sites per region

**Oxnard**  
May/ June



Oleg Daugovich

**Santa Maria**  
August



Peter Shearer

**Watsonville**  
TBD



Mark Boldt



# METHODS

- Sampled at least 40 ripe and 20 overripe strawberries from 3-4 field sites per region

Ripe



Overripe



# METHODS

- Sampled at least 40 ripe and 20 overripe strawberries from 3-4 field sites per region
- Used morphological characteristics to ID to species



# RESULTS – OXNARD



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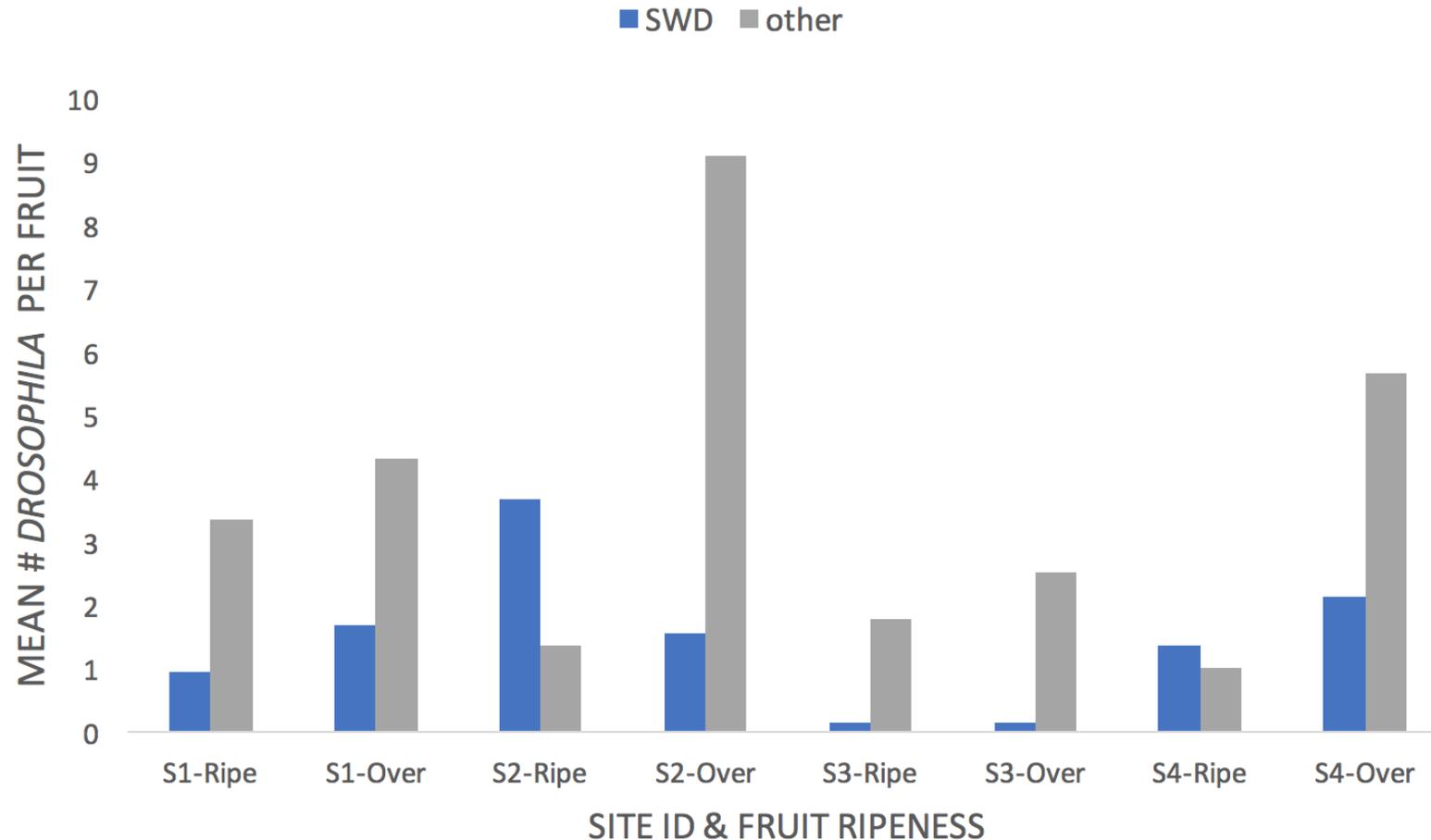
**Average number vinegar fly larvae per fruit**

Ripe: 3.4 (1.9 – 5)

Overripe: 6.8 (2.7 – 10.7)

**$\chi^2 = 128.1, p = 0.0001^{***}$**

# RESULTS – OXNARD



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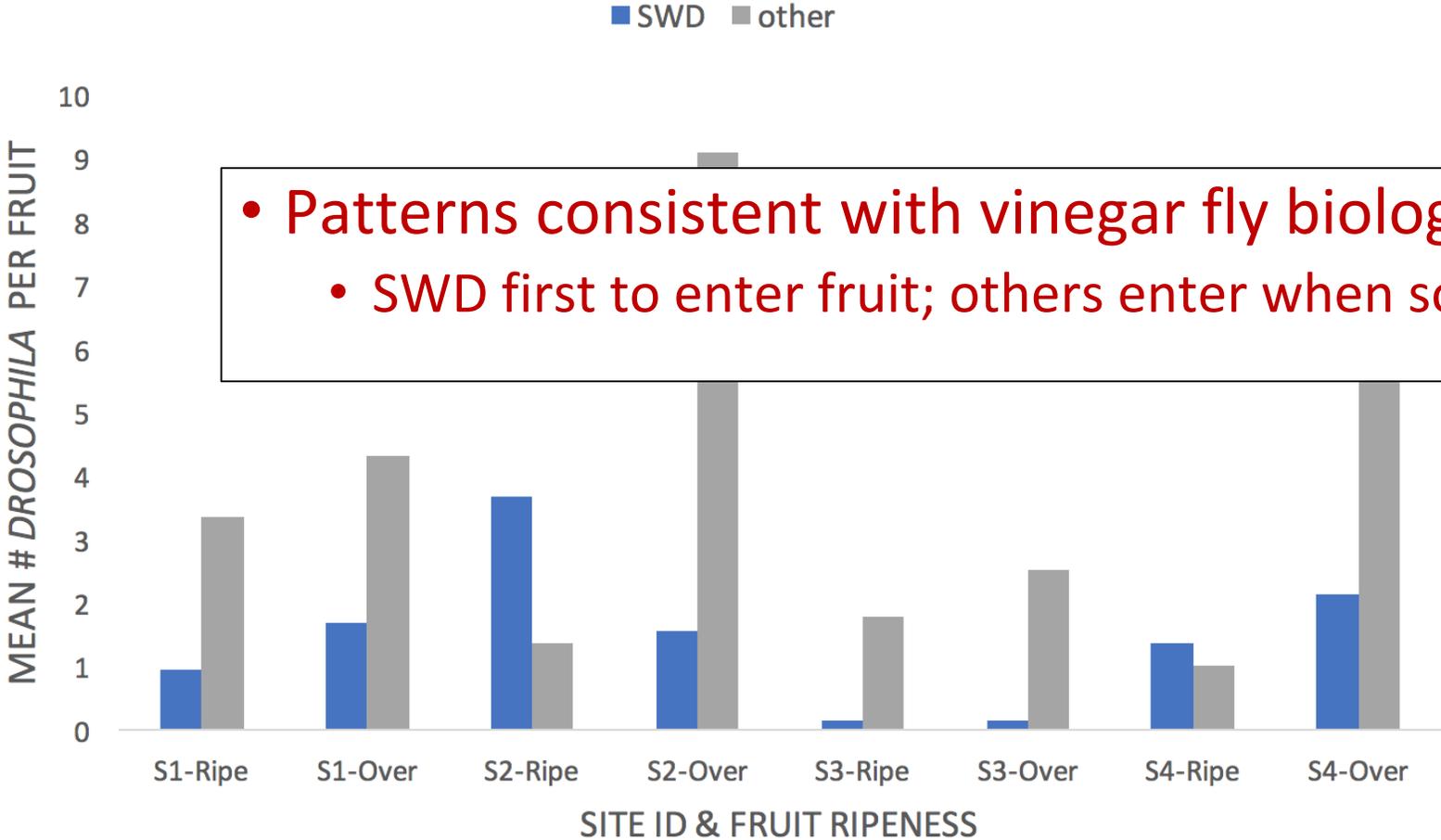
**Percent of total sample represented by SWD**

Ripe: 40% (7.1% – 73.1%)

Overripe: 19% (4.9% - 28%)

**$z = 4.813, p = 0.0002^{**}$**

# RESULTS – OXNARD



- Patterns consistent with vinegar fly biology
  - SWD first to enter fruit; others enter when soft / damaged

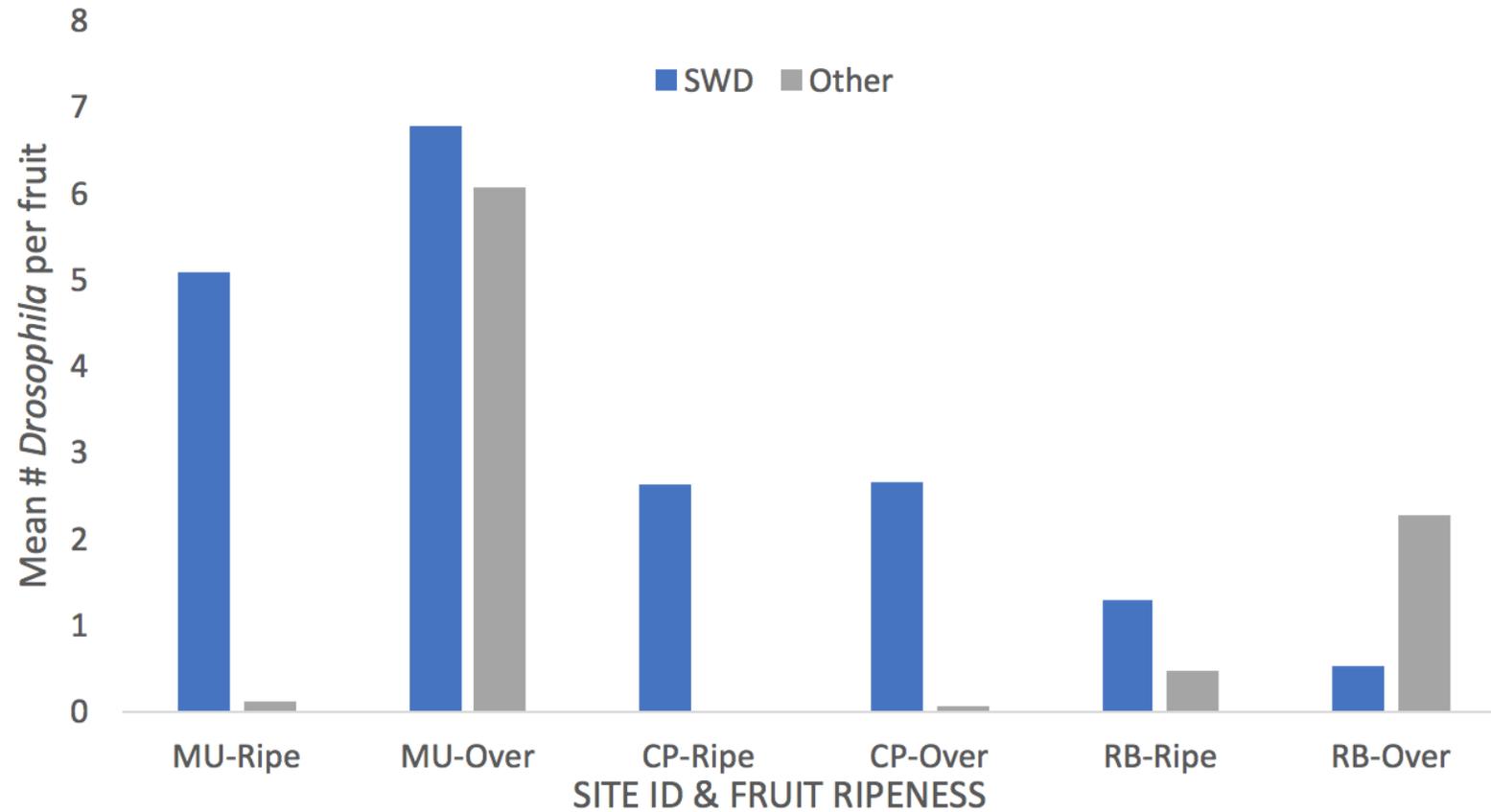
**Average number vinegar fly larvae per fruit**

Ripe: 10.7 (7.1% - 14.3%)  
 Overripe: 10.7 (4.9% - 16.5%)  
**0001\*\*\***

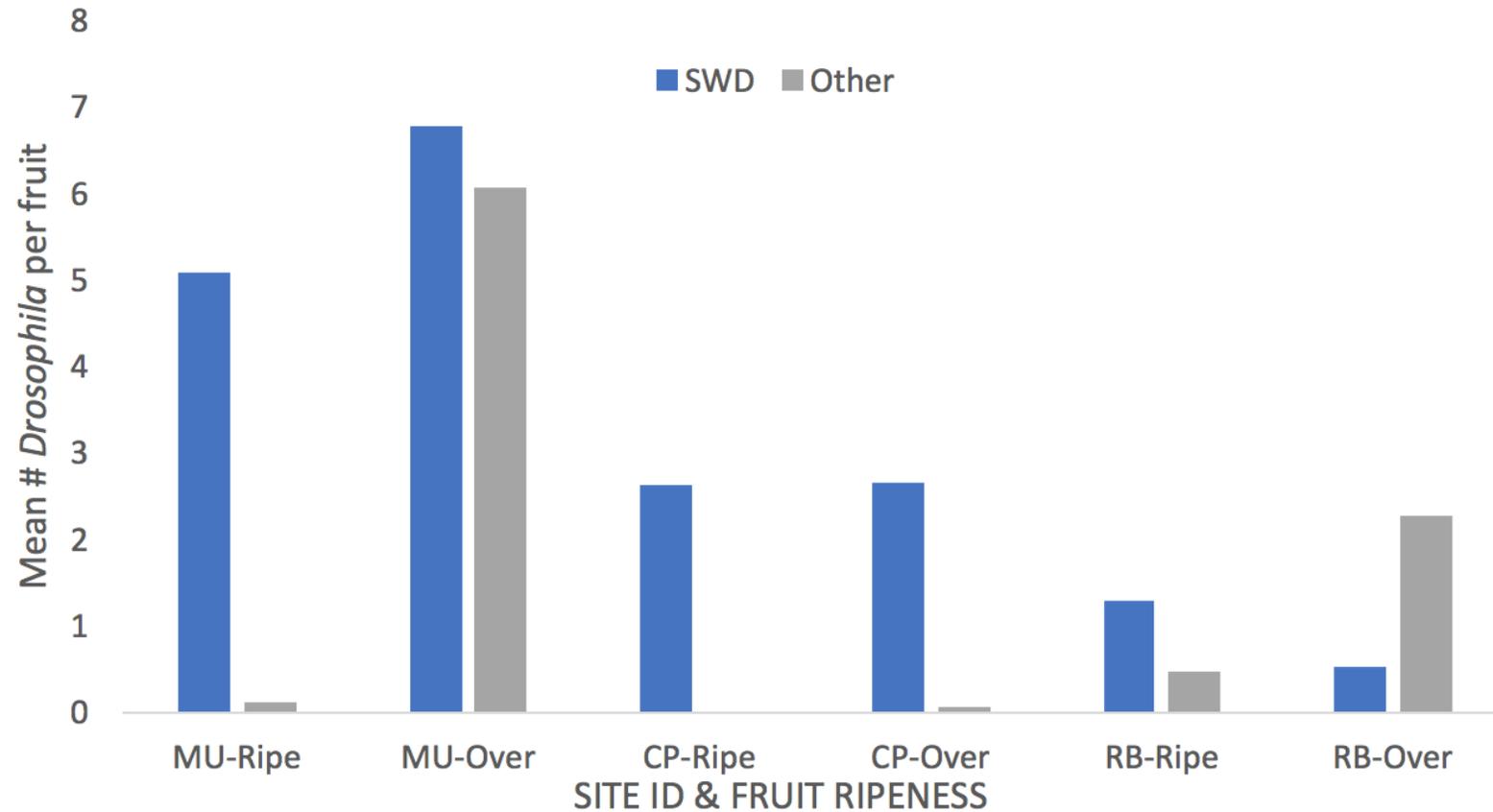
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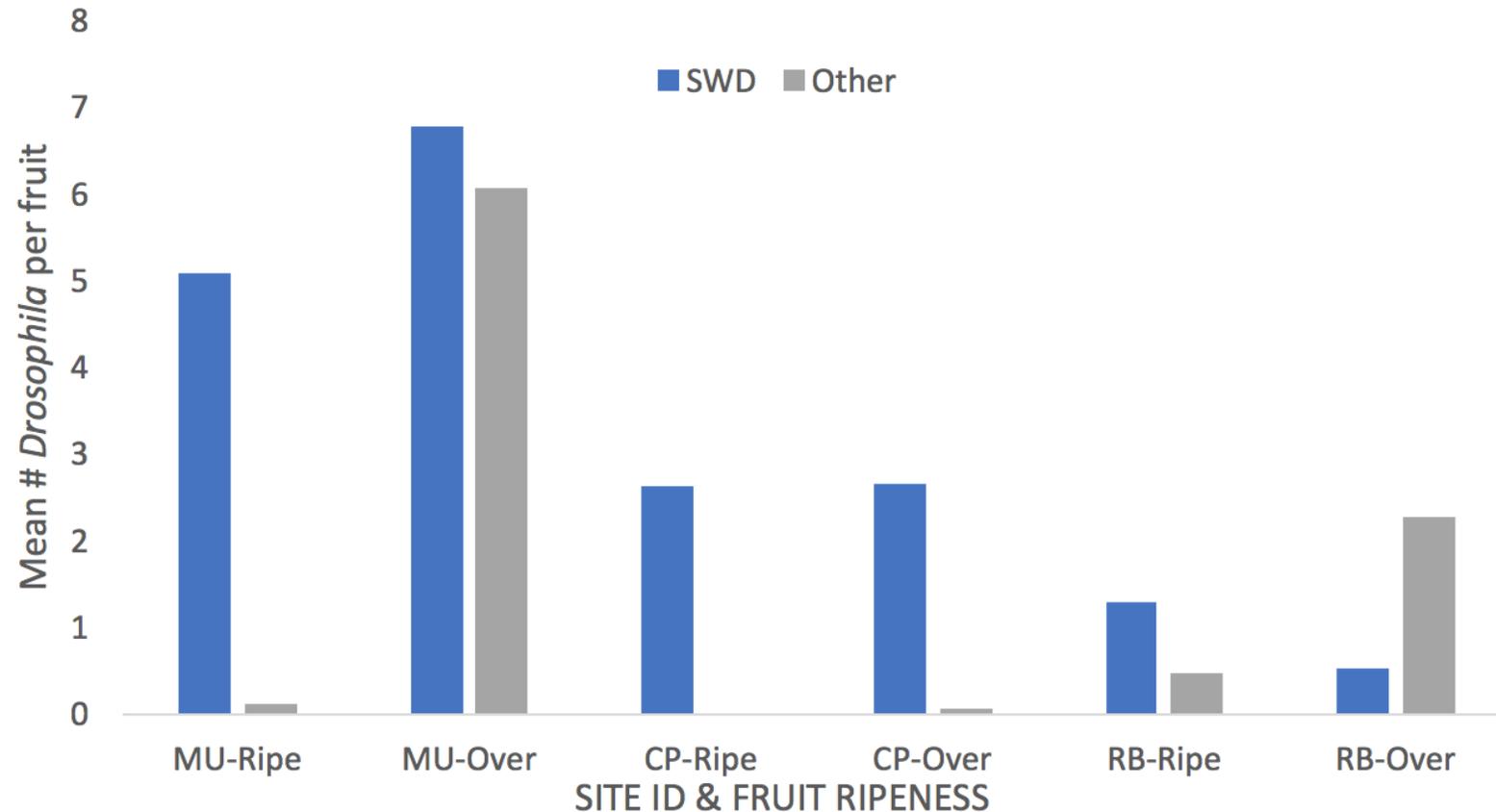
**Average number vinegar fly larvae per fruit**

Ripe: 3.2 (1.7 – 5.2)

Overripe: 6.1 (2.7 – 12.8)

**$\chi^2 = 43.633, p < 0.0001$**

# RESULTS – SANTA MARIA



## Average number vinegar fly larvae per fruit

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Overripe: 6.1 (2.7 – 12.8)

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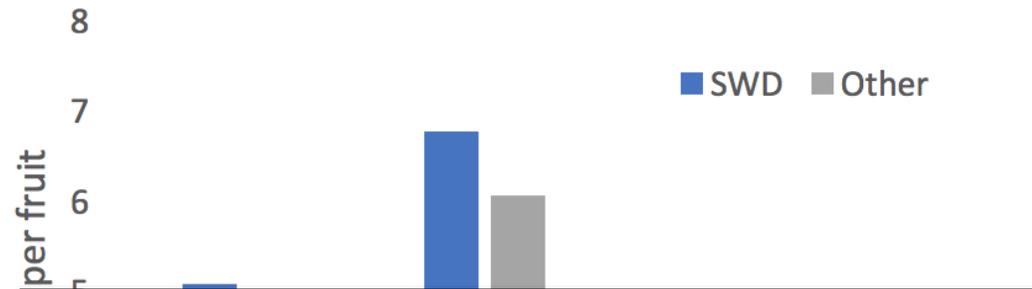
## Percent of total sample represented by SWD

Ripe: 94% (74% – 100%)

Overripe: 55% (19% - 98%)

$Z = 9.139, p < 0.0001$

# RESULTS – SANTA MARIA

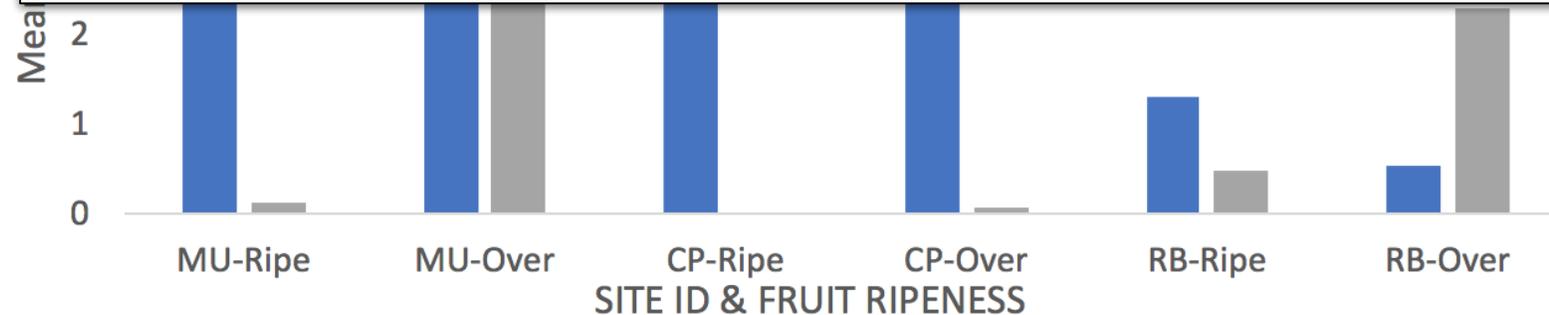


**Average number vinegar fly larvae per fruit**

Ripe: 3.2 (1.7 – 5.2)

Overripe: 6.1 (2.7 – 12.8)

- Suggests SWD could become economic pest of fresh strawberry production in absence of cultural and chemical controls



**represented by SWD**

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Overripe: 55% (19% - 98%)

**Z = 9.139, p < 0.0001**

# SPINOSAD RESISTANCE IN CA SWD

- Low to moderate levels of spinosad resistance emerging in Watsonville region
- Able to tolerate 5-12 x higher concentrations than susceptible SWD
- Significant increase in resistance observed after 5 generations of laboratory selection (~8-17 x)

Strain	LC50	SE	RR <sub>w</sub>	RR <sub>s</sub>
Susceptible (MI)	13.1	5.3	0.44	1
Wolfskill (untreated)	29.4	7.2	1	2.2
Watsonville	152.6	40.6	5.2	11.6
Watsonville-select	227.6	46.0	7.8	17.4

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Is resistance to malathion beginning to emerge in CA SWD populations?

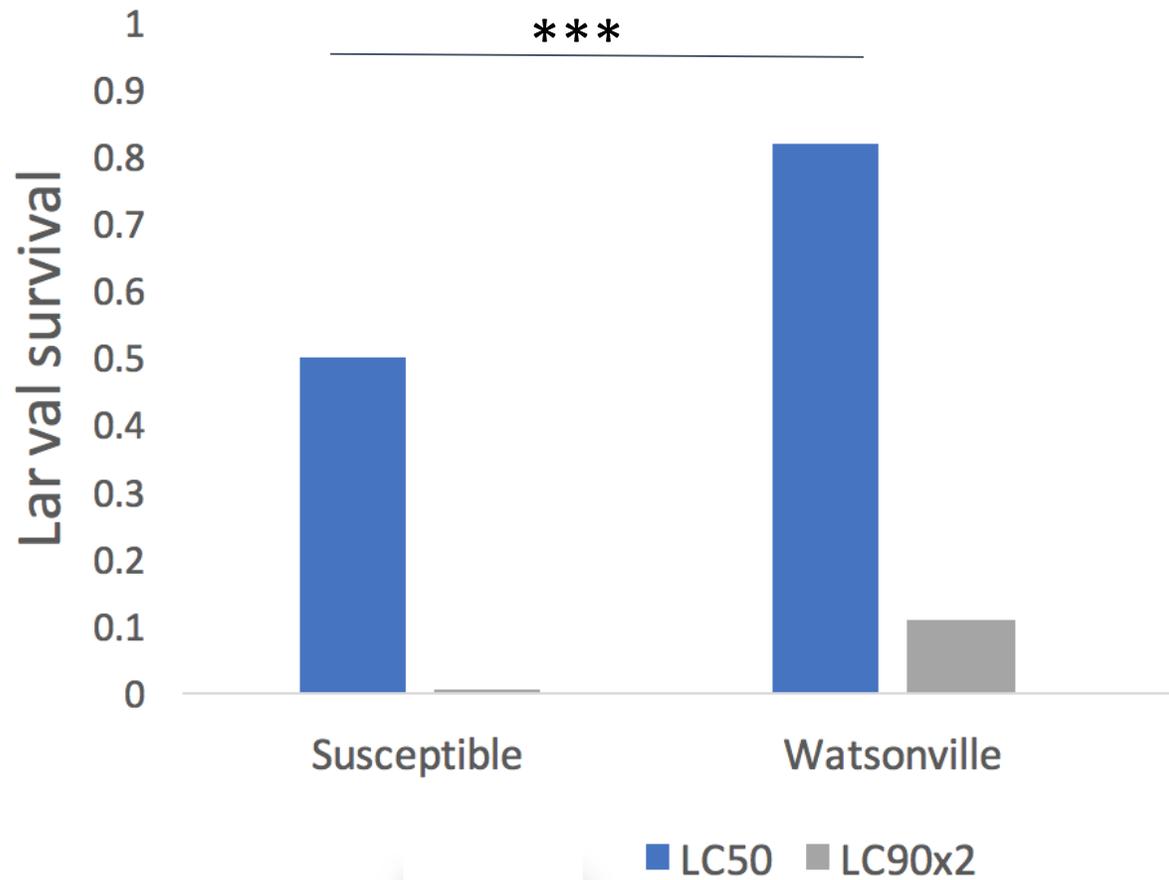
SWD

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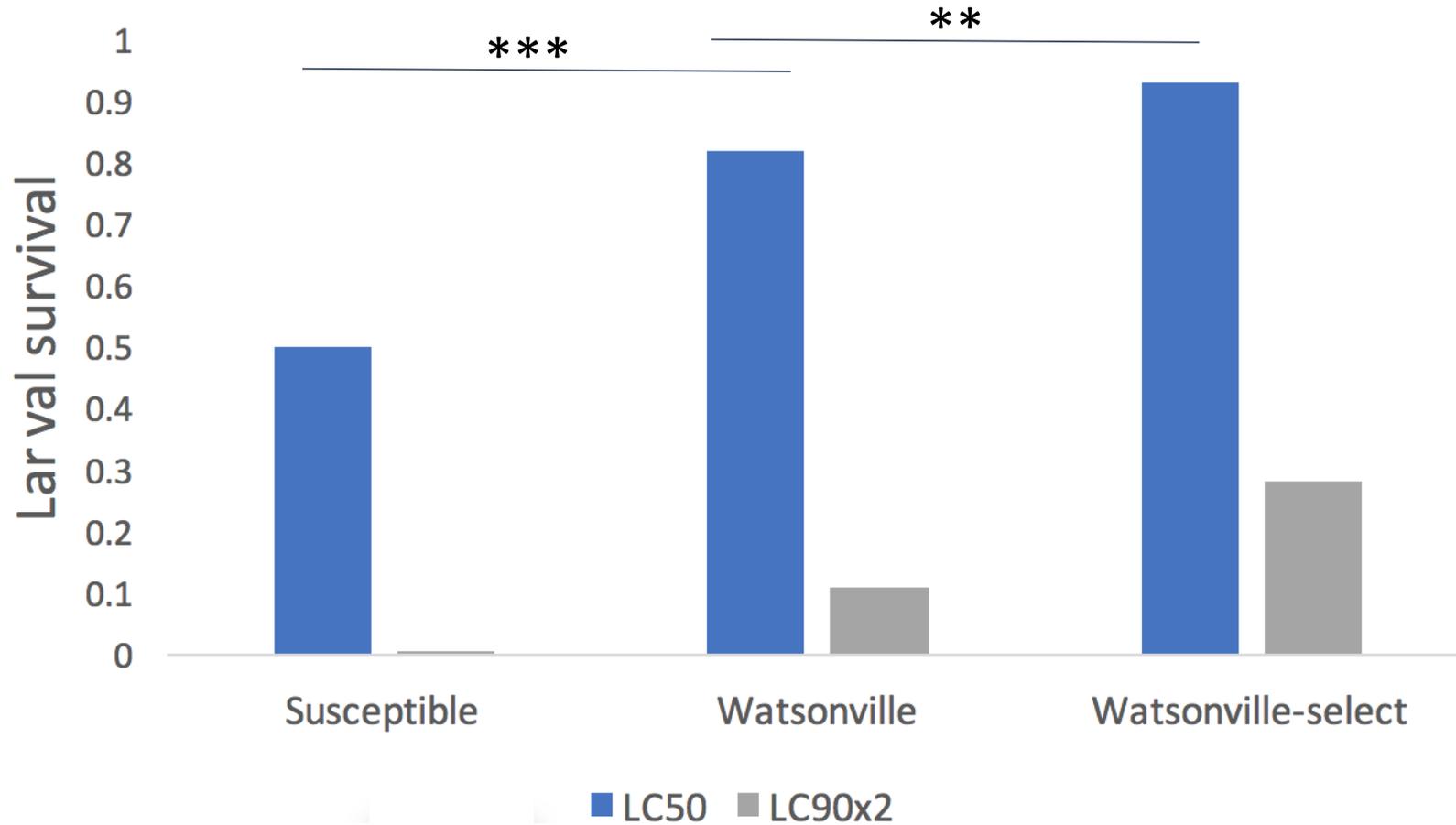
# MALATHION SUSCEPTIBILITY IN WATSONVILLE SWD (ADULTS)

- Initial monitoring effort indicated reduced malathion susceptibility in Watsonville
- Subsequent dose-response bioassays using adults showed that tolerance was low (~2-fold increase)

# MALATHION SUSCEPTIBILITY IN WATSONVILLE SWD (LARVAE)



# MALATHION SUSCEPTIBILITY IN WATSONVILLE SWD (LARVAE)



# CONCLUSIONS

- Vinegar fly larvae were present in fruit from all stages and locations
  - SWD comprise between 5% and 100% of total larval load
  - Likely enter fruit first & create opportunities for other species (*D. simulans*)
- Spinosad & malathion resistance could create problems in fresh market crop
- Tolerance to both insecticides already present in commercial CA fields
- Susceptibility will likely further decline with continued field exposure
- Non-spray alternatives to control SWD need to be developed and implemented

# ACKNOWLEDGEMENTS



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FOOD & AGRICULTURE

