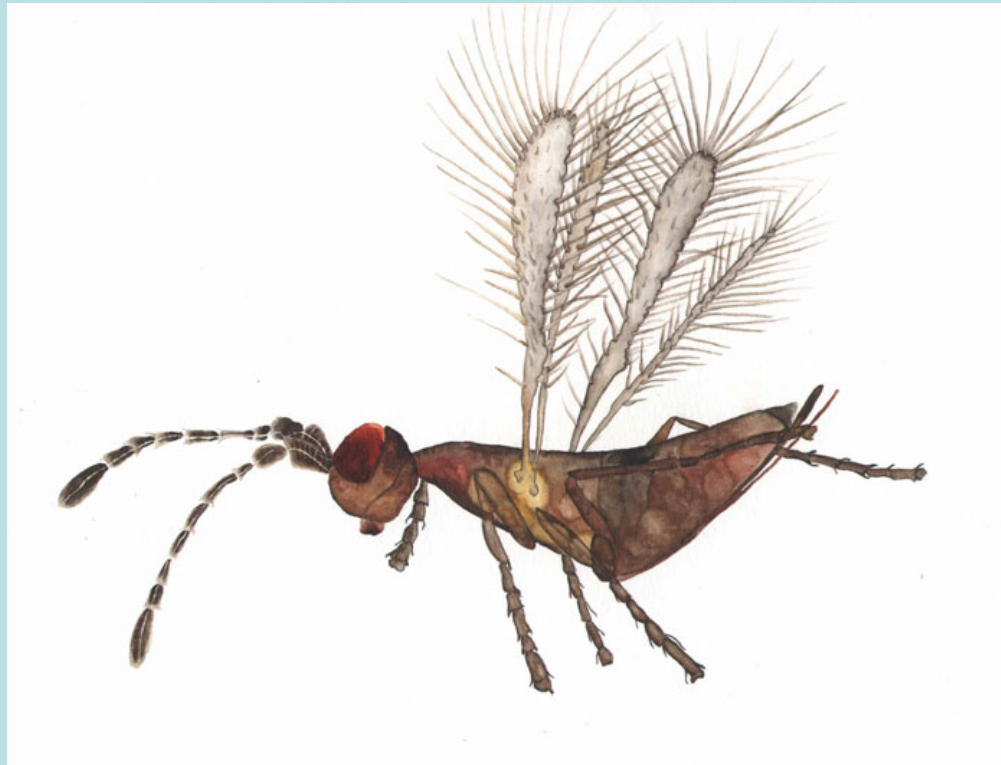


# The impact of sulfur on *Anagrus spp.* And biological control of the Grape Leafhopper

Sarina J. Jepsen and Jay A. Rosenheim





*Erythroneura elegantula*, the western grape leafhopper

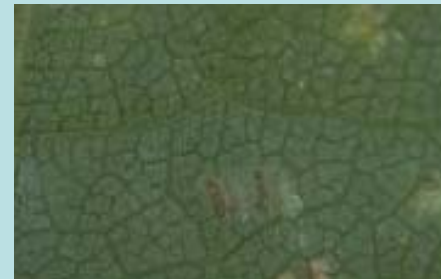


Leafhopper damage to grape leaves



Beneficial insects:  
egg parasitoids  
*Anagrus erythroneuræ*  
and *Anagrus daanei*

- *Anagrus* spp. kill leafhoppers by laying their eggs inside leafhopper eggs



- *A. erythroneuræ* and *A. daanei* are native to California
- Coevolved with the grape leafhopper on wild *Vitis* spp.
- High rates of parasitism are often observed by mid-season



- *Anagrus* spp. need an overwintering refuge containing an alternate leafhopper host



- This approach to leafhopper biocontrol has largely failed

- Entomologists tried planting flowering cover crops in vineyards to provide *Anagrus spp.* with nectar resources, in order to increase the wasp's lifespan



Why isn't leafhopper  
biocontrol working?

Is sulfur poisoning *Anagrus* spp., thus inhibiting leafhopper biocontrol?



## **Experimental approach:**

1. *Anagrus* and leafhopper field cage bioassays
2. Vineyard comparison observational study
3. Treated vineyard plots experiment

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## BIOASSAYS

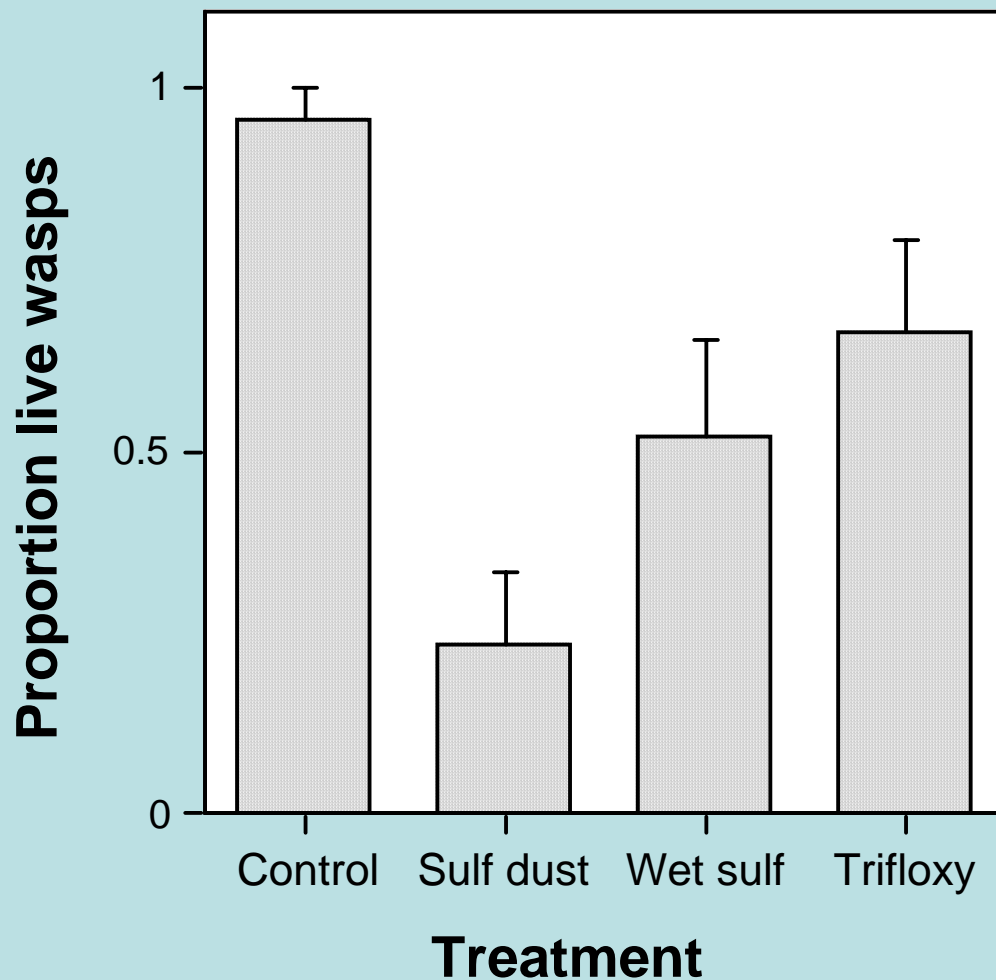
- *Anagrus* cages checked after 6 hours
- Leafhopper cages monitored for two weeks

Treatments included: sulfur dust, wettable sulfur, trifloxystrobin (*Anagrus* bioassays only) and water (control).



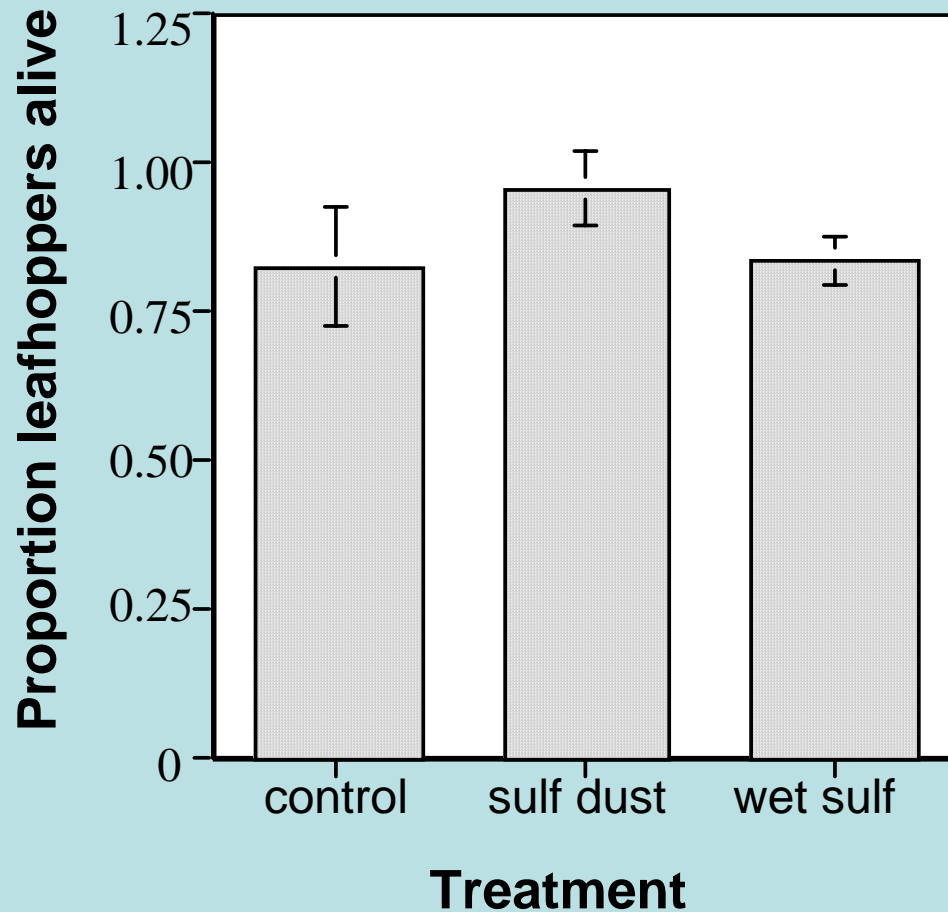
## ***Anagrus* field-cage bioassays**

- *Anagrus* in all treatments had shorter lifespans compared to control wasps (ANOVA, sulfur dust,  $P < 0.0001$ , wettable sulfur,  $P = 0.002$ , trifloxystrobin,  $P = 0.02$ )



## Leafhopper field-cage bioassays

- Neither formulation of sulfur is toxic to grape leafhoppers (survival analysis,  $P= 0.90$ )



## Experimental approach:

1. *Anagrus* and leafhopper field cage bioassays
2. Vineyard comparison observational study
3. Treated vineyard plots experiment

## Objective:

To determine if there is a difference in how many eggs *Anagrus* are laying in leafhopper hosts in sulfur vineyards and untreated vineyards

## Methods:

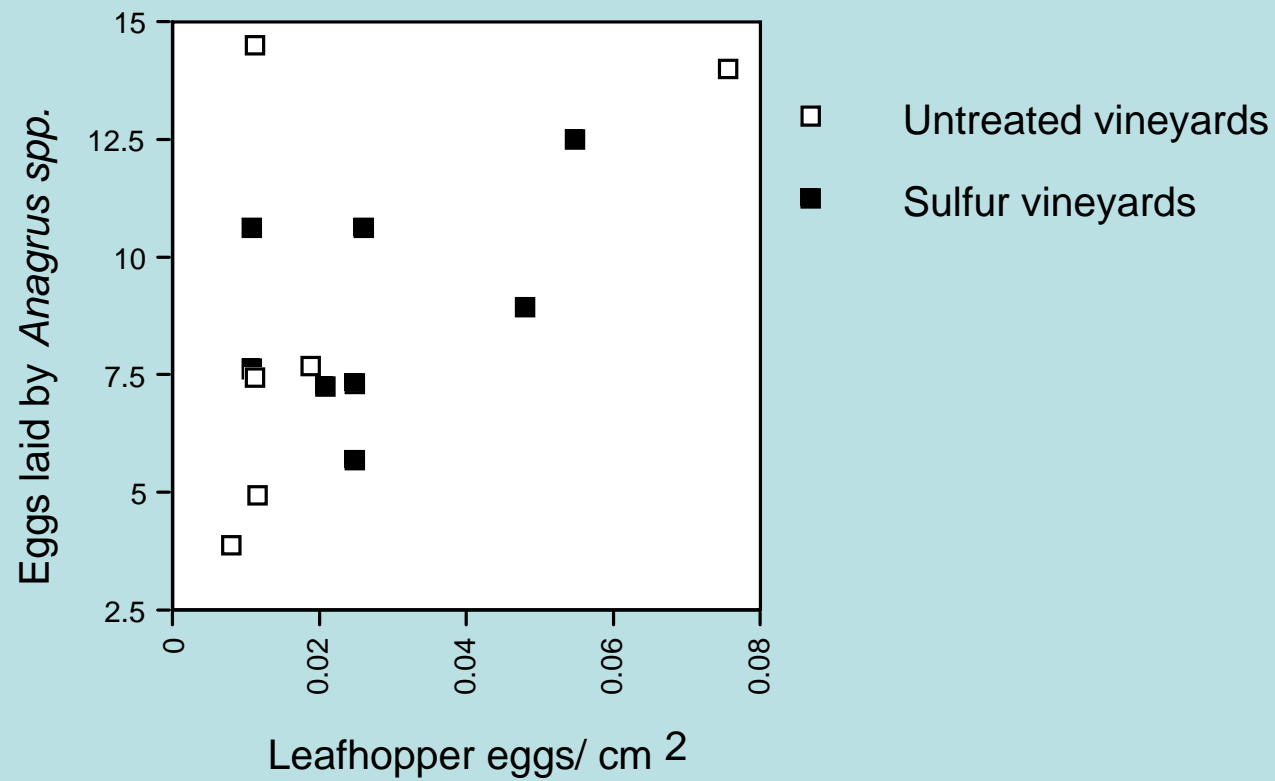
- 1.collected live *Anagrus* females at untreated vineyards and sulfur treated vineyards
- 2.dissected each parasitoid and counted its eggs

## *Anagrus* spp. are **proovigenic**

- Females don't mature eggs throughout their adult lifetime
- The number of eggs an *Anagrus* has at any given time is equal to the number of eggs she started her life with, minus the number she has laid.

$$\left[ \begin{array}{c} \text{Initial egg} \\ \text{load} \end{array} \right] - \left[ \begin{array}{c} \# \text{ of eggs observed in} \\ \text{field collected wasp} \end{array} \right] = \left[ \begin{array}{c} \# \text{ of eggs laid} \\ \text{by individual} \\ \text{wasp} \end{array} \right]$$

## Eggs laid by *Anagrus spp.* in sulfur treated and untreated vineyards



## Experimental approach:

1. *Anagrus* and leafhopper field cage bioassays
2. Vineyard comparison observational study
3. Treated vineyard plots experiment

## Objective:

To determine if sulfur has an effect on leafhopper biocontrol

## Methods:

7 acre vineyard in Davis, split into 30 plots

3 Treatments = Wettable sulfur, trifloxystrobin (Flint)  
and Control



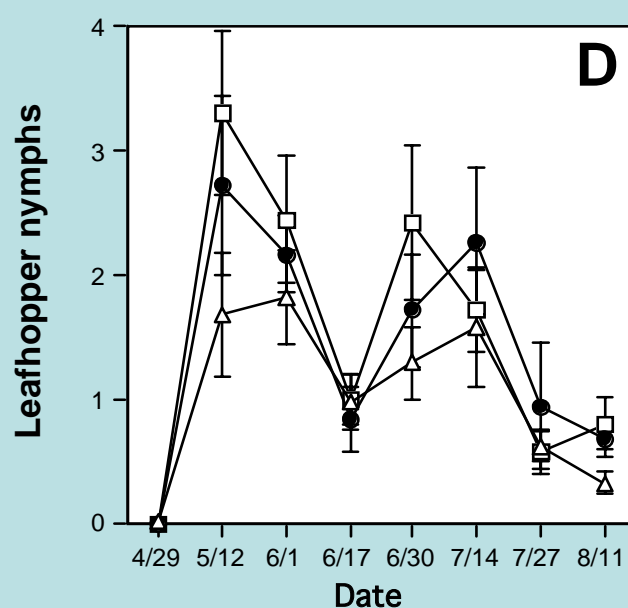
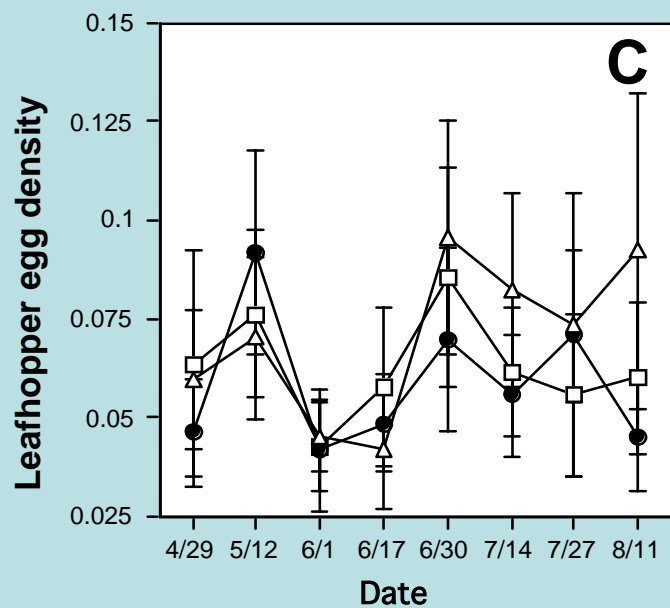
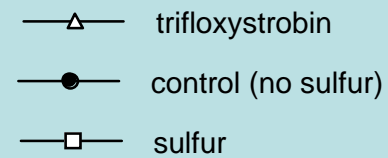
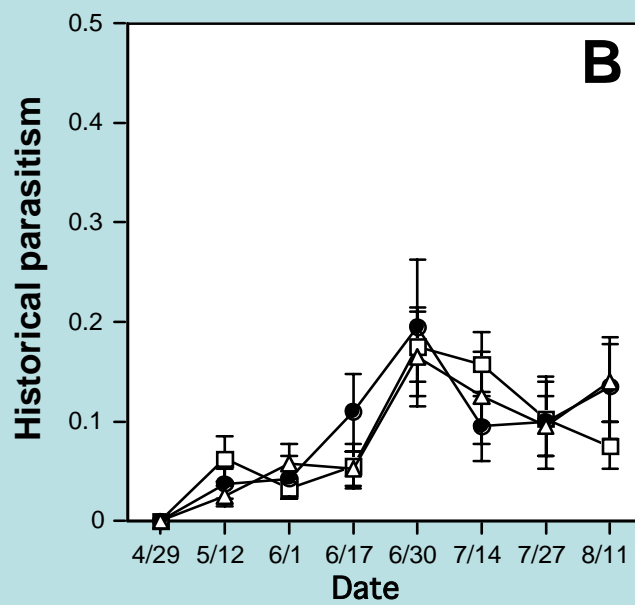
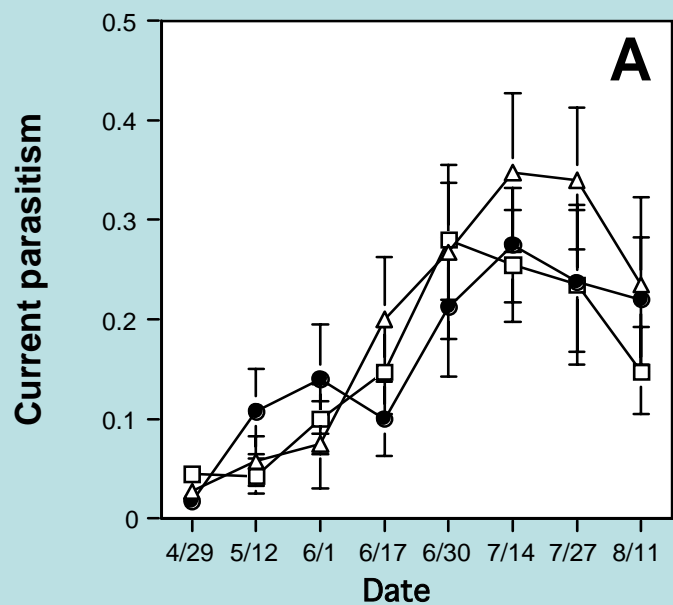
Measured:

Current parasitism of leafhopper eggs by *Anagrus*

Historical parasitism of leafhopper eggs by *Anagrus*

Leafhopper egg density

Leafhopper nymph density



**In conclusion...**

We saw that sulfur is very toxic to *Anagrus*,  
and not to leafhoppers, but...

It doesn't seem to matter in the field!

## Future experiment:

- + Add Nectar resources (by planting flowering cover crops)
- Remove sulfur

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