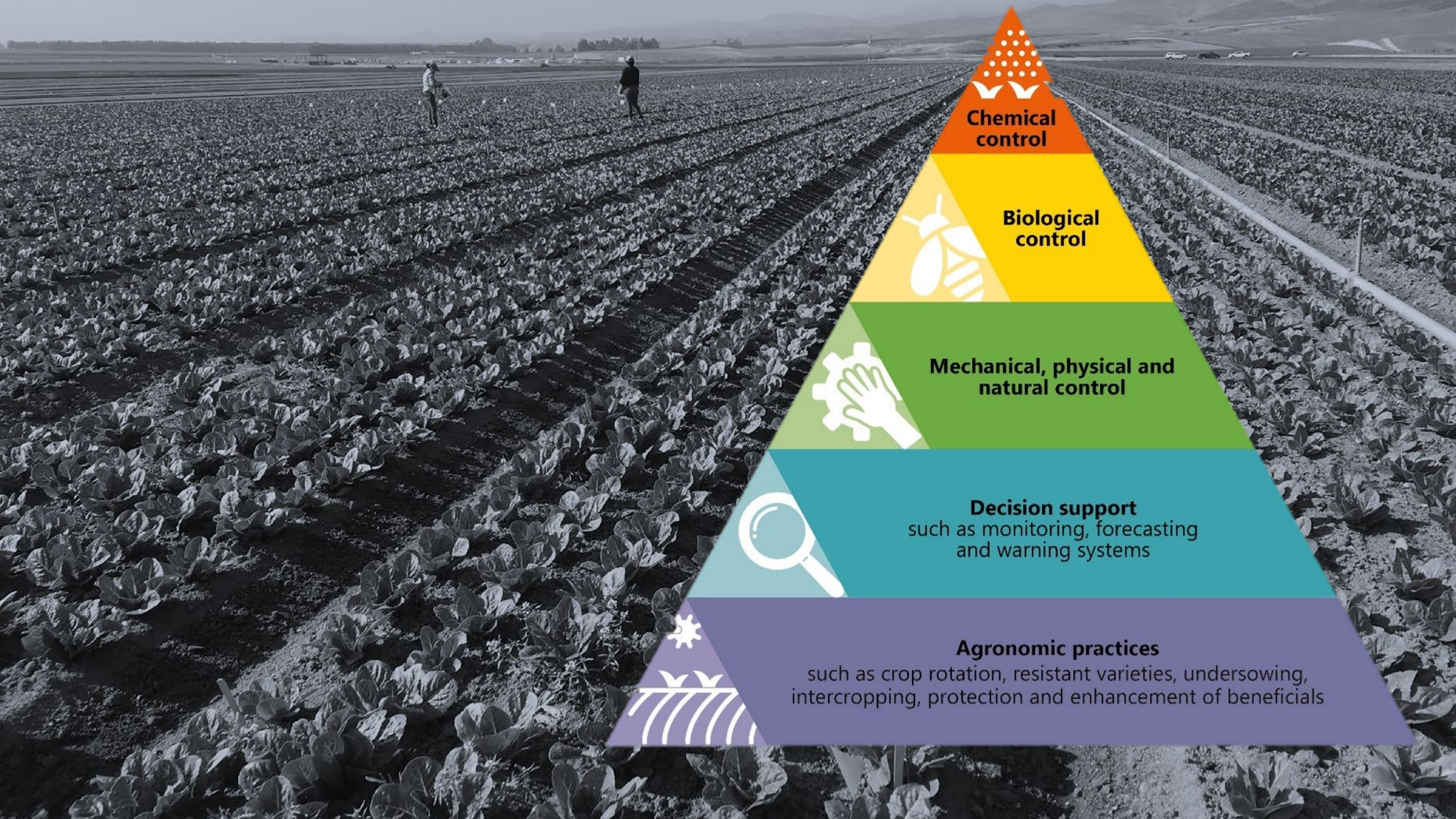
# *Management of insect pests in lettuce and cole crops: research updates*

Ian Grettenberger, Sophie Allen, Jadyn Sacoolas, Addie Abrams, and Daniel Hasegawa


Chemical control
Biological control
Mechanical, physical and natural control
Decision support
such as monitoring, forecasting and warning systems
Agronomic practices
such as crop rotation, resistant varieties, undersowing, intercropping, protection and enhancement of beneficials

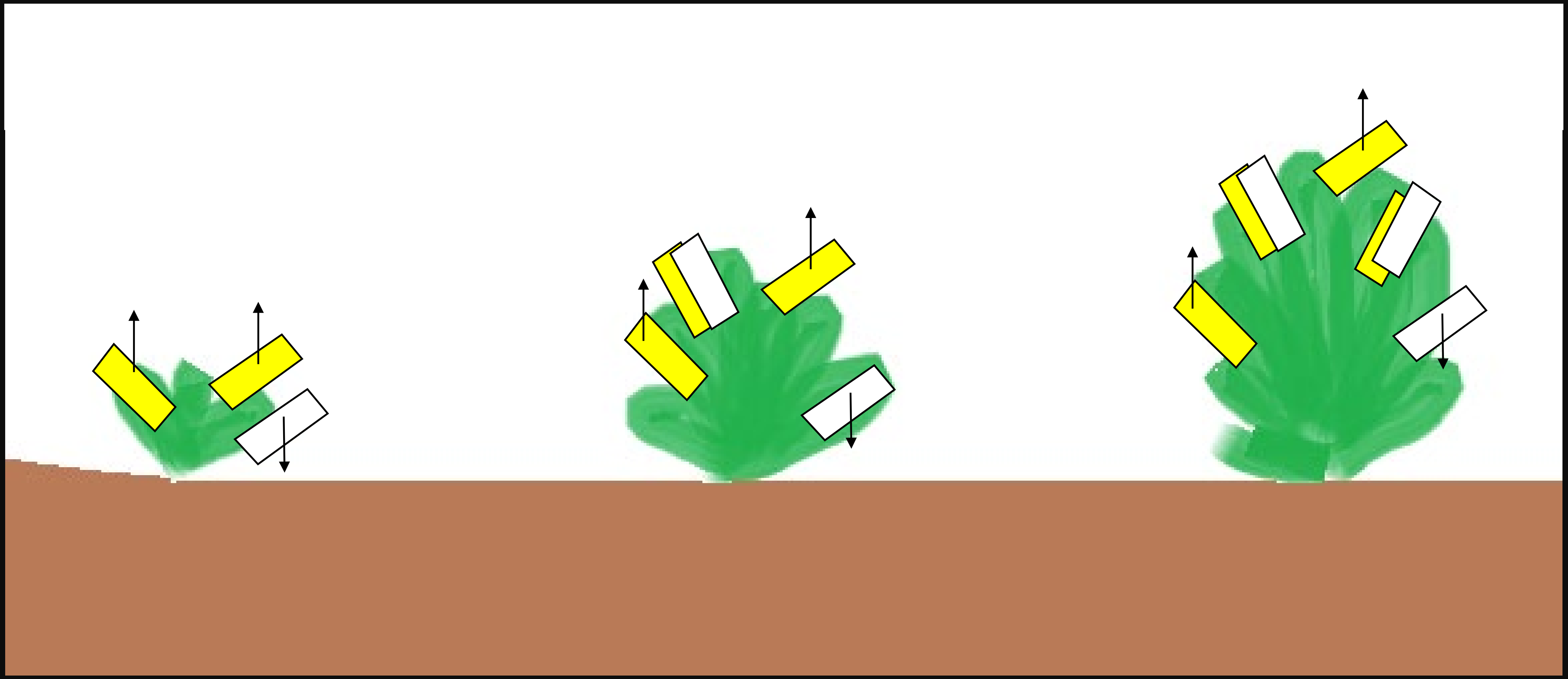

Kuo et al. 2014

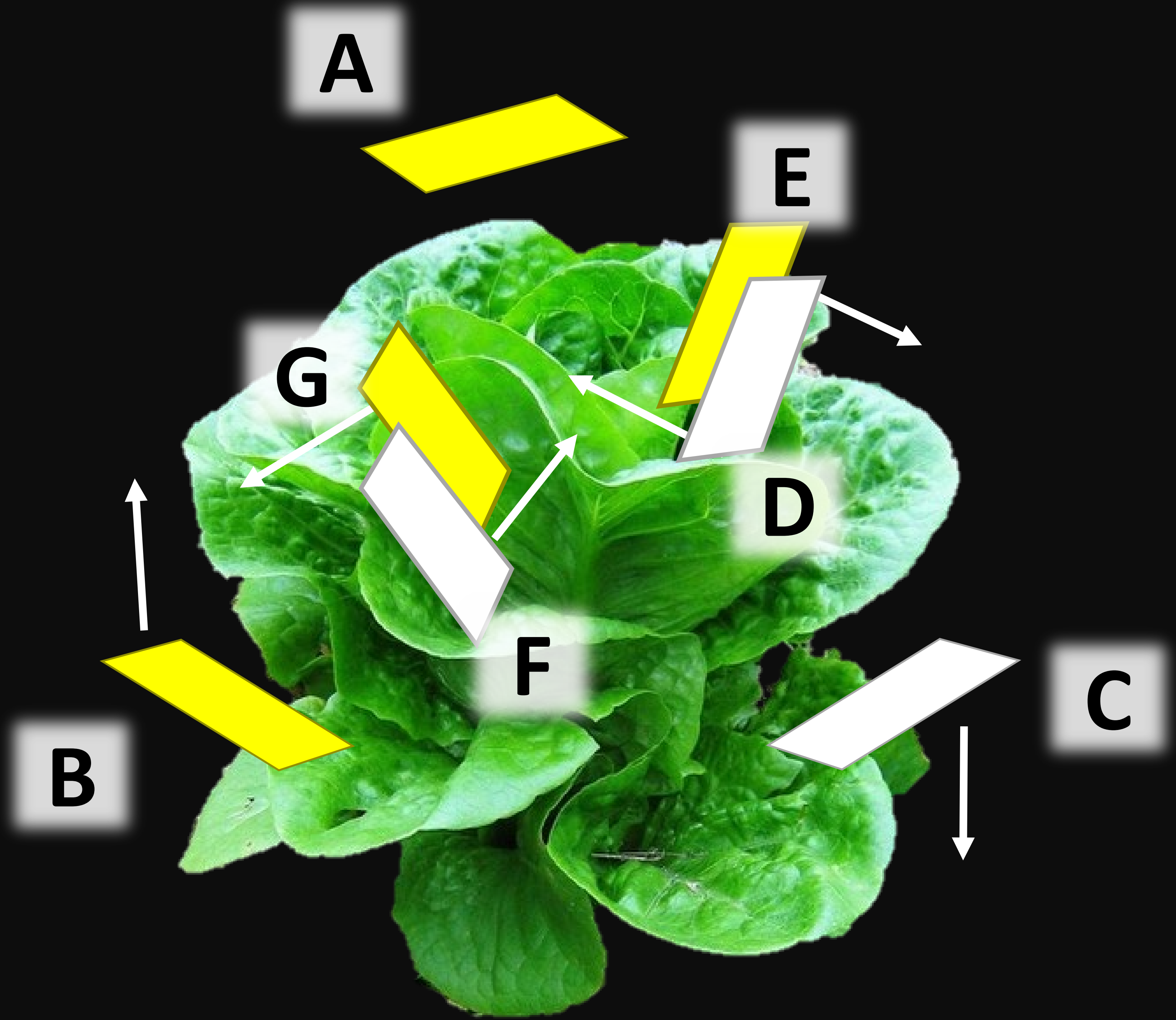

Chemical control
Biological control
Mechanical, physical and natural control
Decision support
such as monitoring, forecasting and warning systems
Agronomic practices
such as crop rotation, resistant varieties, undersowing, intercropping, protection and enhancement of beneficials
Estwing


3 cards

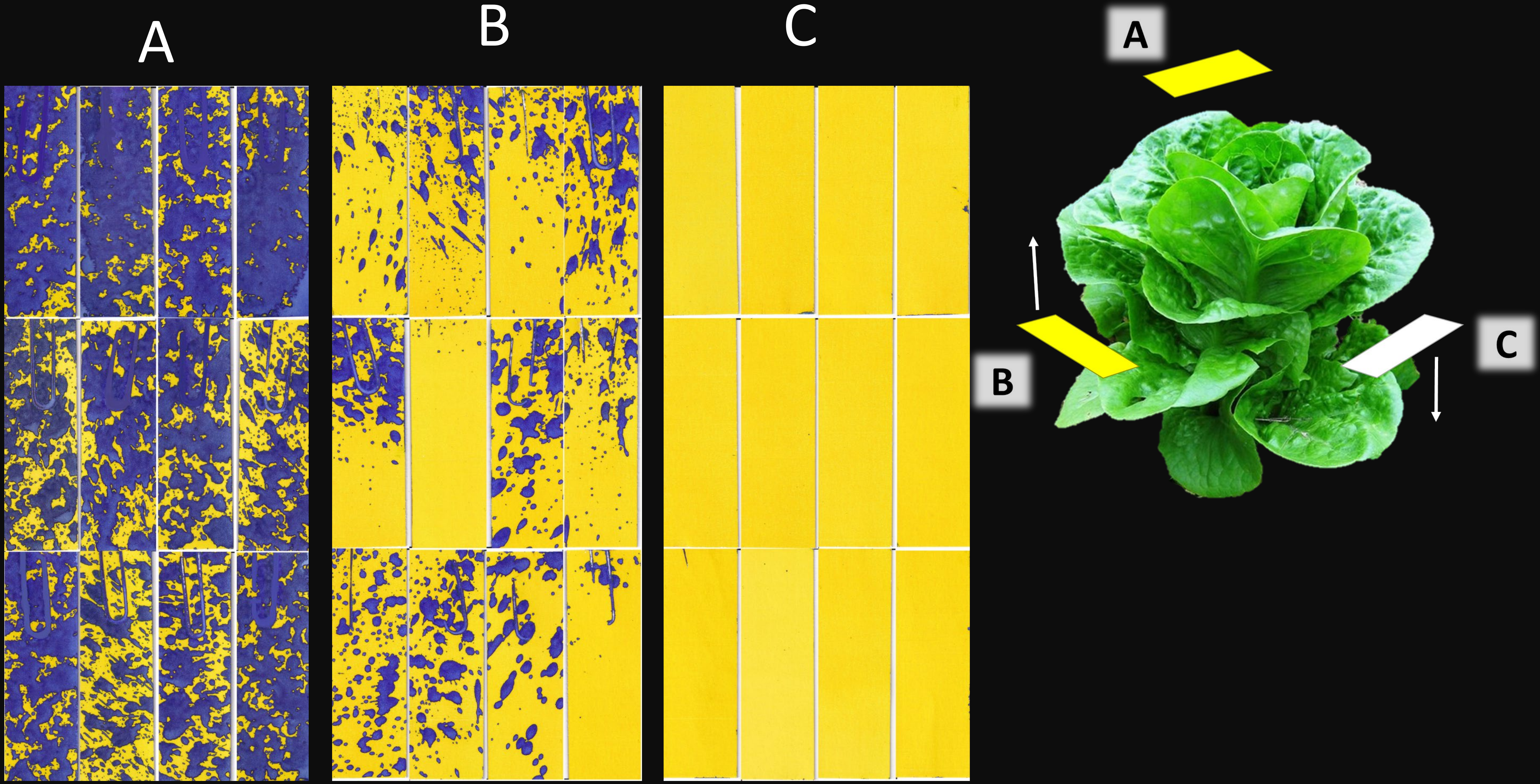
5 cards

7 cards



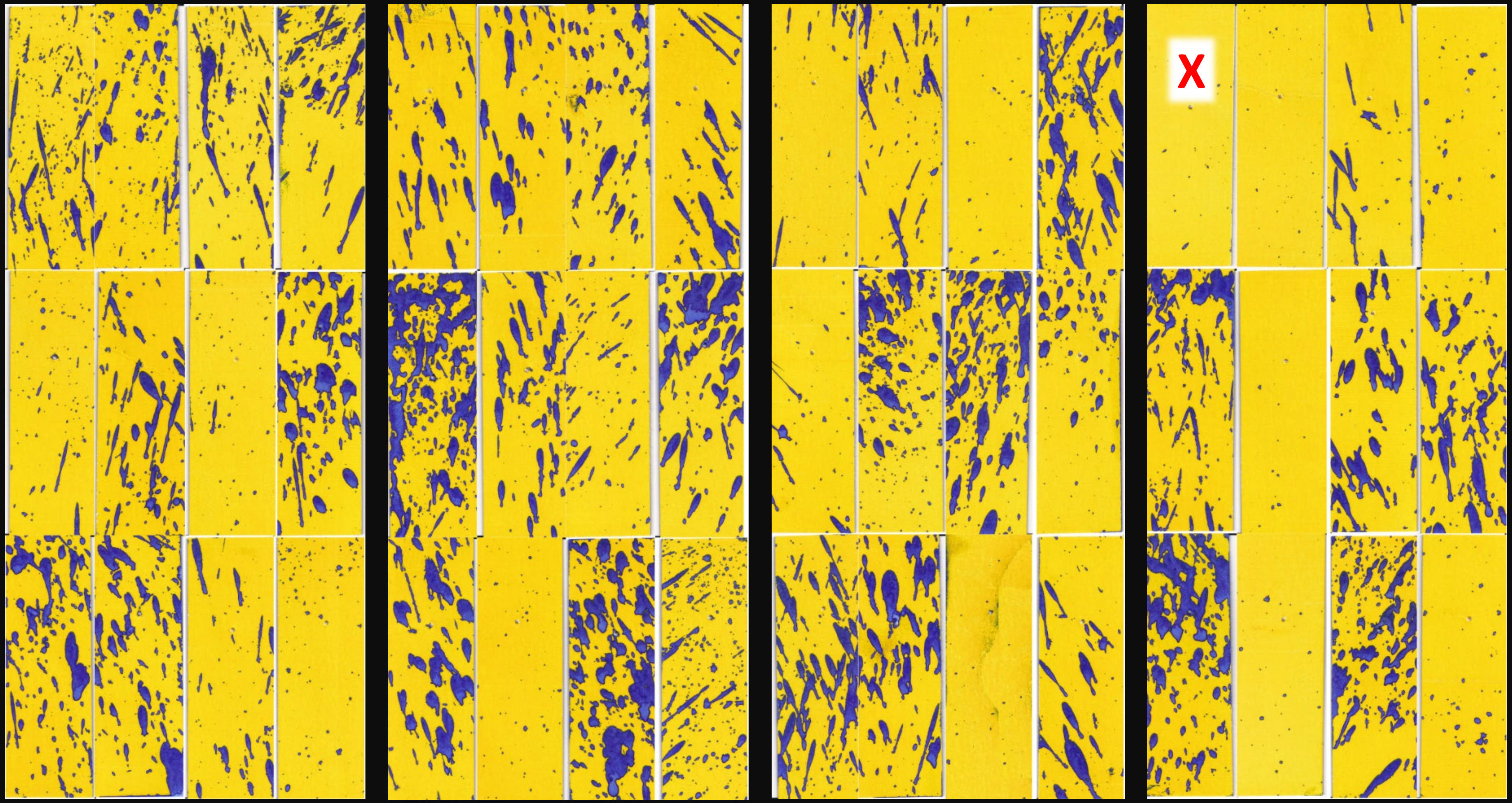

A
E
G
D
F
C
B

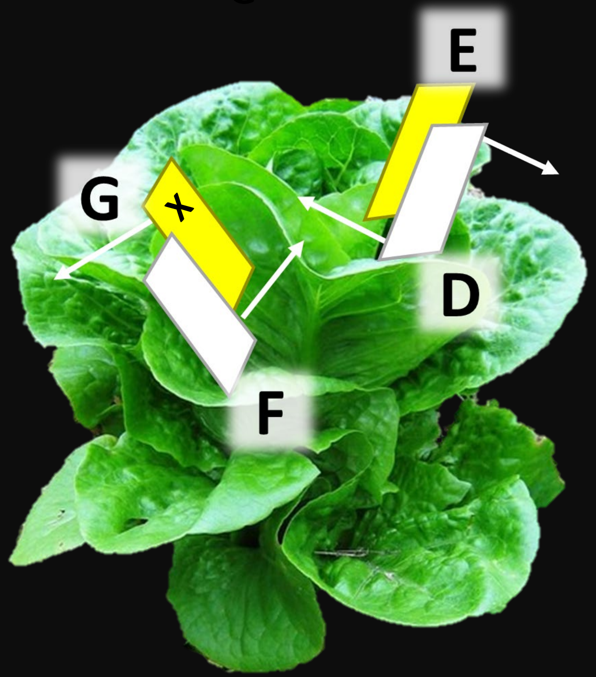


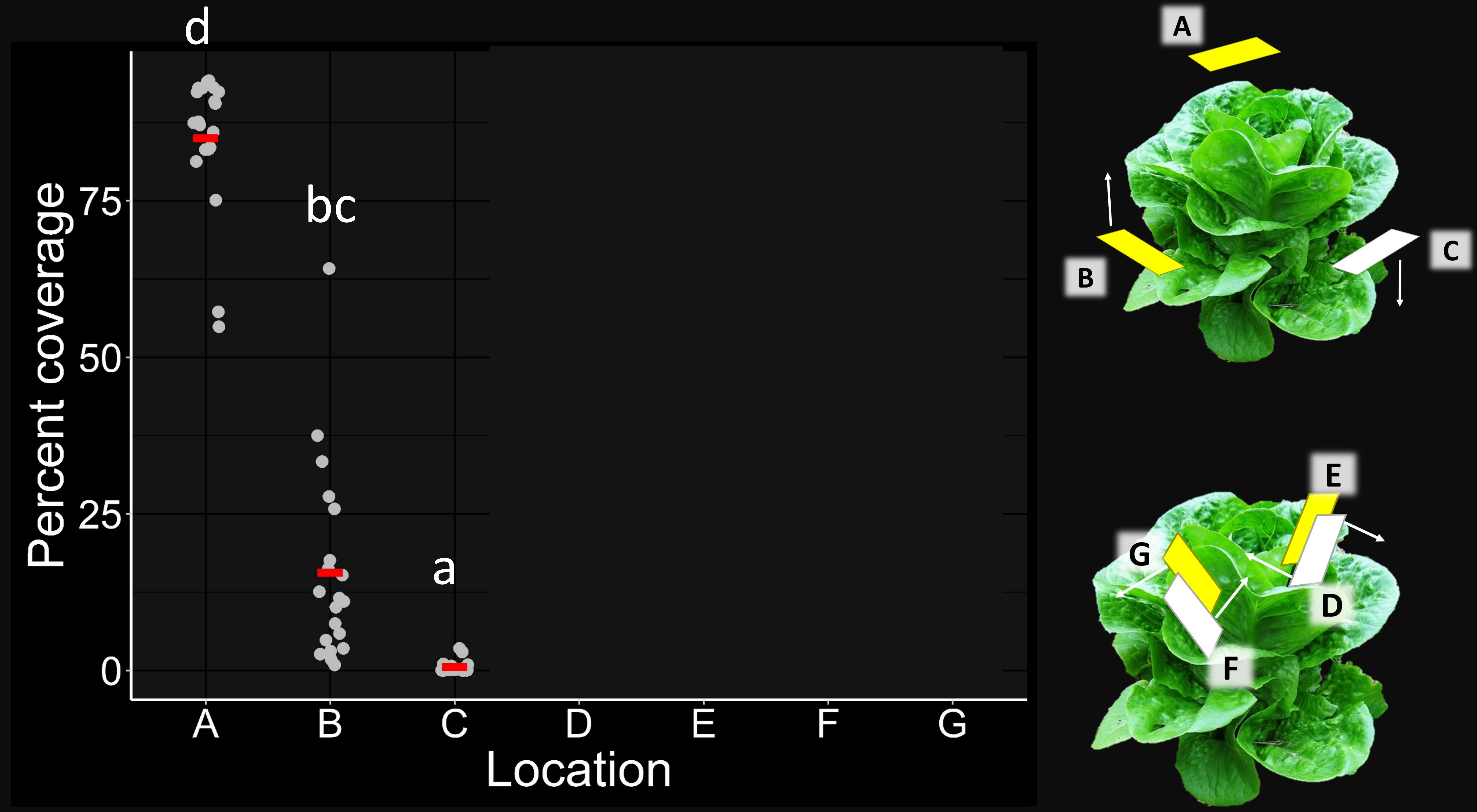

A
B
C
A
B
C

D E F G

D E F G



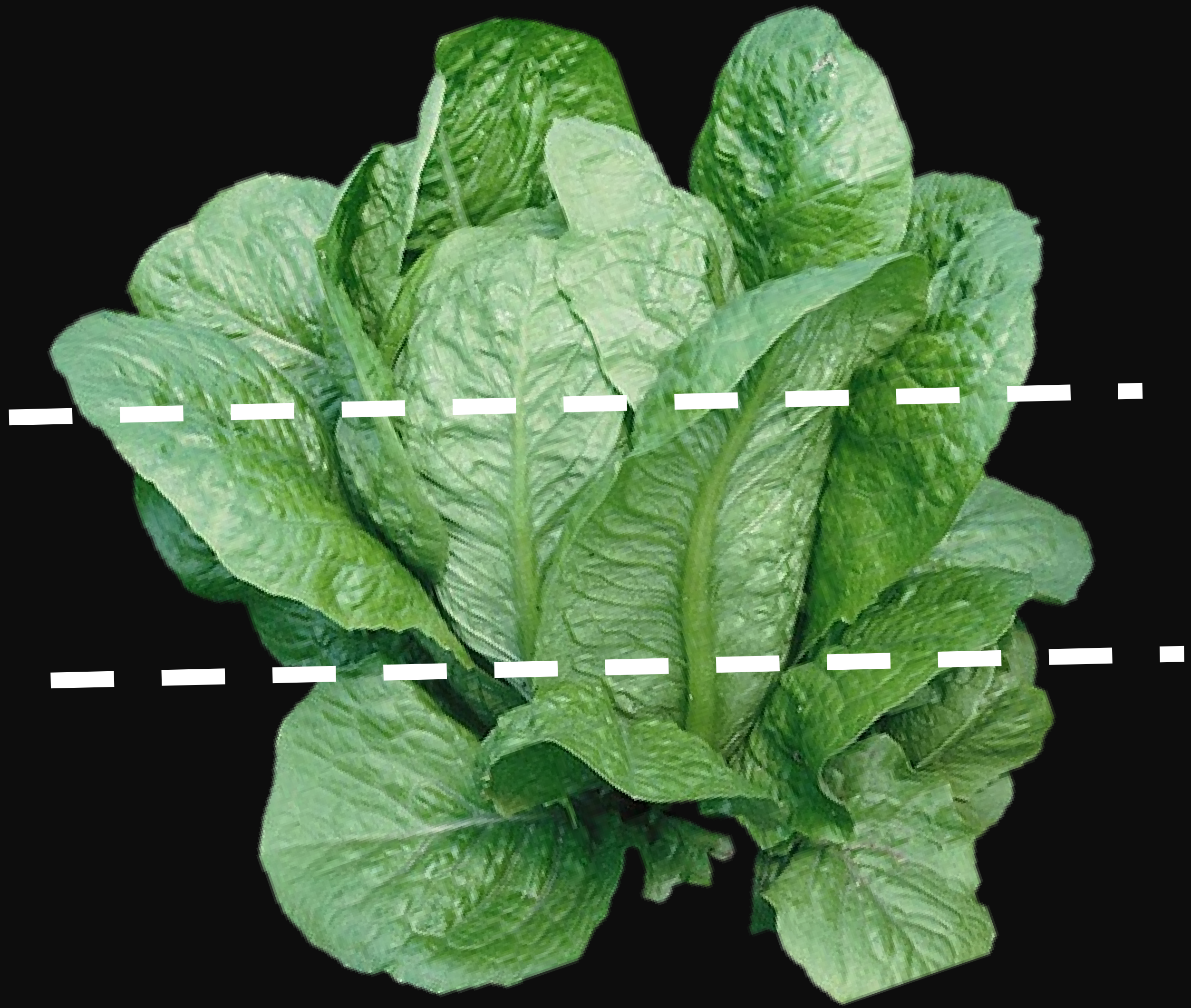





d
bc
a
Percent coverage
0
25
50
75
A
B
C
D
E
F
G
Location
A
B
C
E
G
D
F

- Two fields (Romaine)
- Two time points
  - Day
  - Night
- Vertical distribution

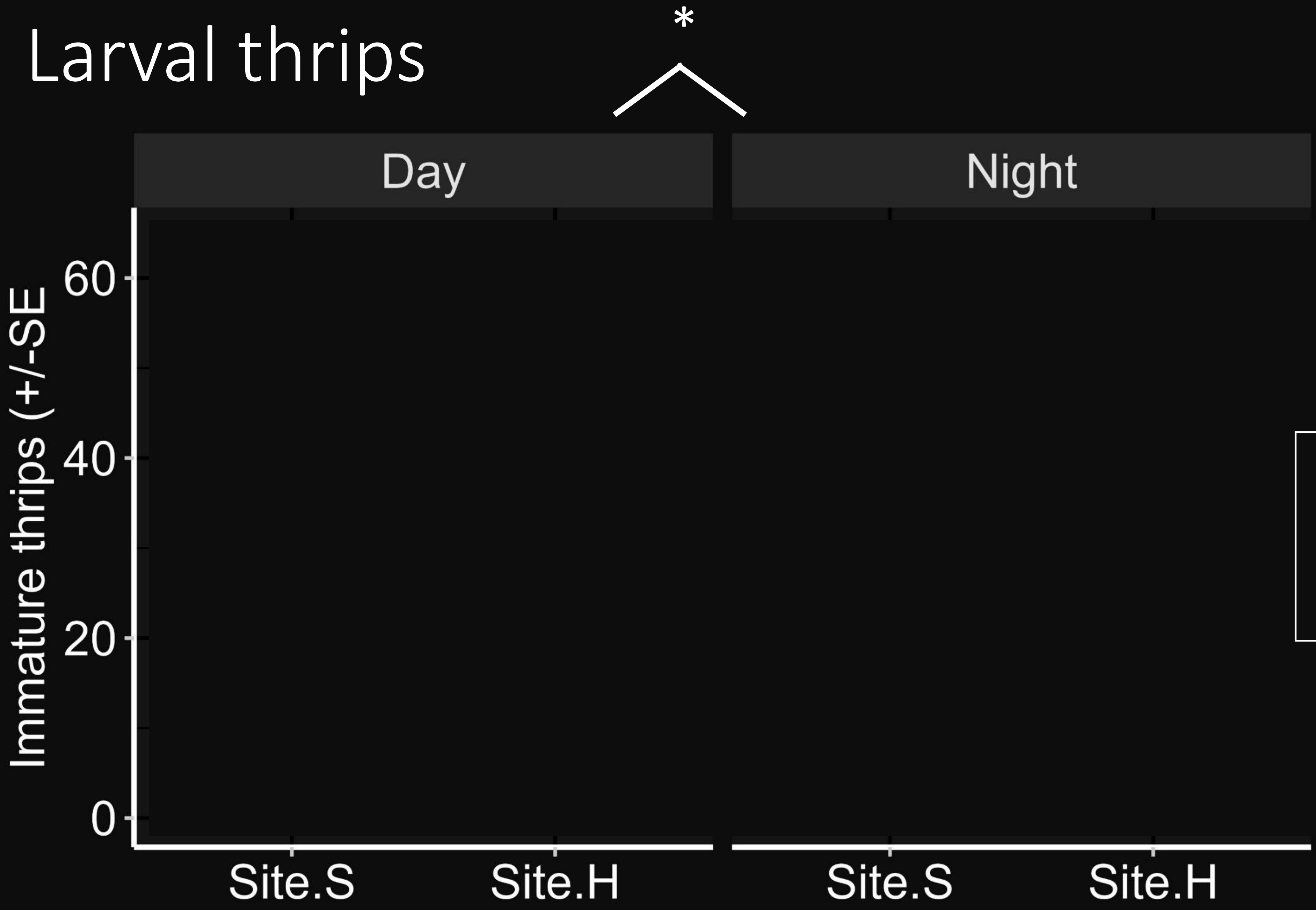
# Upper vs. middle vs. lower lettuce



# Day vs. night

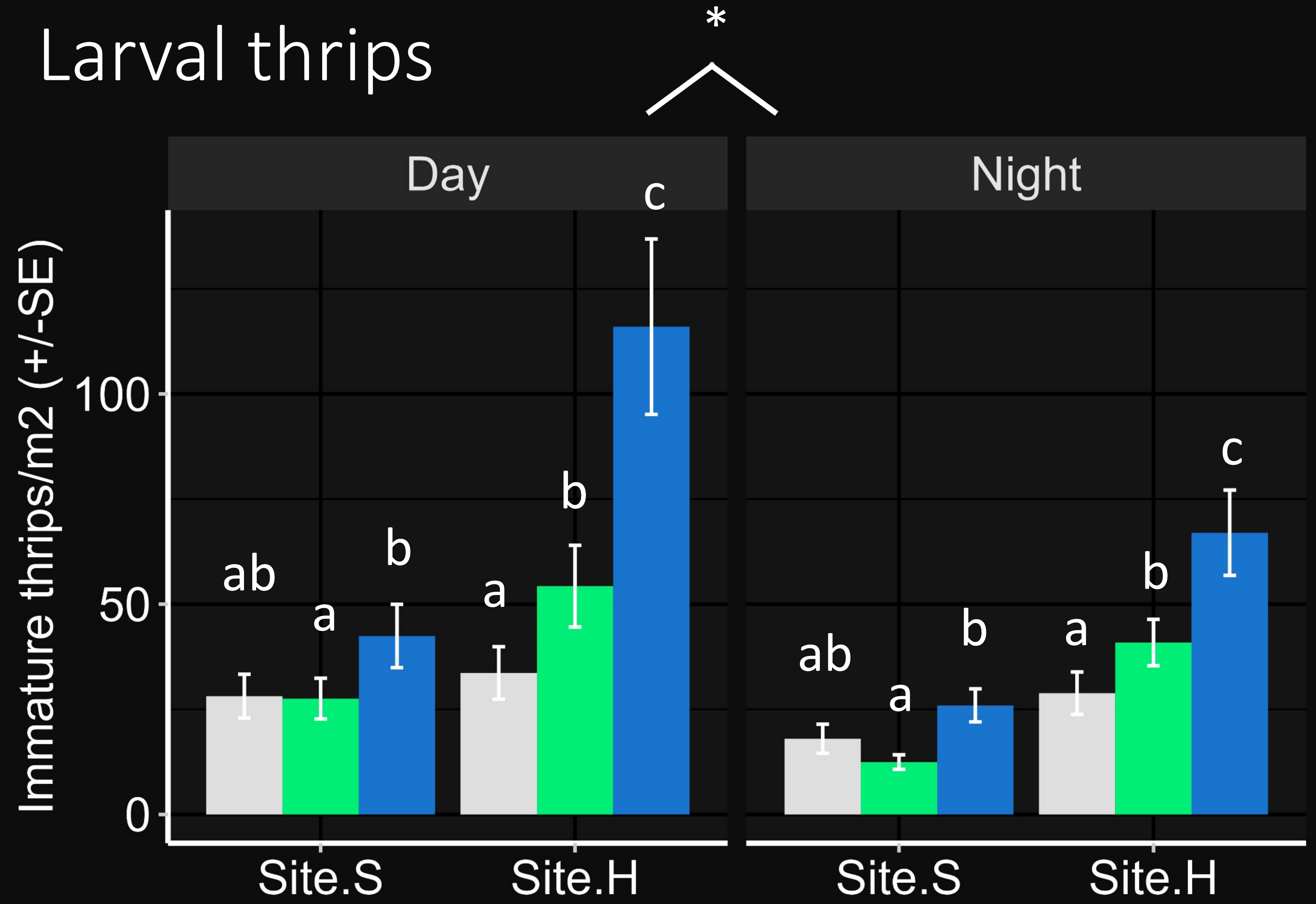
# Assess surface area – pests operating at this level

# Larval thrips




Raw count

# Larval thrips

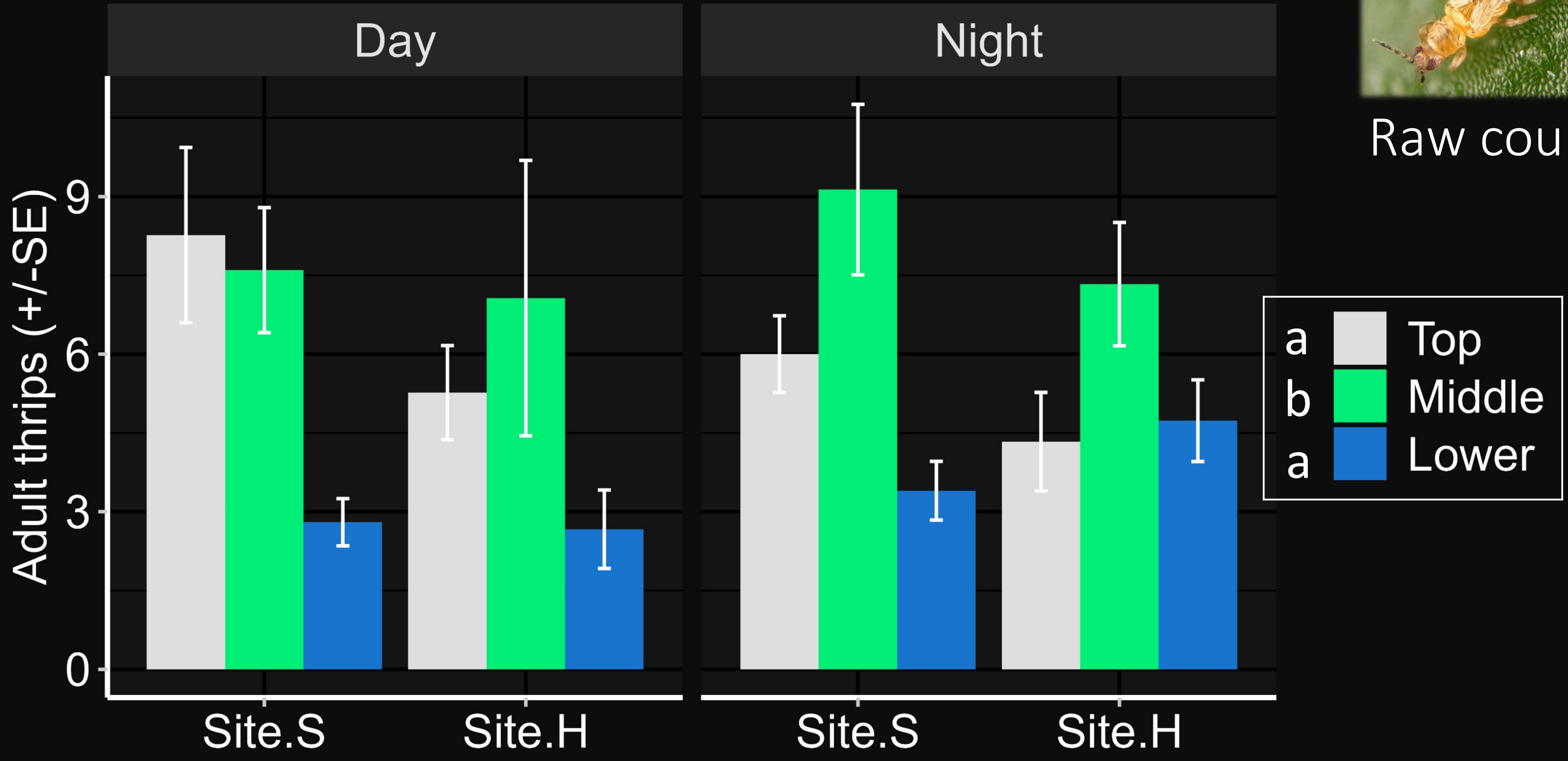



per m$^2$

# Adult thrips

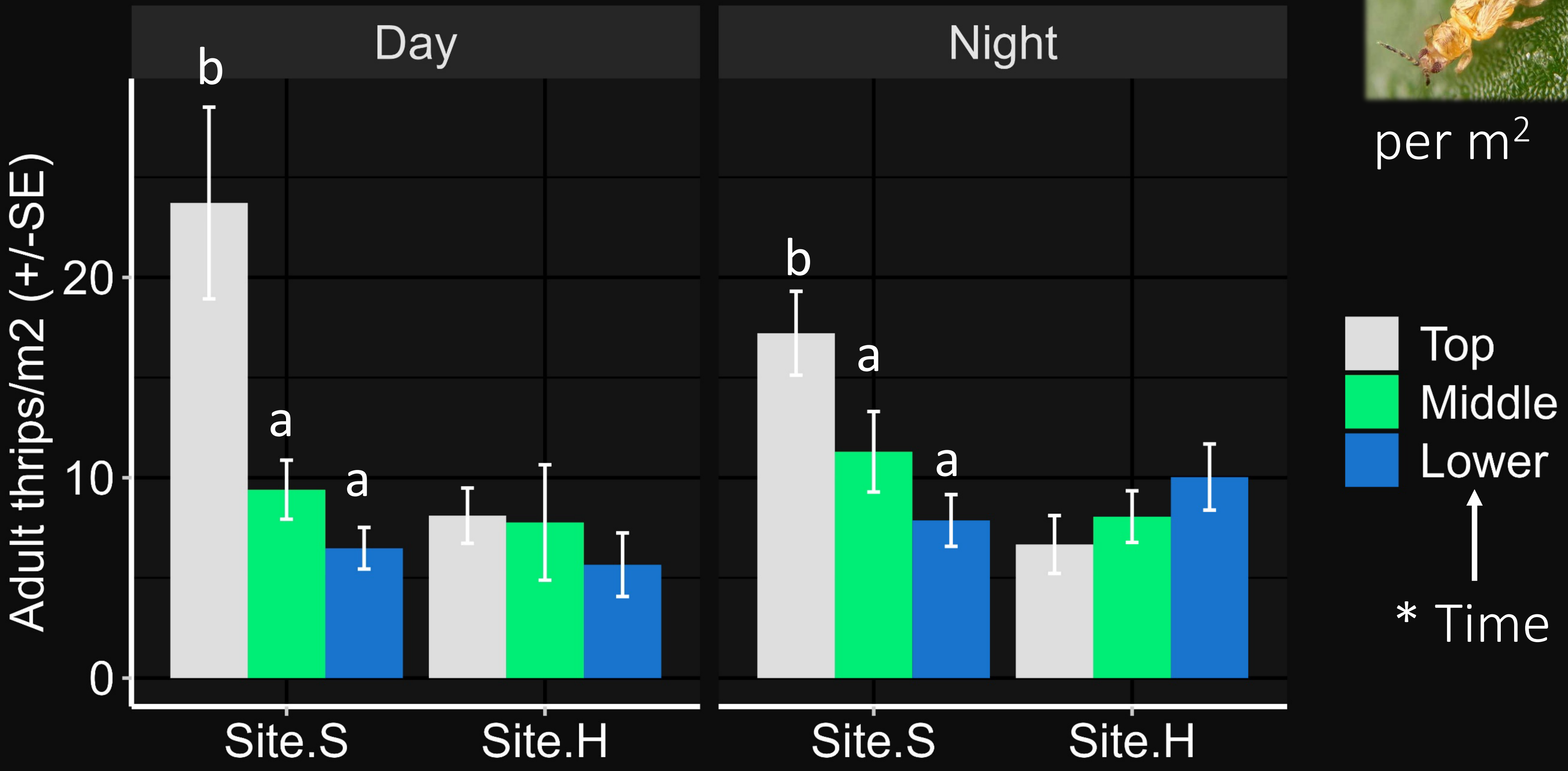
Raw count

# Adult thrips



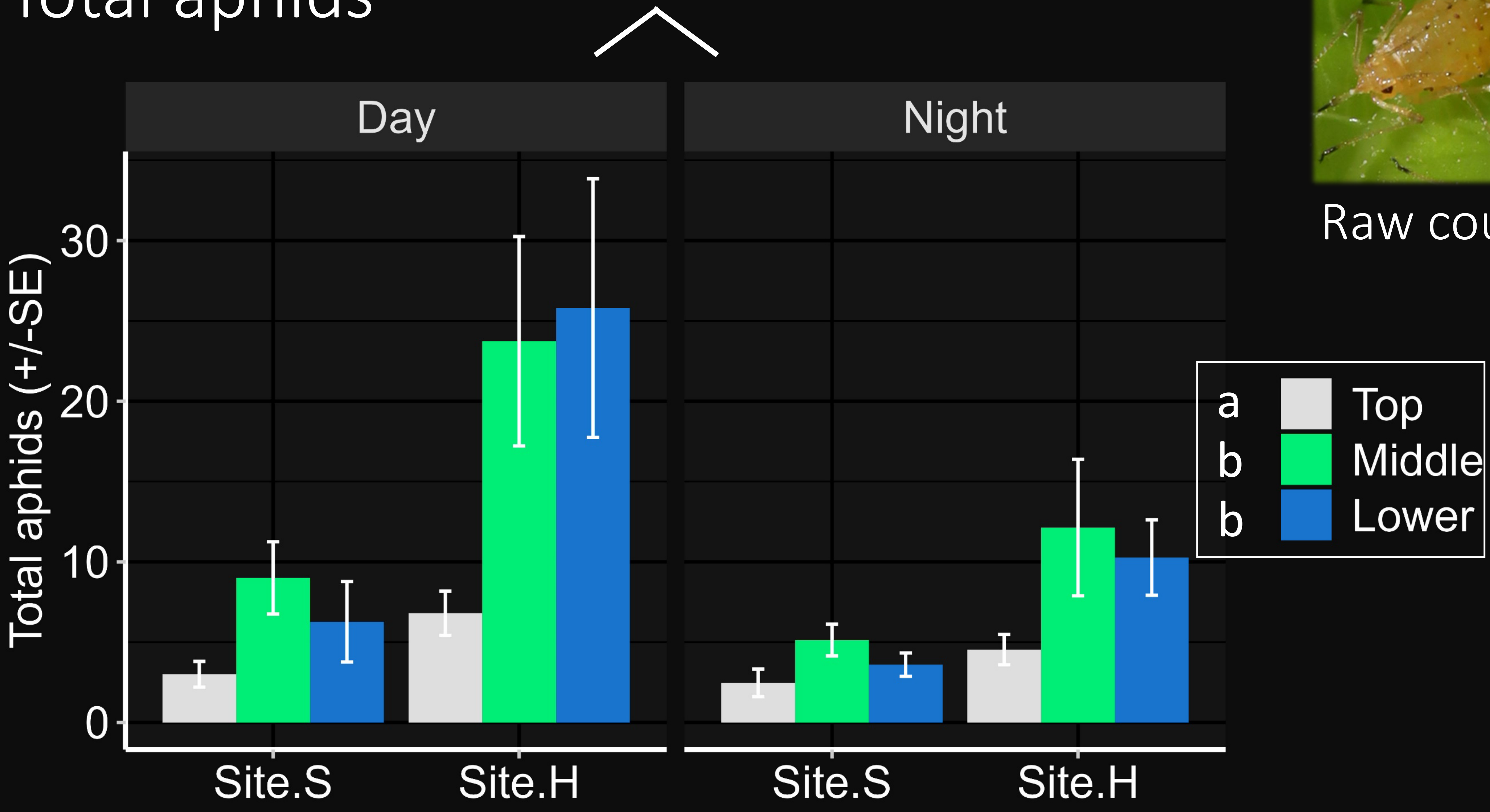

Raw count

# Adult thrips



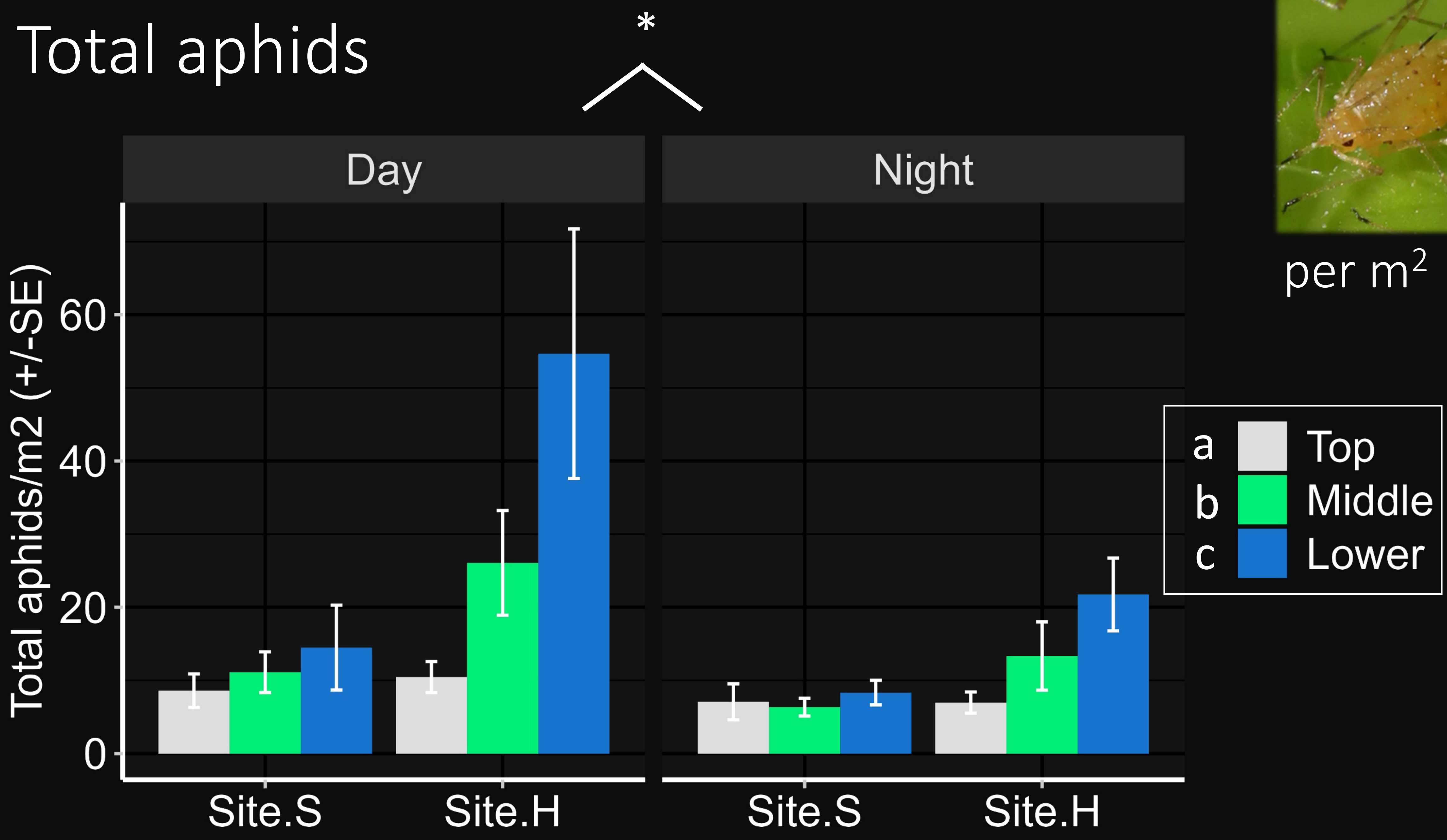

per m$^2$

# Total aphids

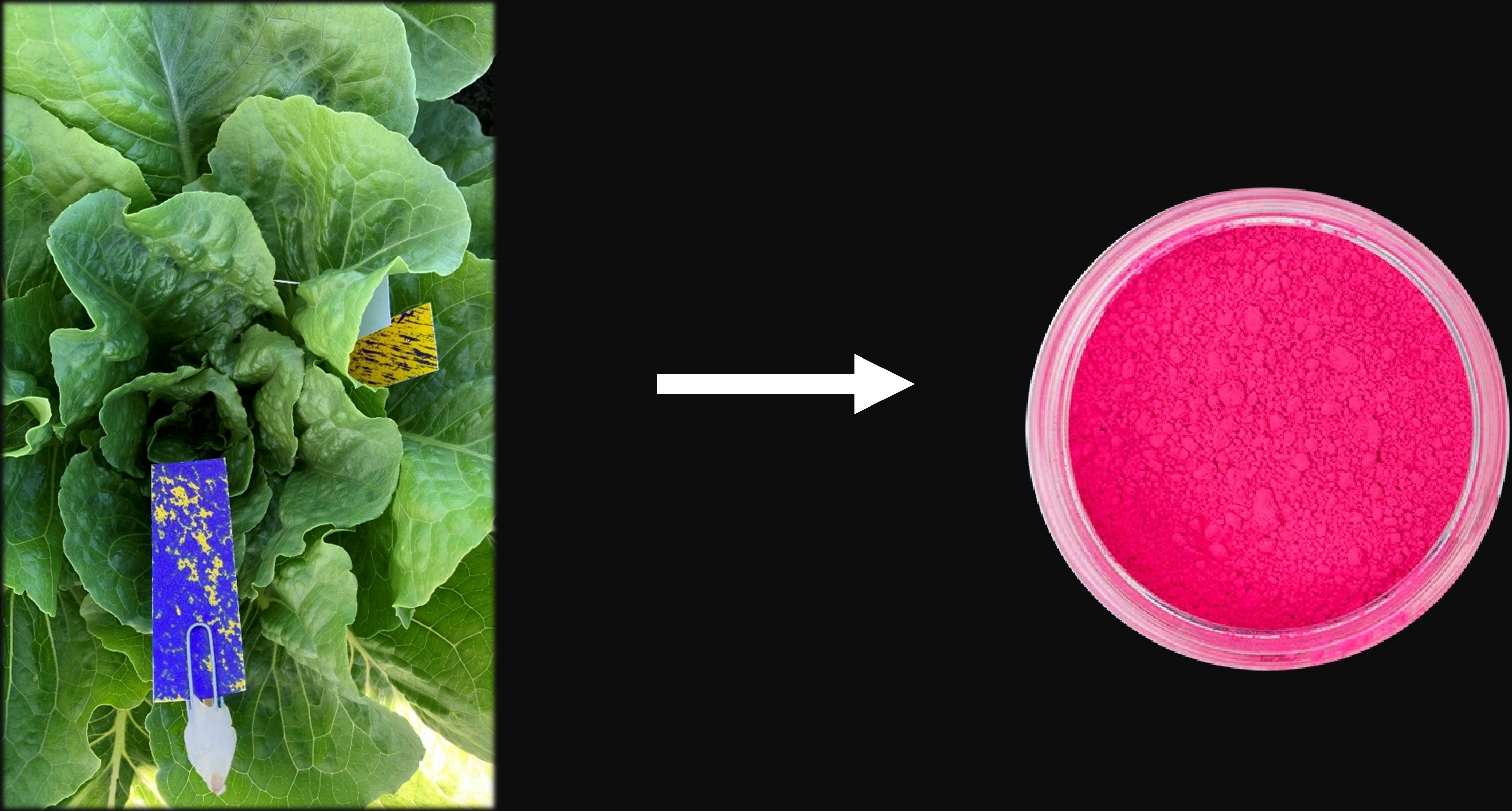



Raw count

# Total aphids

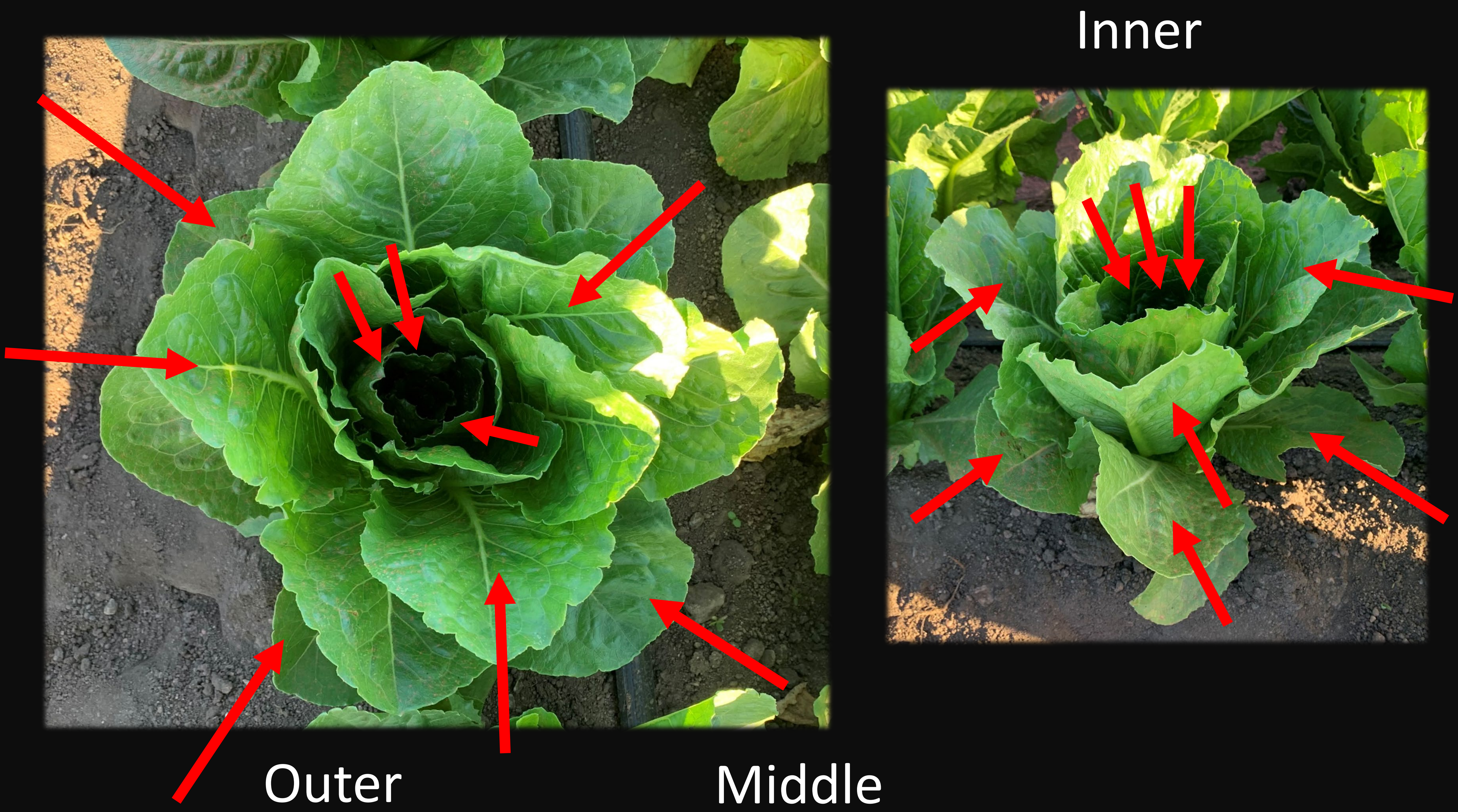



per m$^2$

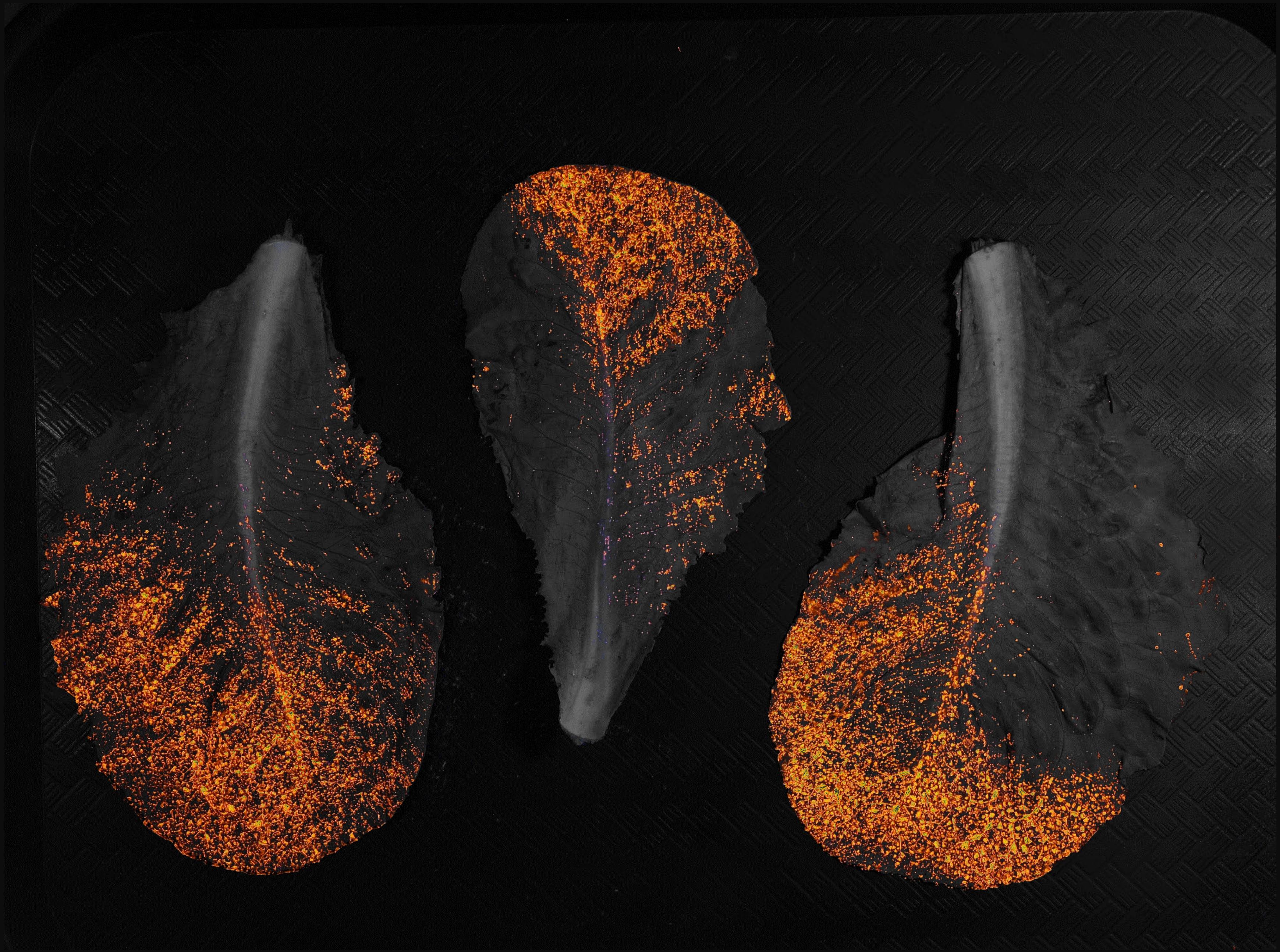


# Coverage:
# Leaf location × adjuvant × volume

- 3 Adjuvants
  - Embrece-EA (16 oz/100gal)
  - SYL-COAT (8 oz/100gal)
  - ~~Dyne-Amic (16 oz/100gal)~~
- 2 Volumes
  - 60 GPA
  - 90 GPA
- Rocket Red DayGlo powder – 0.5%
- XR8004VS XR TeeJet

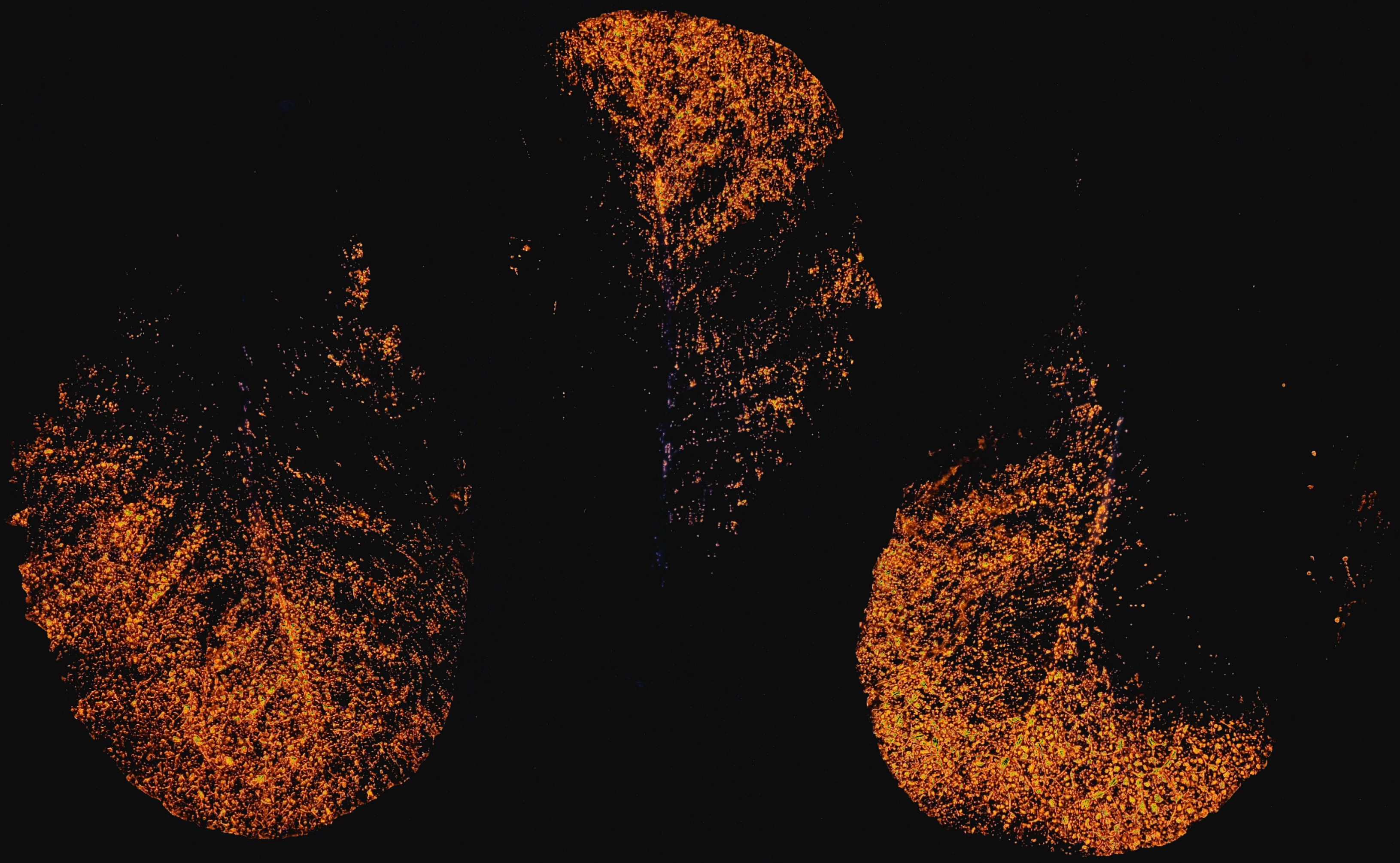

Inner
Outer
Middle

Outer
Upper



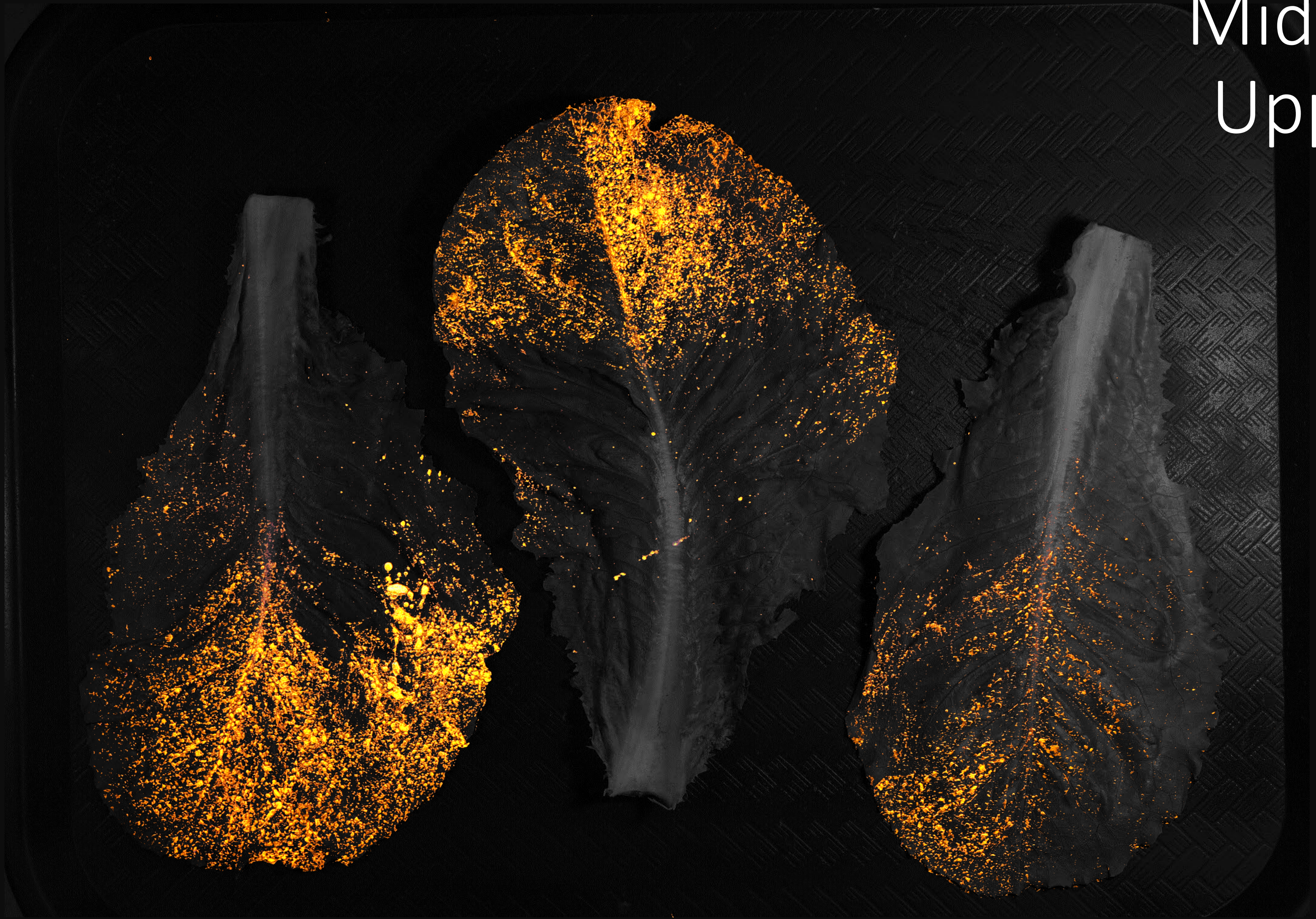
Outer
Upper

Outer
Upper

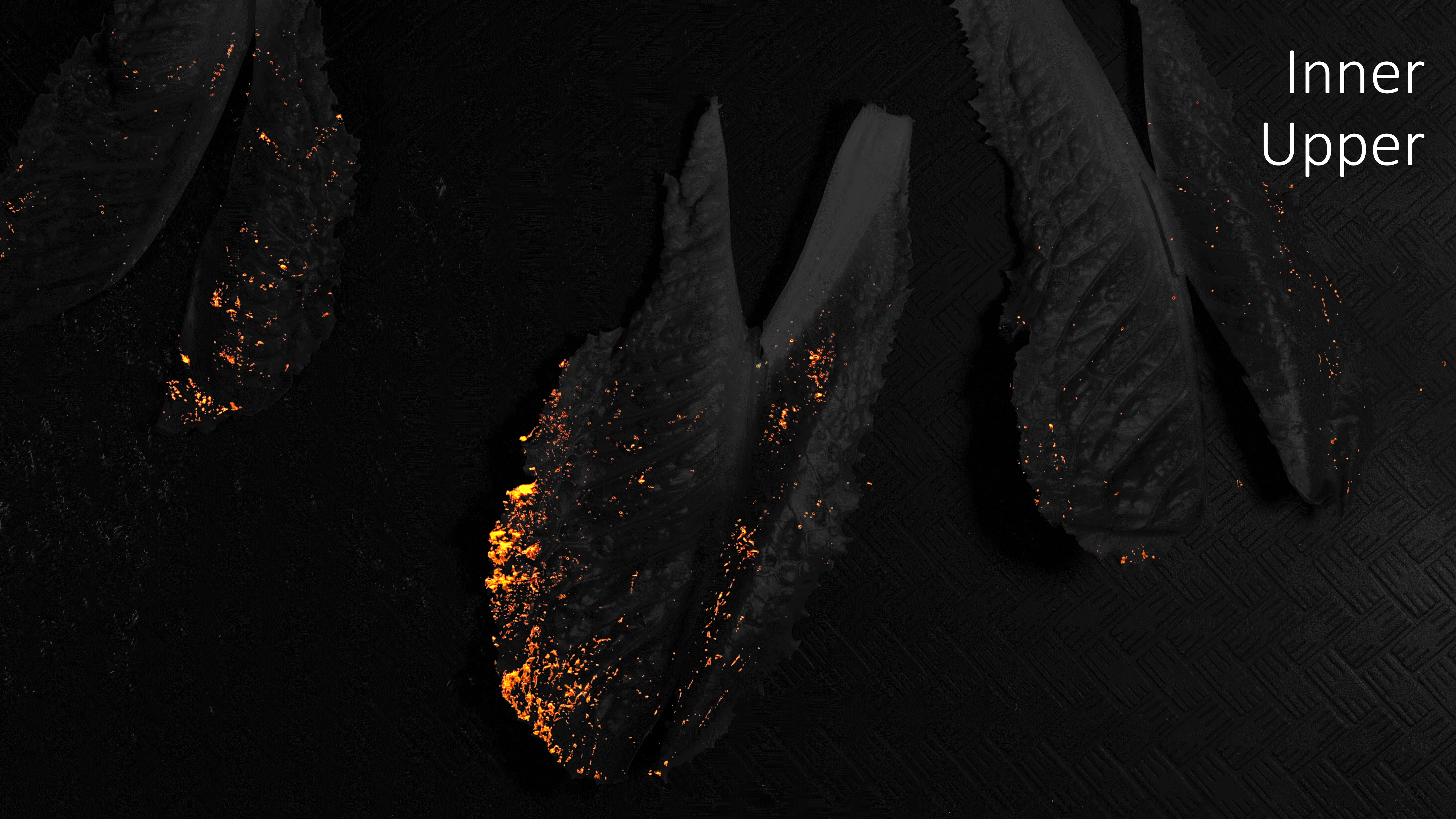


# Outer Underside


Middle
Upper


Middle
Upper

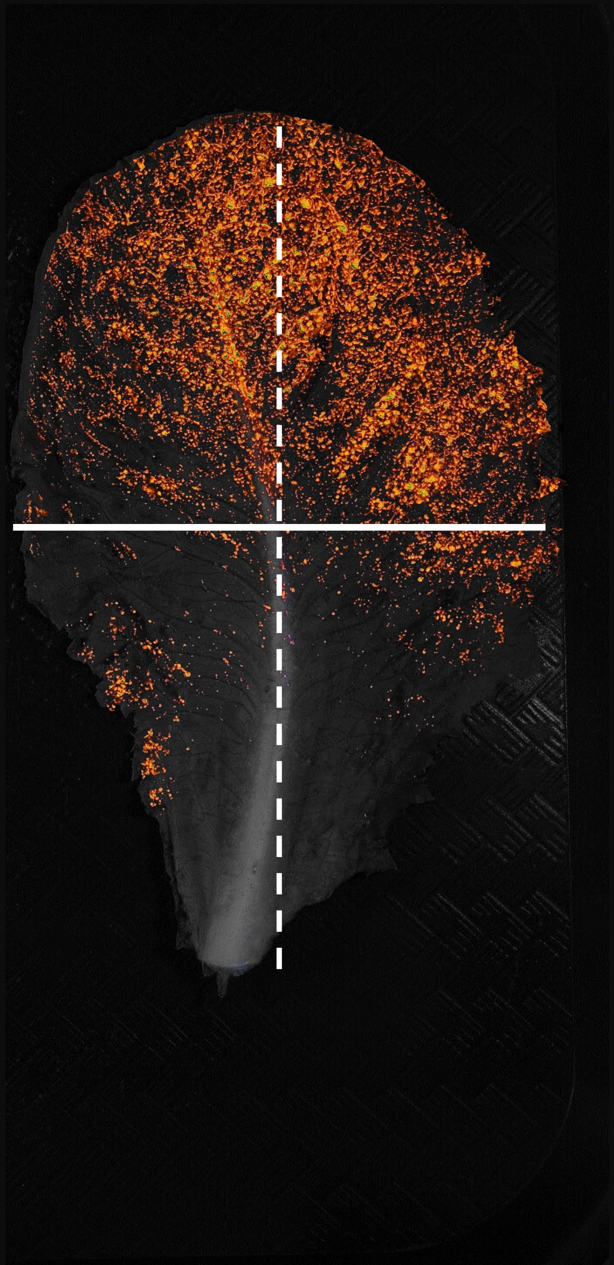
Inner Upper

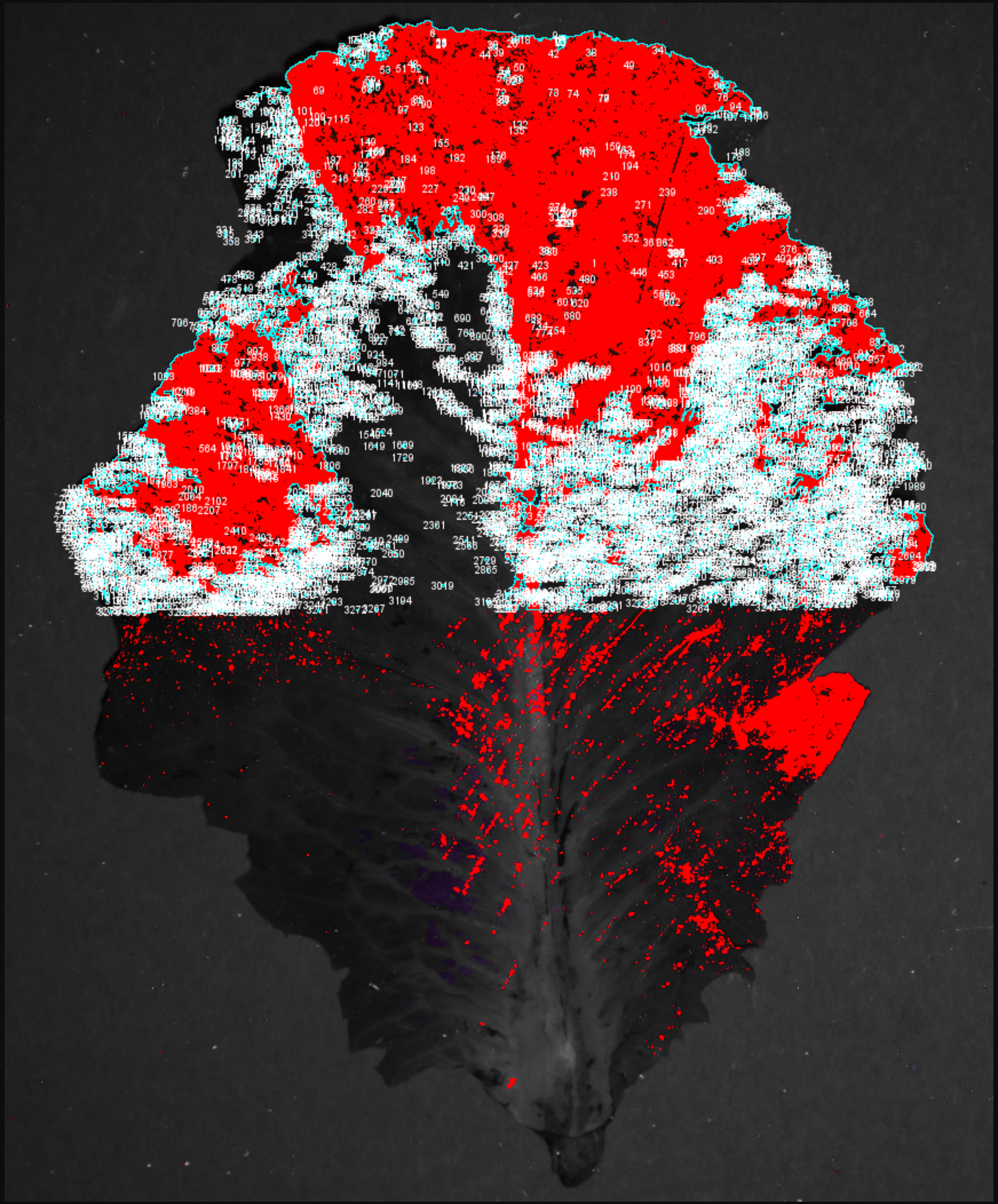

Inner
Upper

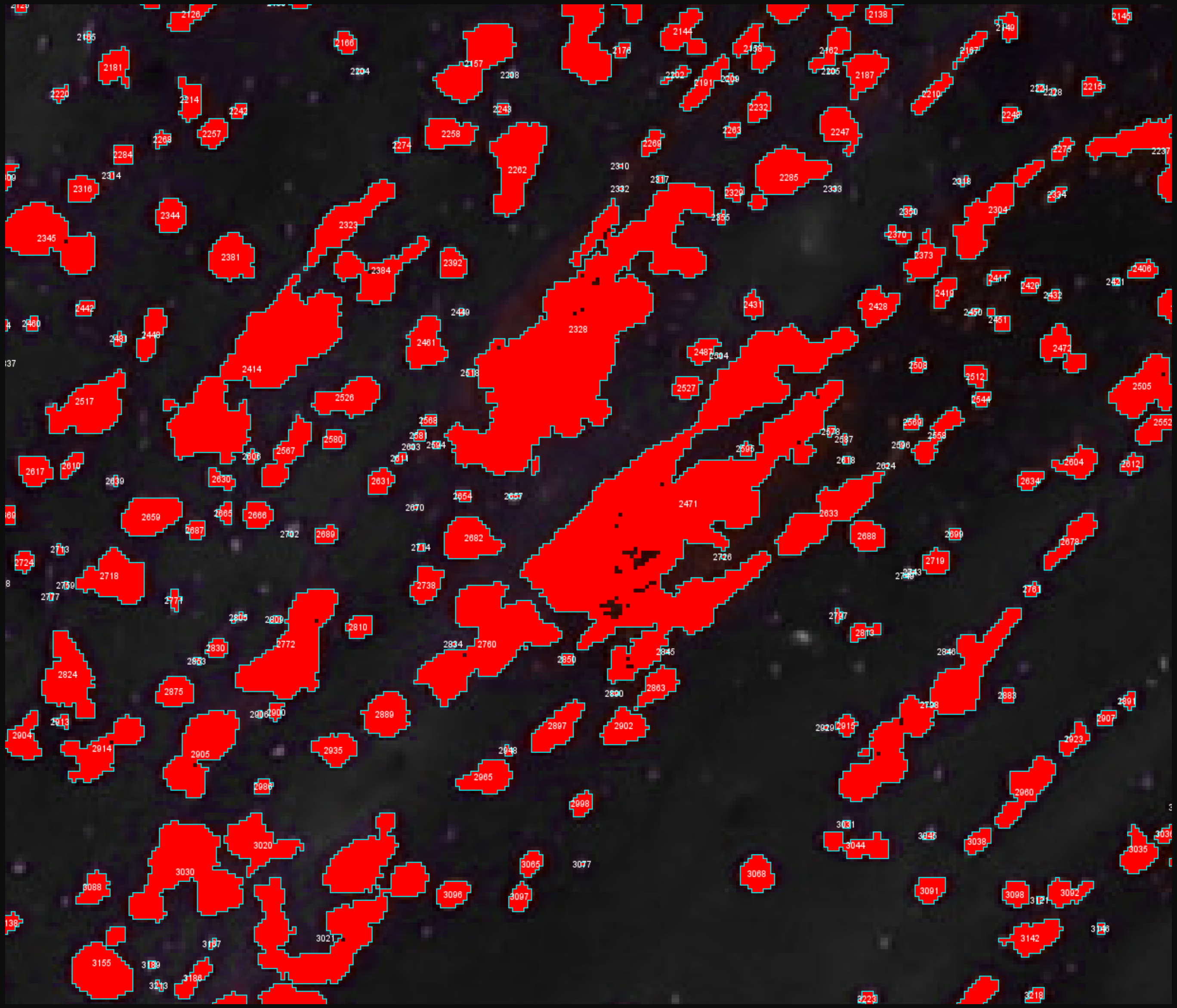
Outer
Upper

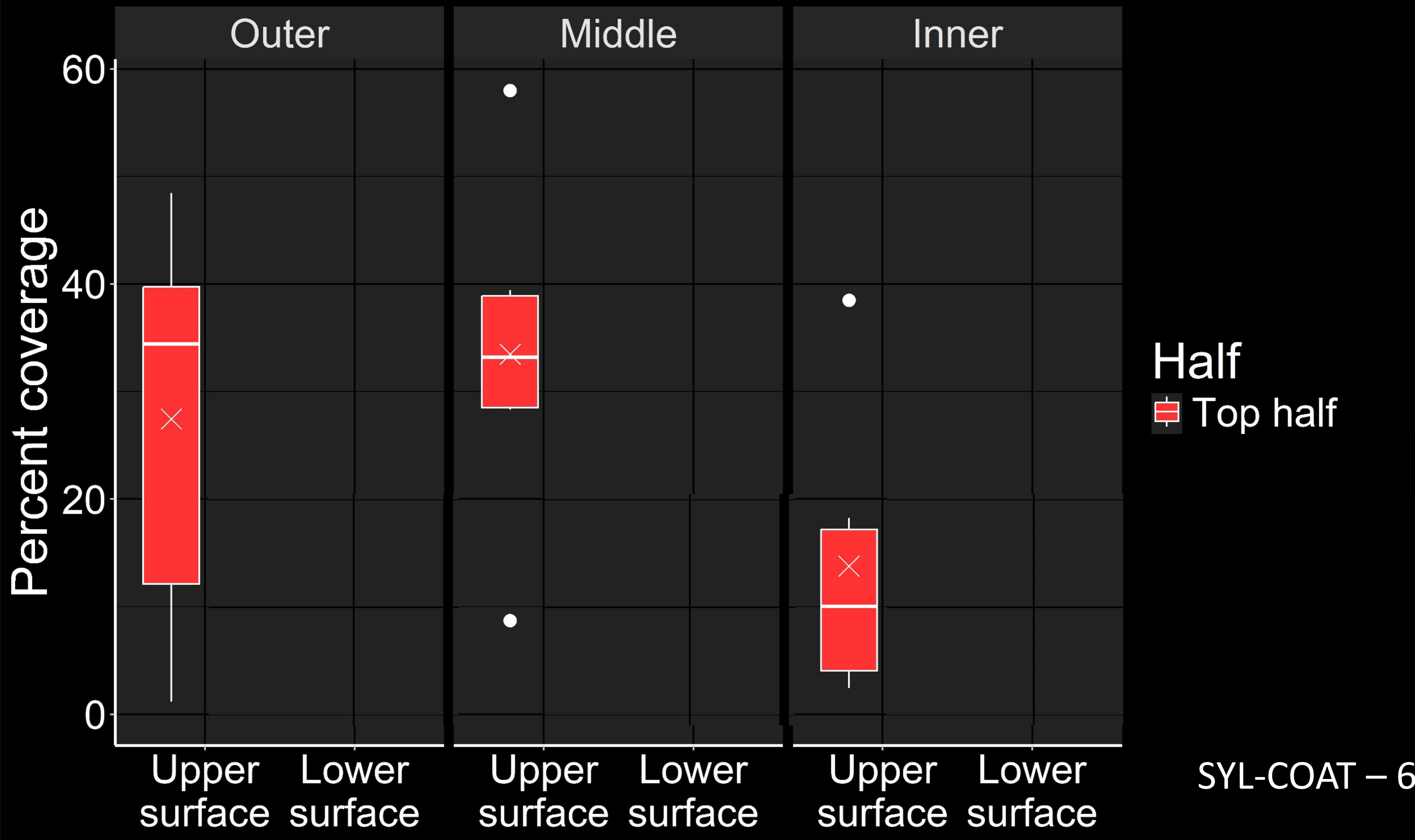
Top half

Bottom half

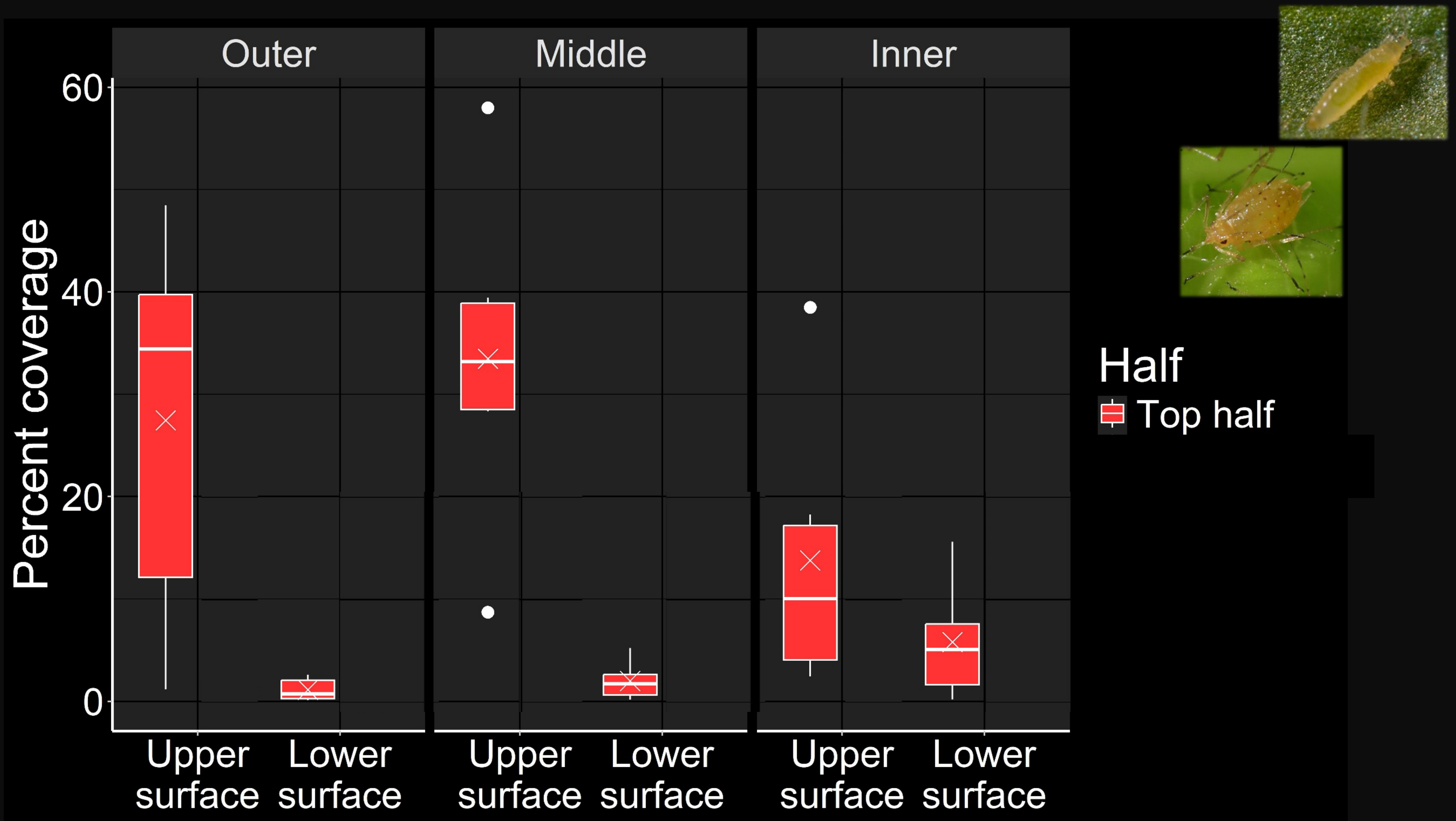


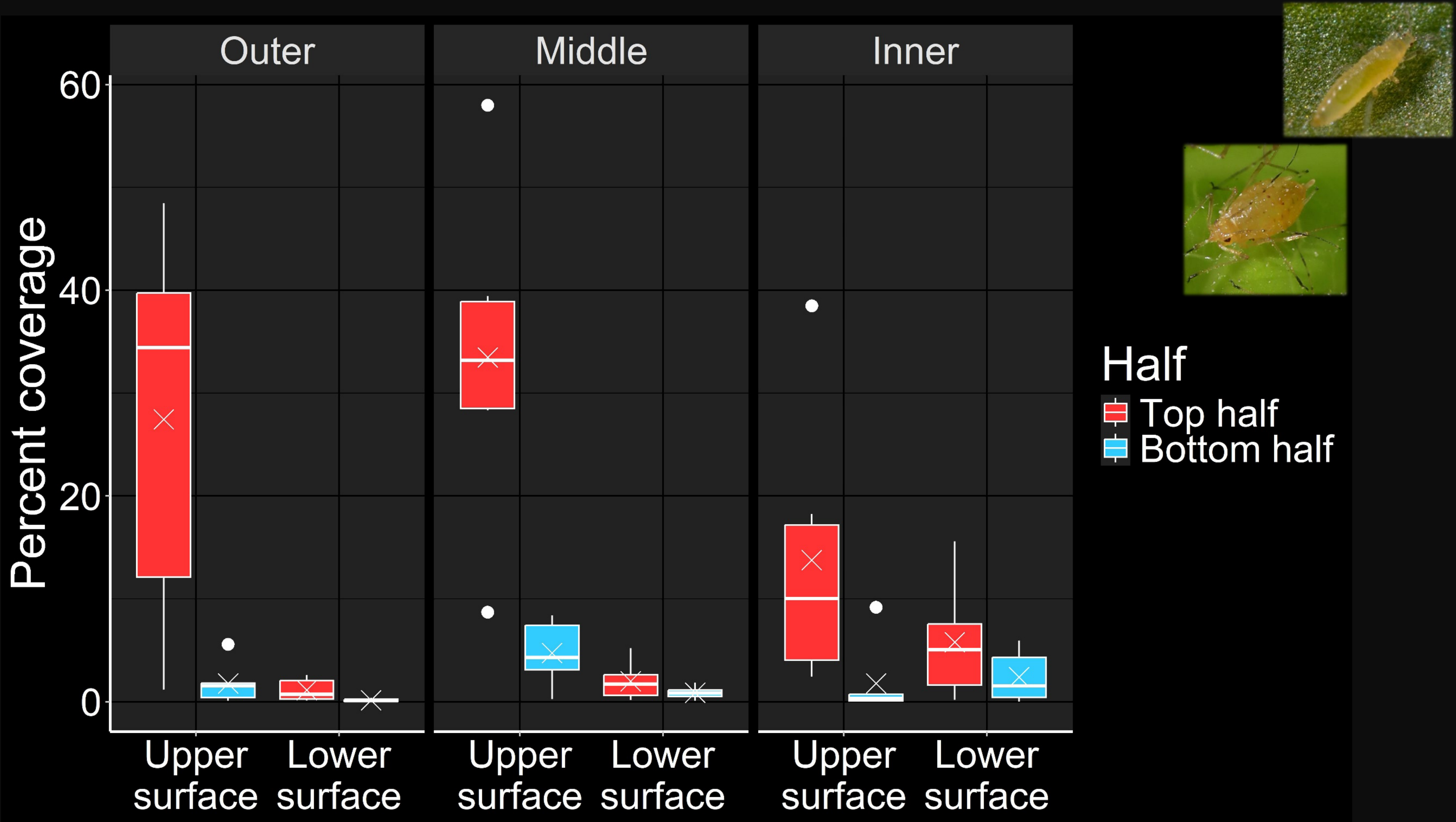




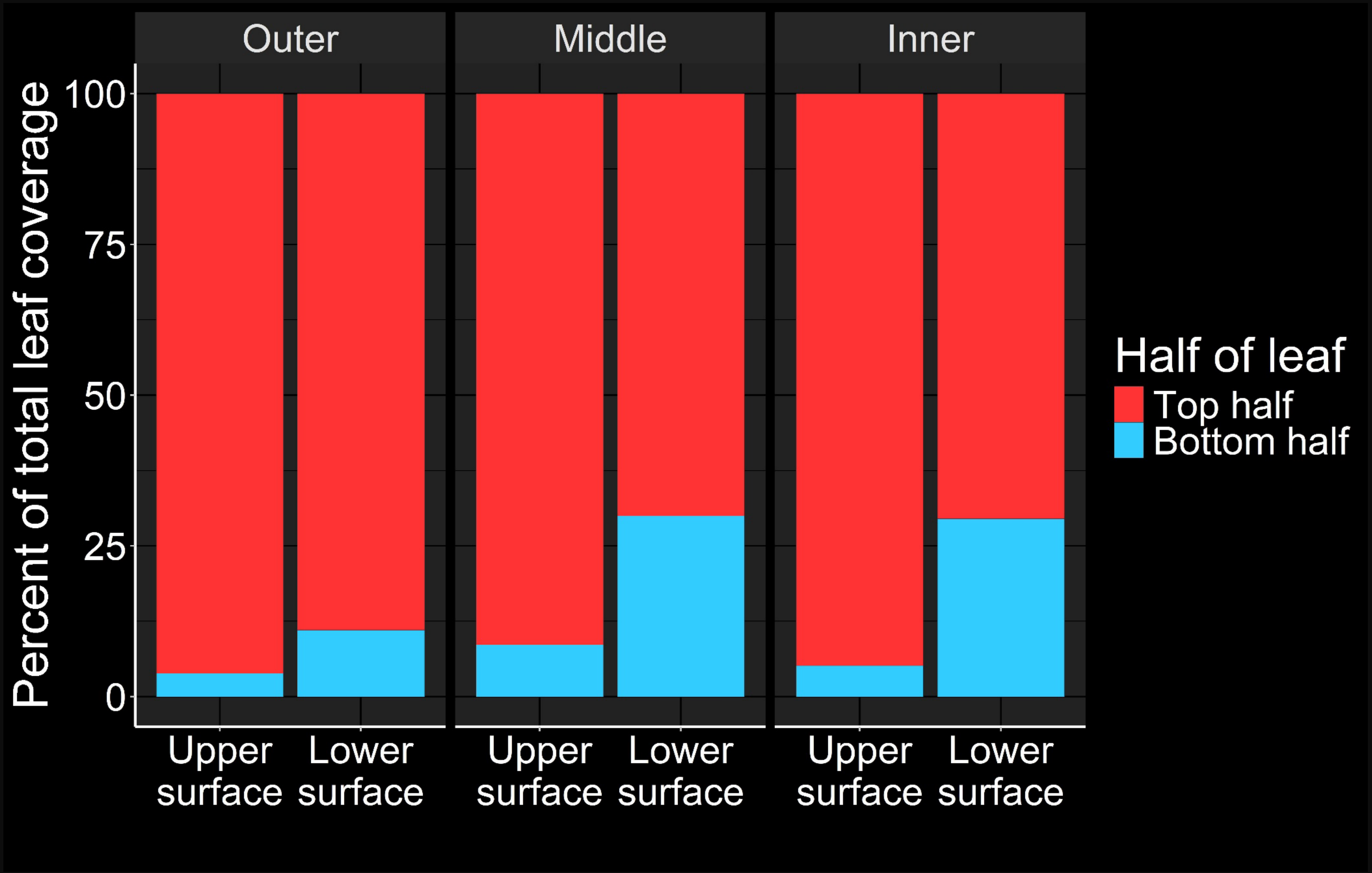


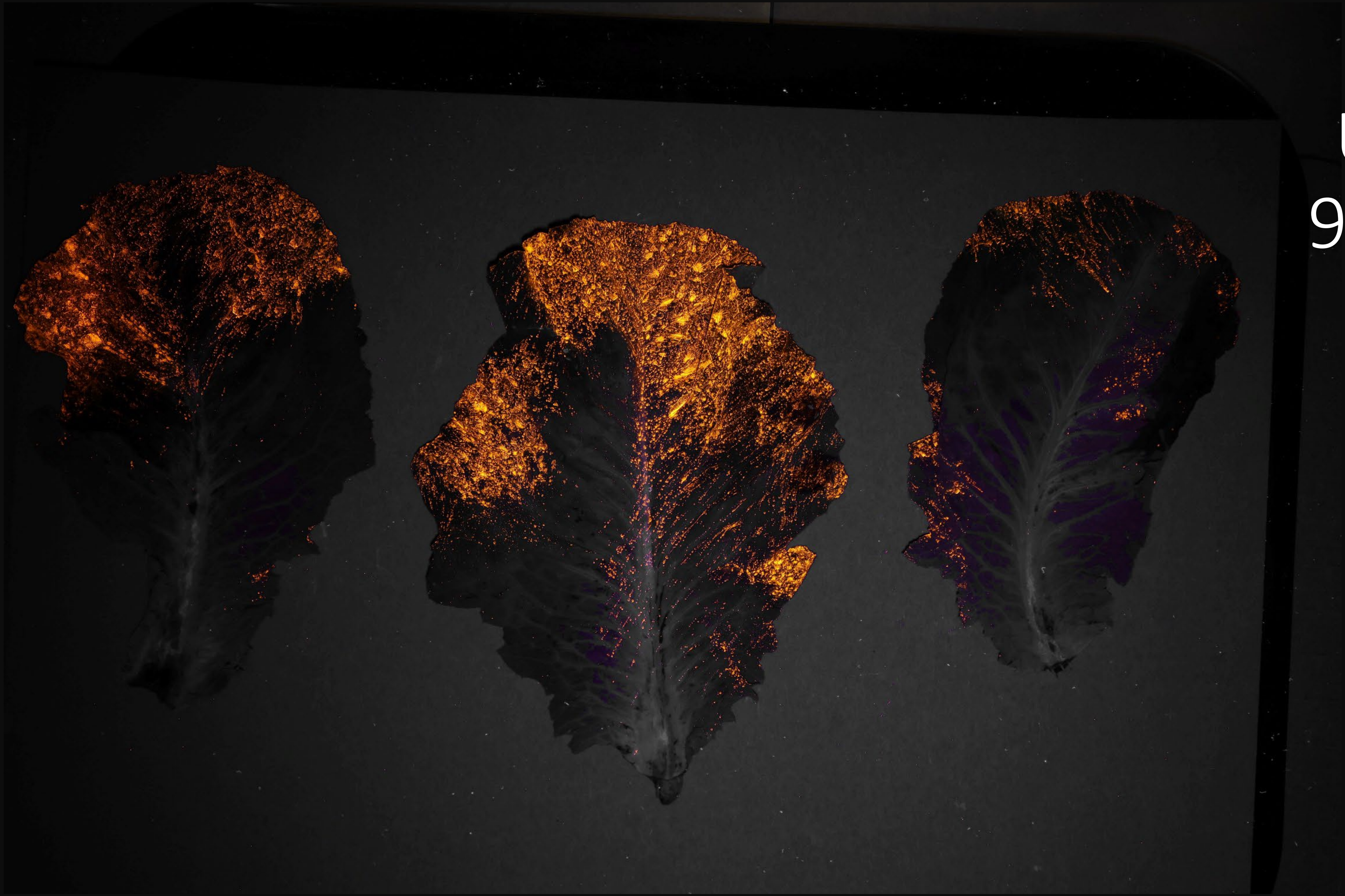

SYL-COAT – 60 GPA


Outer
Middle
Inner
Percent coverage
60
40
20
0
Upper surface
Lower surface
Upper surface
Lower surface
Upper surface
Lower surface
Half
Top half


Outer
Middle
Inner
Percent coverage
60
40
20
0
Upper surface
Lower surface
Upper surface
Lower surface
Upper surface
Lower surface
Half
Top half
Bottom half

# Vast majority of the spray is on the top halves of leaves (60GPA)





Outer
Upper
90 GPA

Middle
Upper
90 GPA

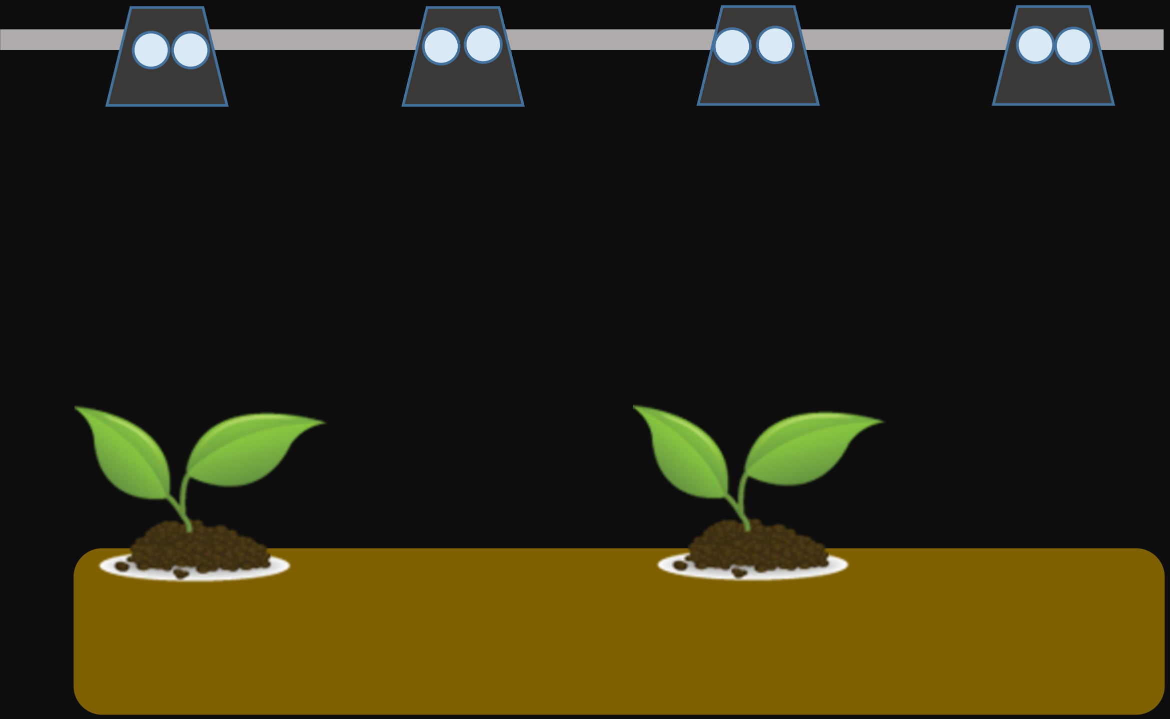
# Considerations:

- Application methods/parameters: boring but critical aspect of improving efficacy
- Highly relevant for a variety of materials
- Other vegetable systems

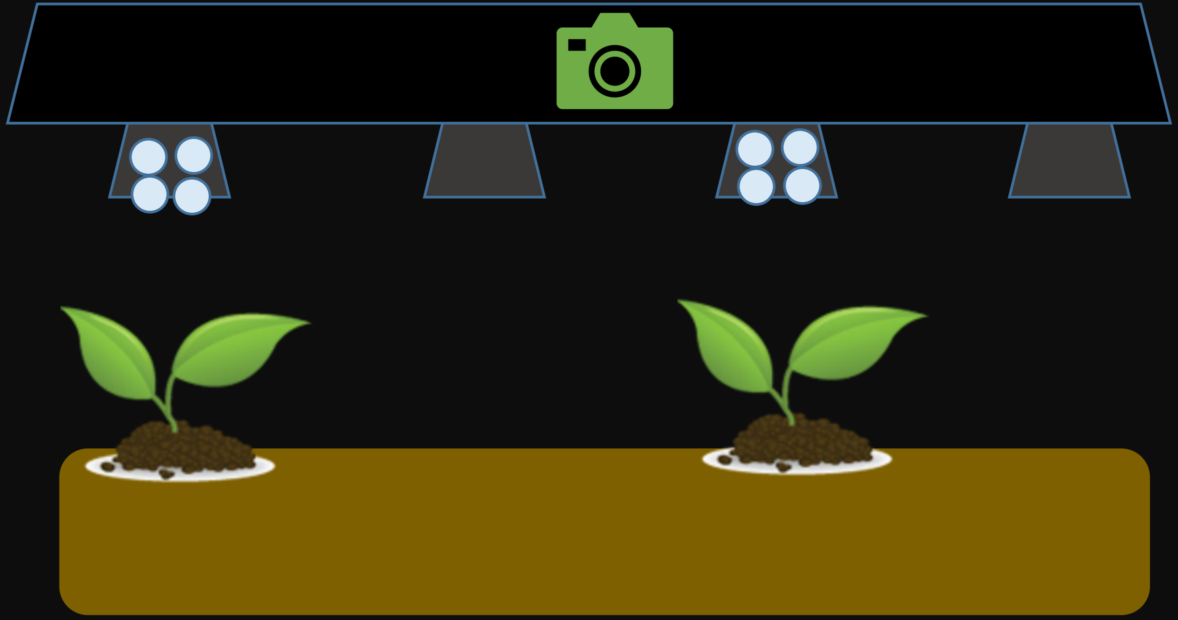
*Standard applications:*
Broadcast spray

*Opportunities for applications?:*
Automated precision sprayer

Broadcast



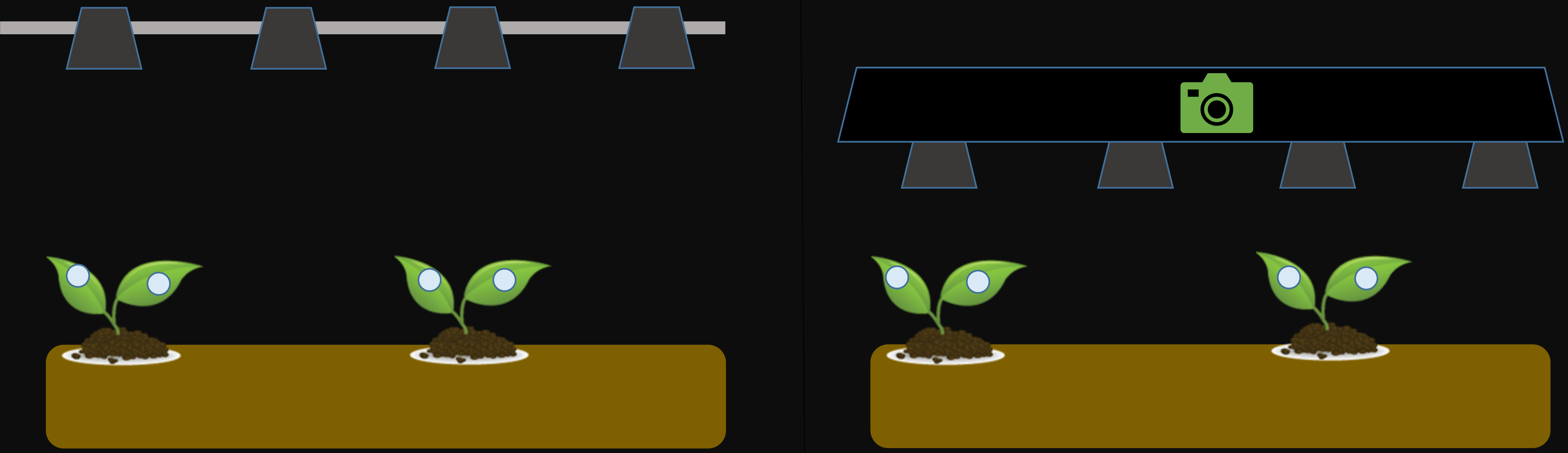
Precision



Same per acre rate, <u>different per plant rate</u>

Broadcast

Precision



Same per plant rate

- Insecticides put where they need to be
- Higher rate applied “per plant” → efficacy?
- Higher per plant rates could extend residual efficacy
- Better coverage?

## Organic

- Aphids and thrips

## Conventional

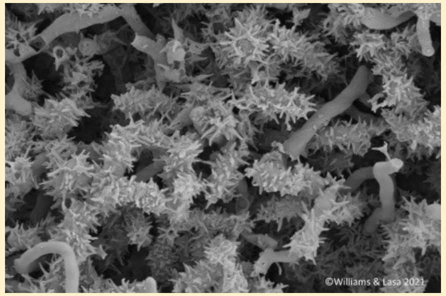
- Thrips
- **Aphids**

# Organic – aphids and thrips

- Two trials
- Romaine
- Start 3 weeks post planting (manual thinning)
- Broadcast vs. precision
  - Materials at the same “per acre” rate
- Two applications
- Plots: 2x 80-in beds, 50 ft
- 5 replicates per trial


## Pyrethrin

## Spinosad

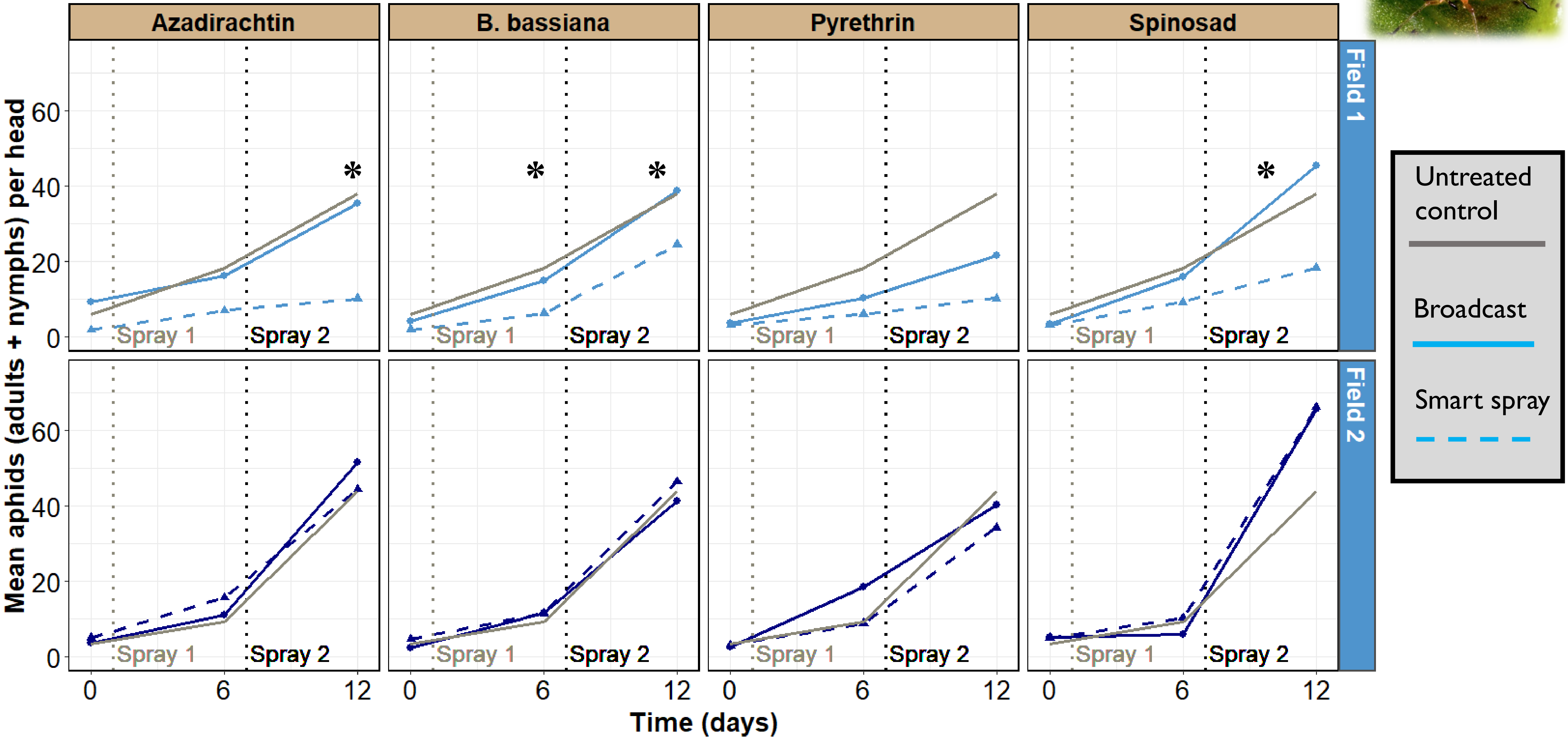



## Azadirachtin

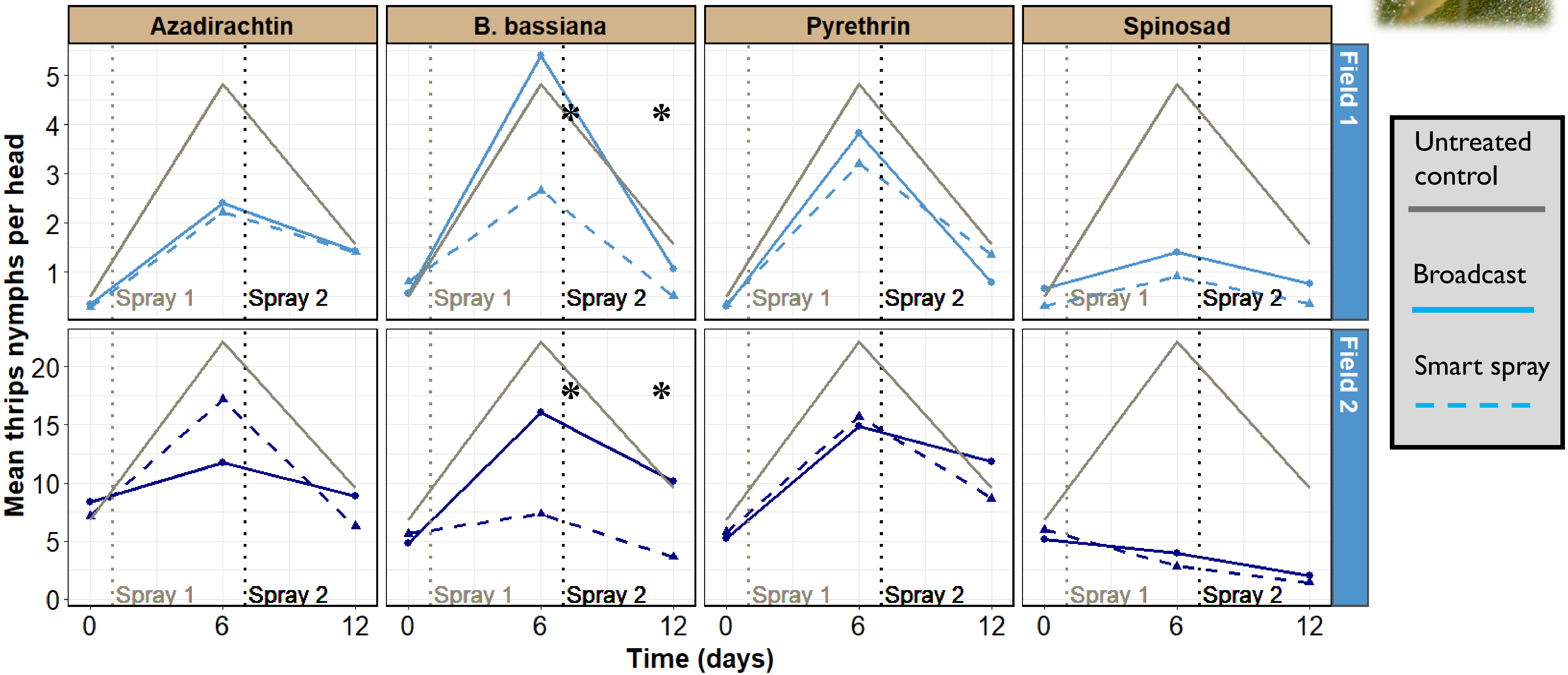
## Beauvaria bassiana

- Precision sprays ~3x higher “per plant”
- Sampled at:
  - 0 DAT
  - 6 DAT App 1
  - 6 DAT App 2
- 10 plants/plot, plants washed
- Insects counted

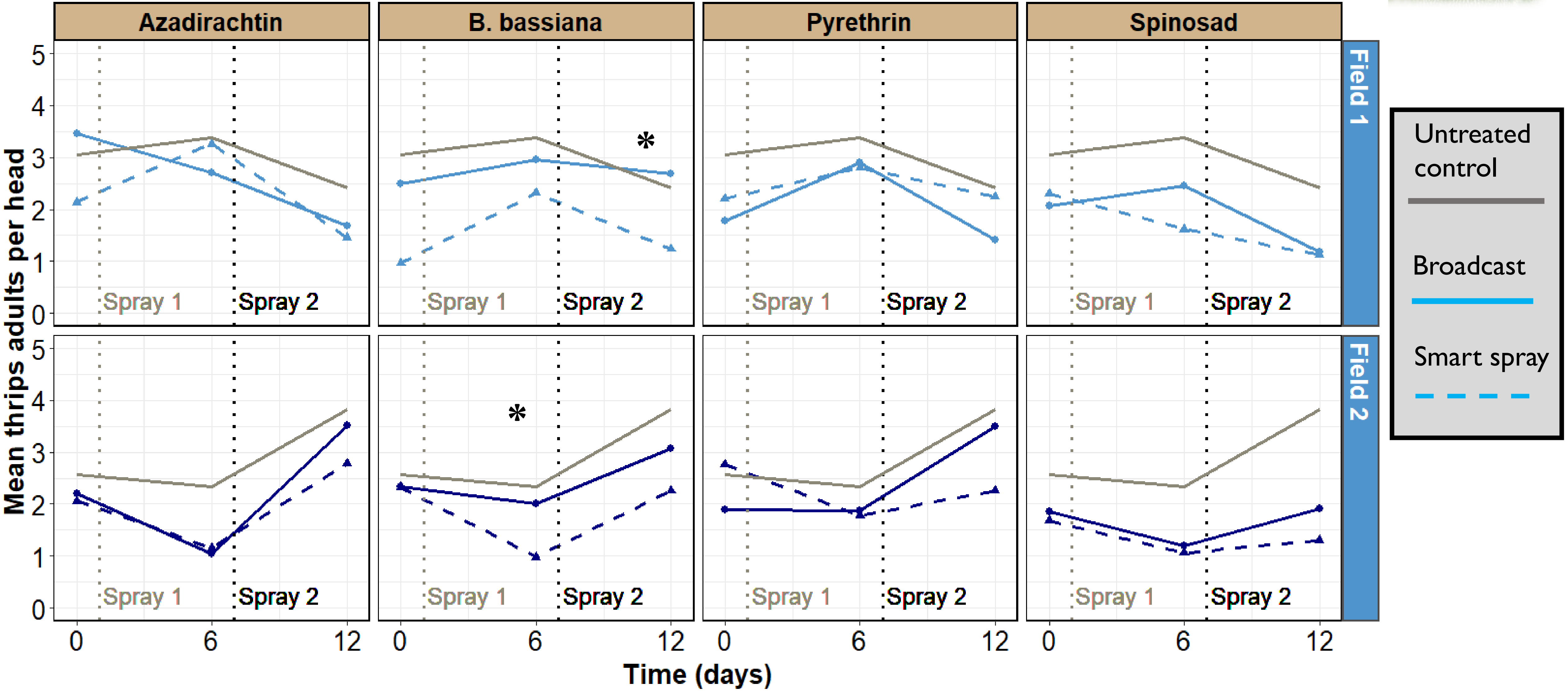
# Aphids


Azadirachtin
B. bassiana
Pyrethrin
Spinosad
Field 1
Field 2
Mean aphids (adults + nymphs) per head
Time (days)
0
20
40
60
0
6
12
Spray 1
Spray 2
*
Untreated control
Broadcast
Smart spray

# Thrips nymphs



# Thrips adults



# Conventional, thrips/aphids

# Experimental methods:

- Conventional romaine lettuce 2 weeks post-seeding
- Two applications spaced 10 days apart
- 2 insecticide products to target aphids
  - Spirotetramat
  - Thiamethoxam
- Broadcast and smart sprayer applications of each material

## Thiamethoxam Precision

Applied at 5.5, 1.8 and 0.55 oz/acre

## Thiamethoxam Broadcast

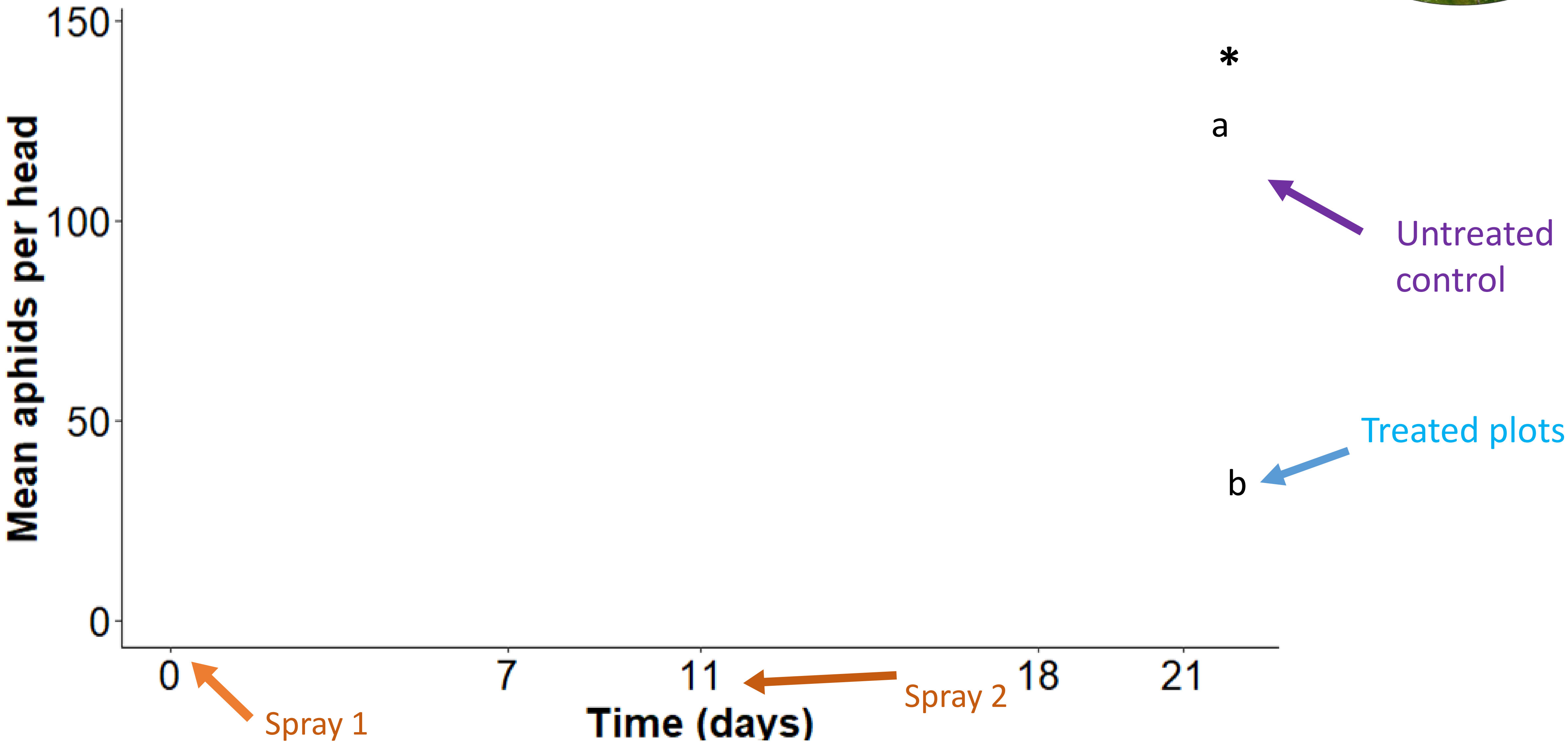
Applied at 5.5 oz/acre

## Spirotetramat Precision

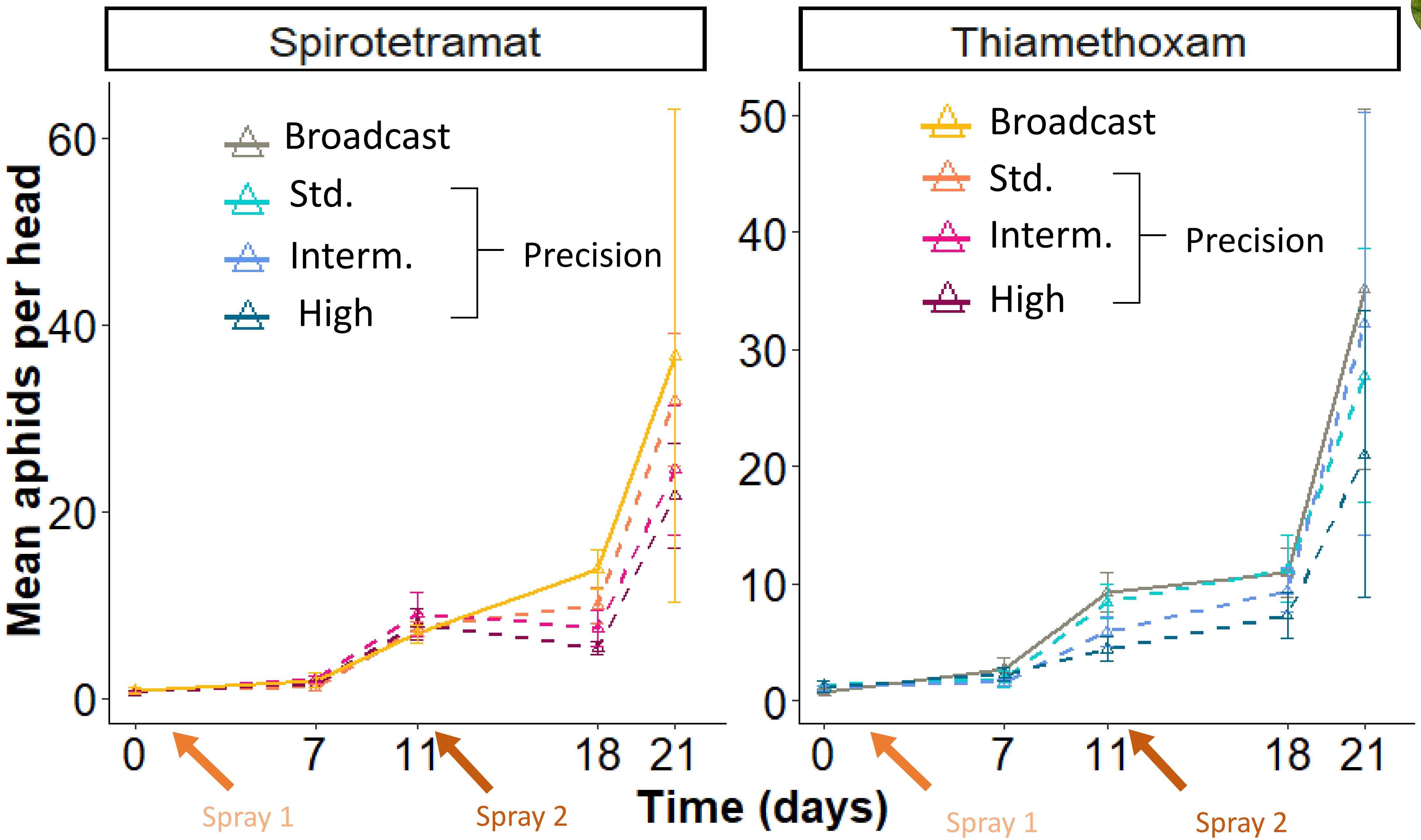
Applied at 5, 1.7 and 0.5 oz/acre

## Spirotetramat Broadcast

Applied at 5 oz/acre



150
100
50
0
Mean aphids per head
0
7
11
18
21
Time (days)
Spray 1
Spray 2
*
a
b
Untreated control
Treated plots


Spirotetramat
Thiamethoxam
Mean aphids per head
0
20
40
60
Broadcast
Std.
Interm.
High
Precision
0
10
20
30
40
50
0
7
11
18
21
Spray 1
Spray 2
Time (days)

# Precision sprays: conclusions

- *Organic* – could provide efficacy with materials that are otherwise ineffective
- *Conventional* – Rate effect for thrips management, longer residual/reduced spray number (?)
- Additional data will be coming

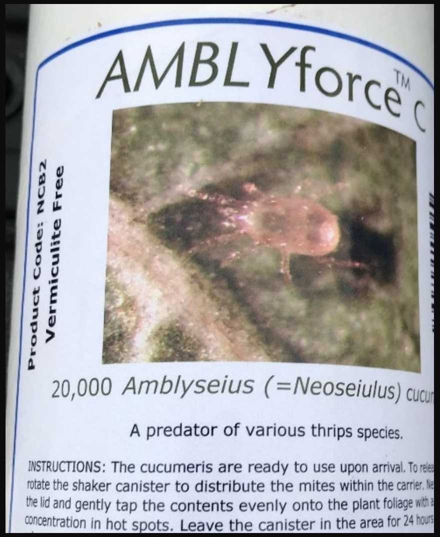
# Conservation biological control can work


# Can inundative releases of natural enemies using drones manage aphids and thrips in lettuce?

# In-field releases

2 predatory species studied

- Predatory mites (*Neoseiulus cucumeris)*
- Green lacewing (*Chrysoperla rufilabris)*

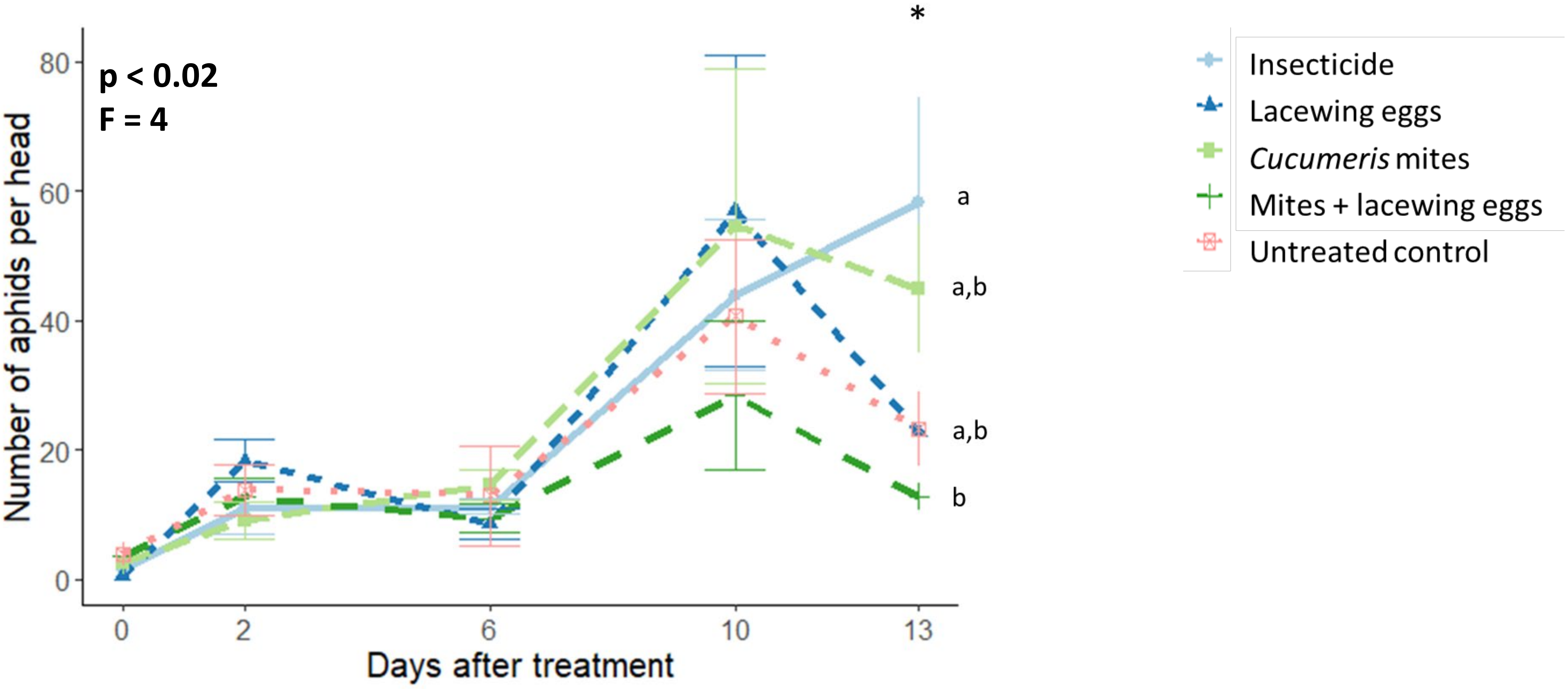

| 2021 | 2022 | 2023 |
|---|---|---|
| • Two trials<br>• Single release pilot study | • One trial<br>• Systems-based multiple release study | • One trial<br>• Systems-based multiple release study |

# Methods

- 10 lettuce heads/plot
  - Y1: Prior to treatment and 2, 6, 10 and 13 days after release
  - Y2: Prior to first release and 6 days after each release
- Harvest <7 days after final sample
- Samples pulled from center of plot

# Results

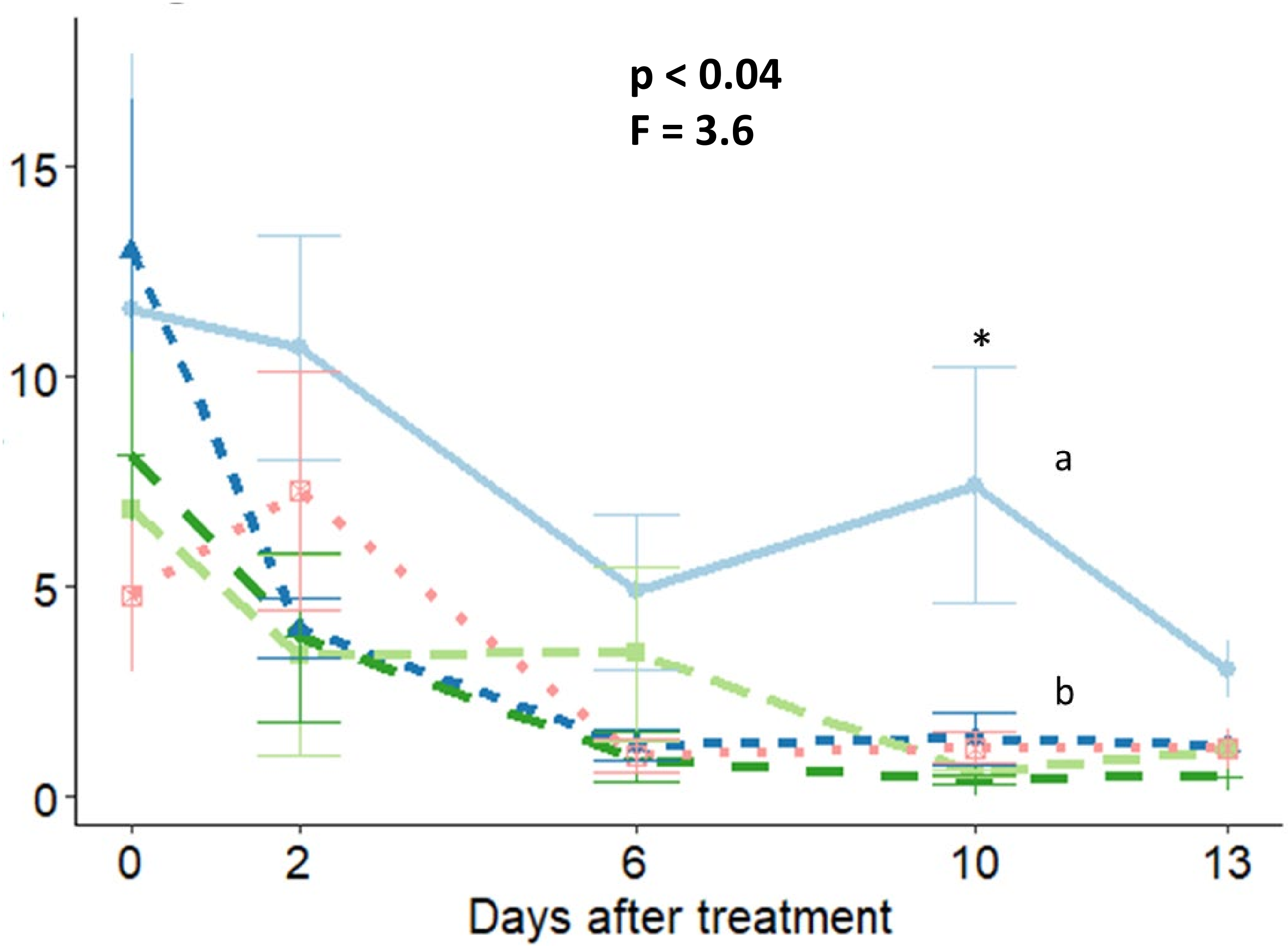
## Year 1 Aphids: Field 2




* *Differences detected between treatments*

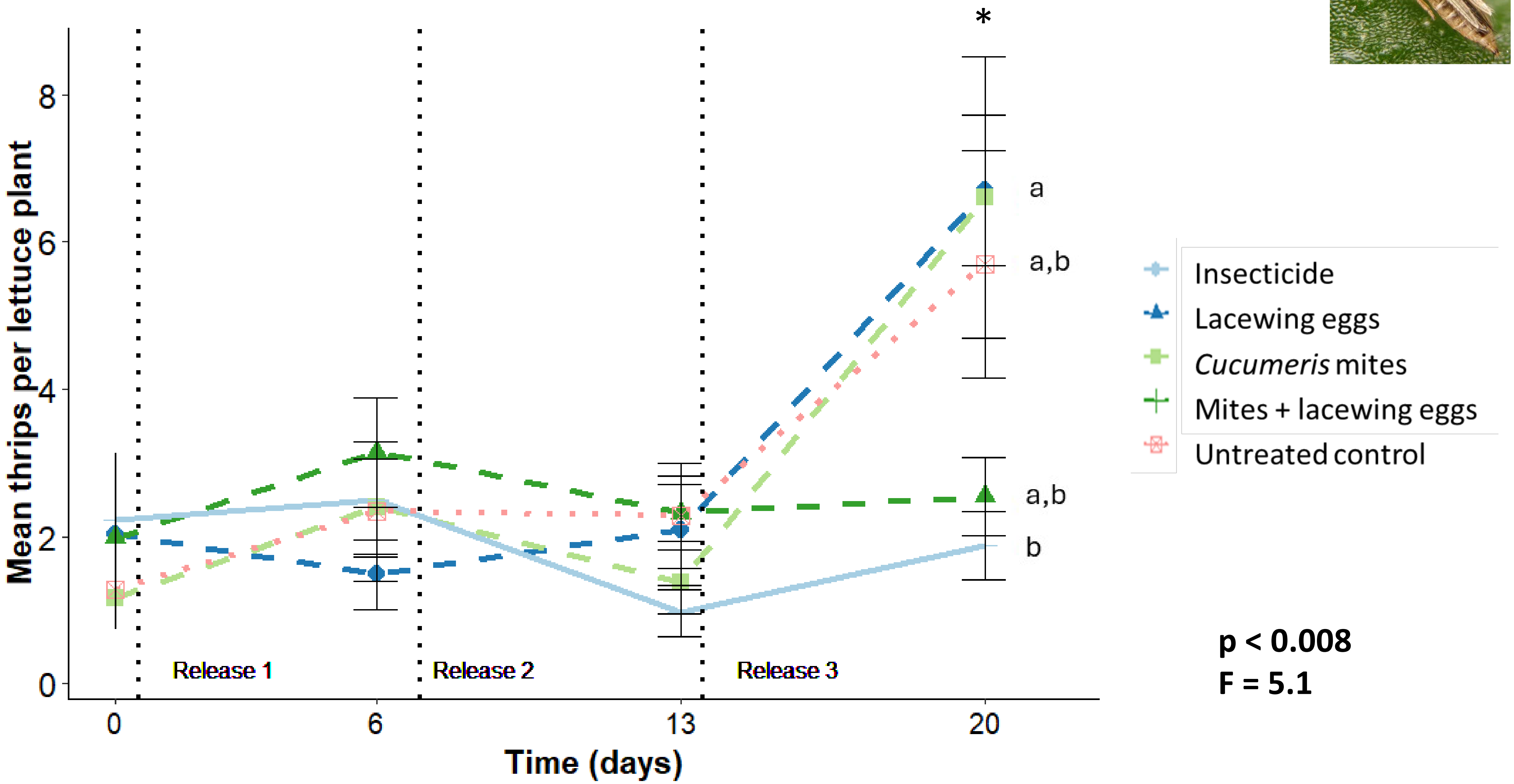
# Results

## Year 1 Aphids: Field 1




# Results

## Year 2: Thrips

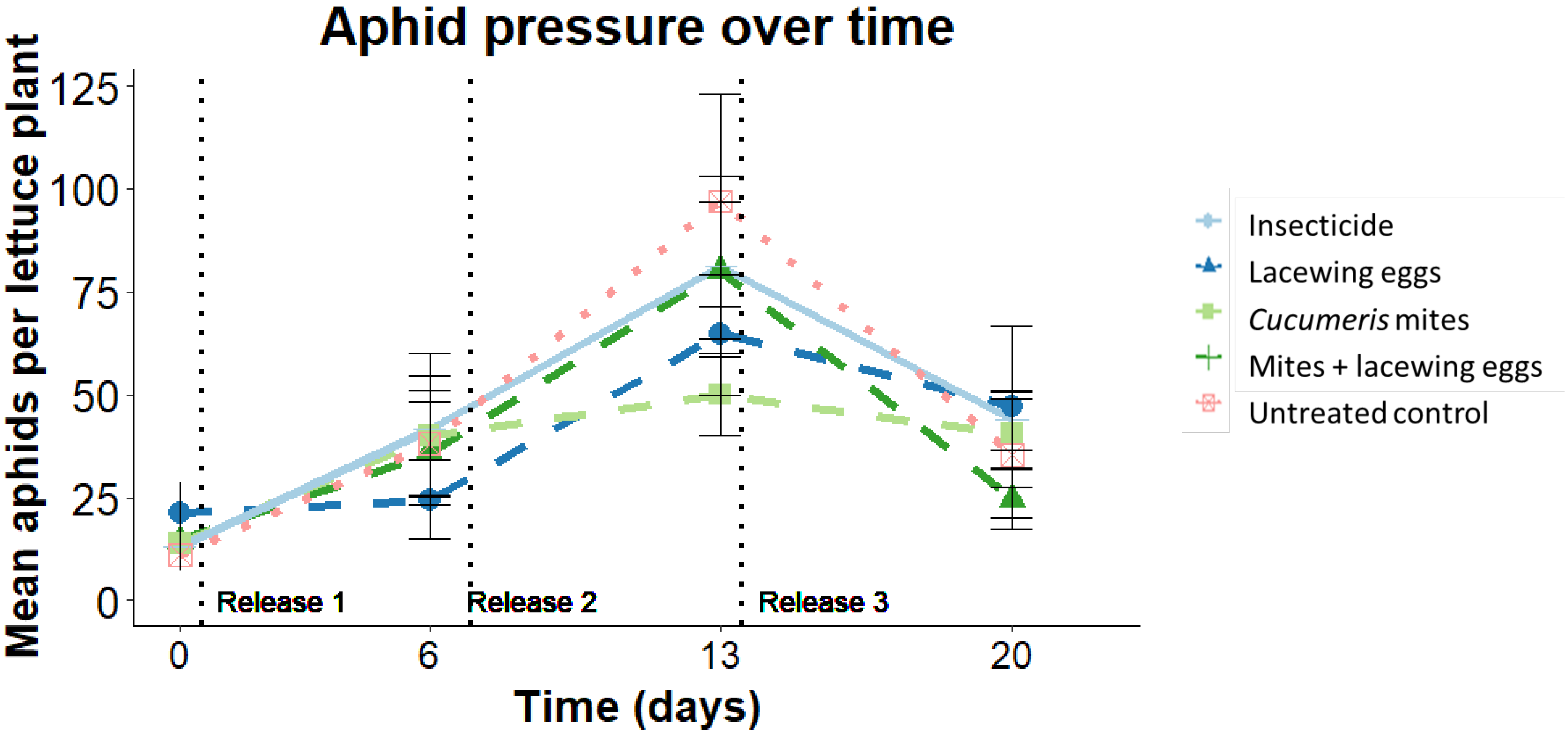



**$p < 0.008$**
**$F = 5.1$**

# Results

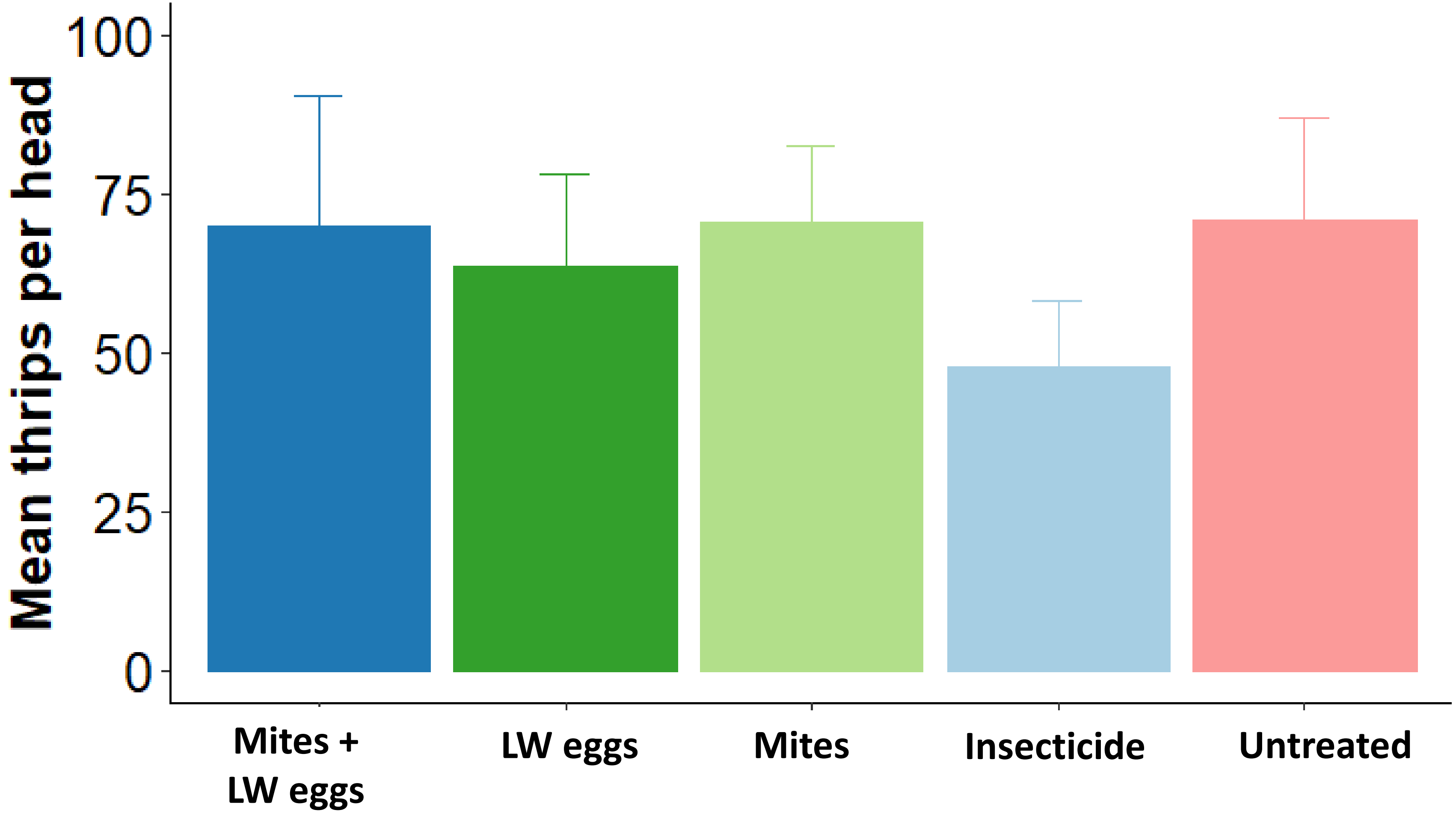
## Year 2: Aphids

*No differences between treatments*



# Results

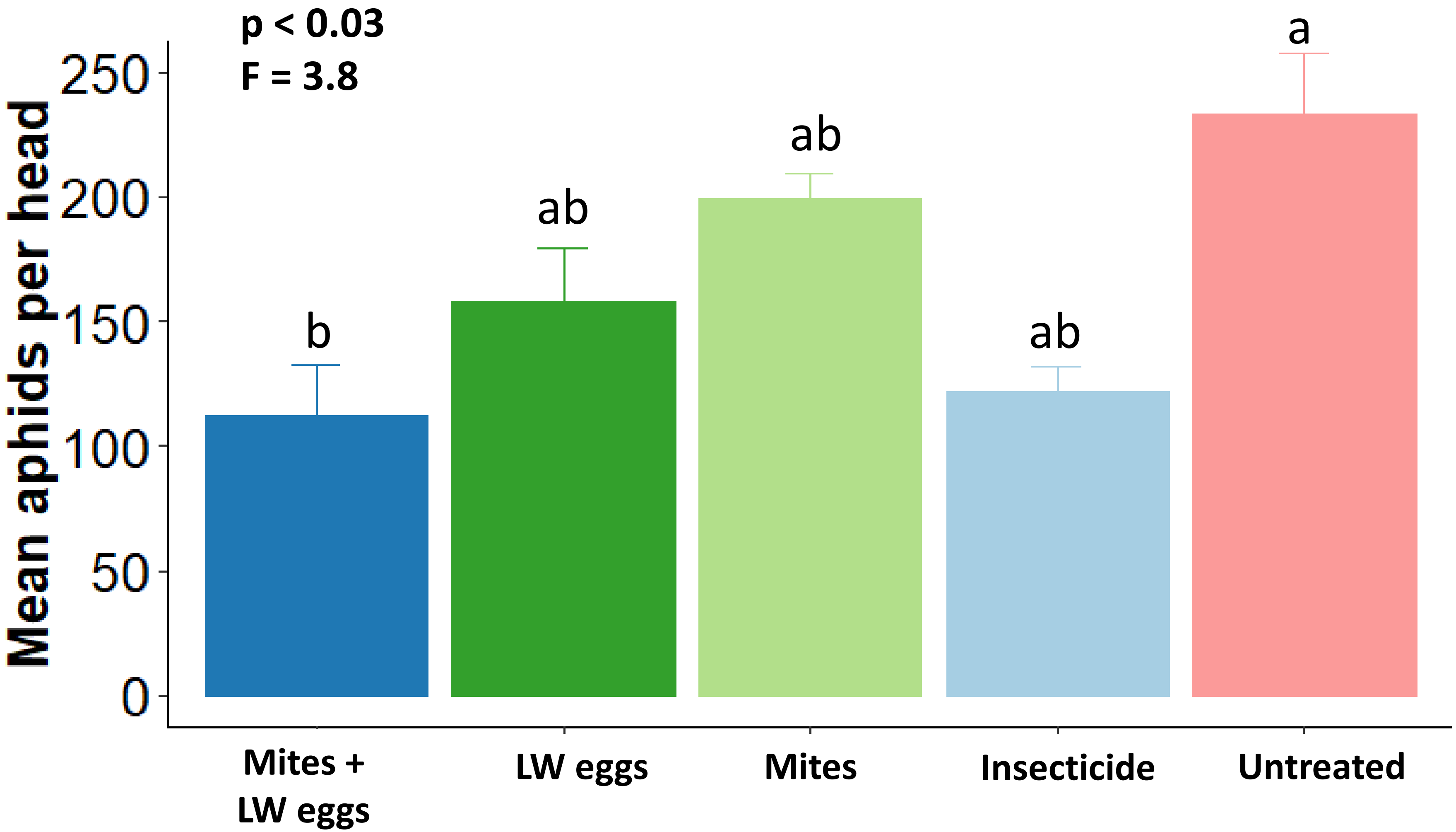
## Year 3: Thrips




*only 4 of 5 blocks counted

# Results

## Year 3: Aphids

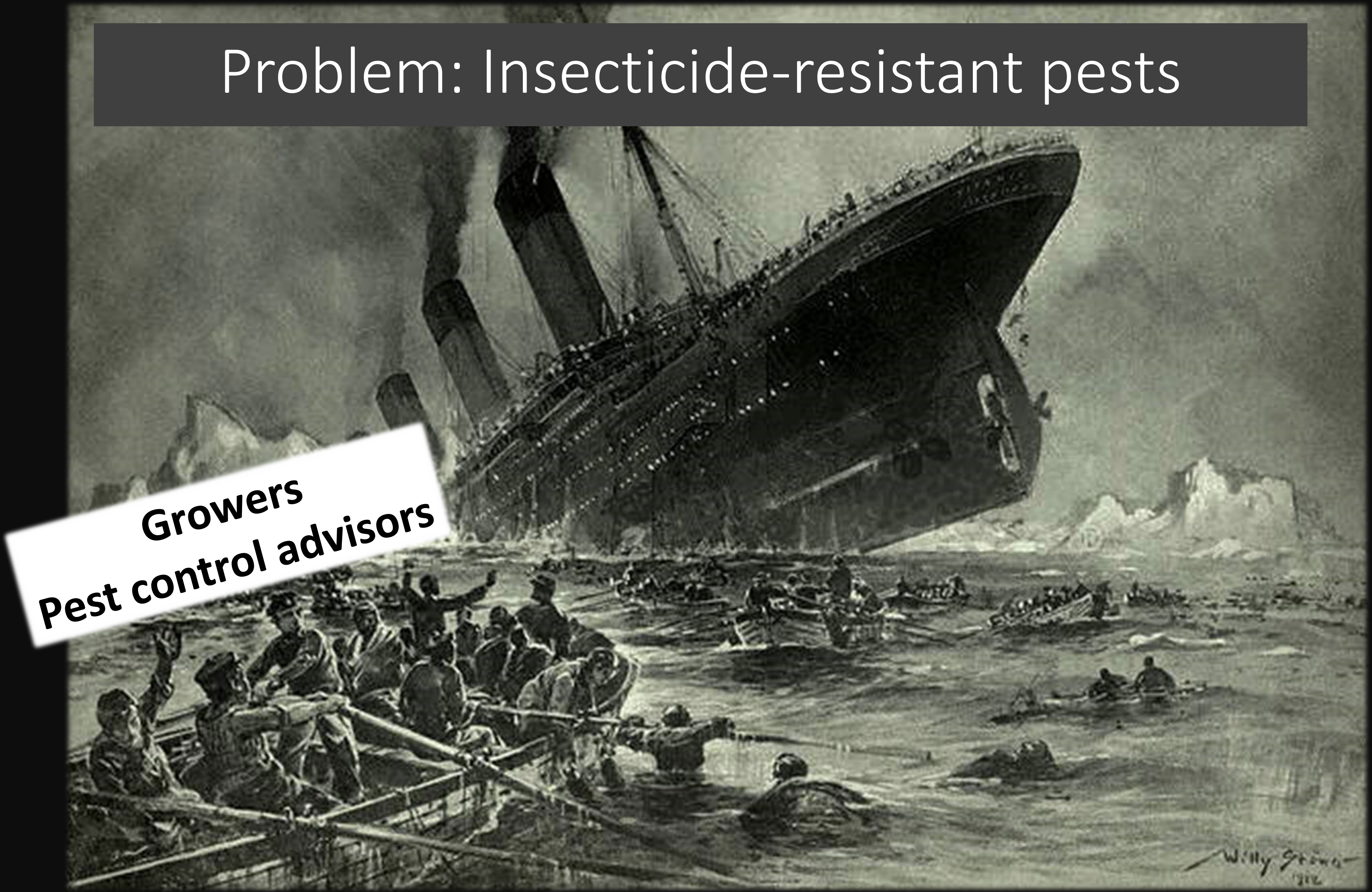


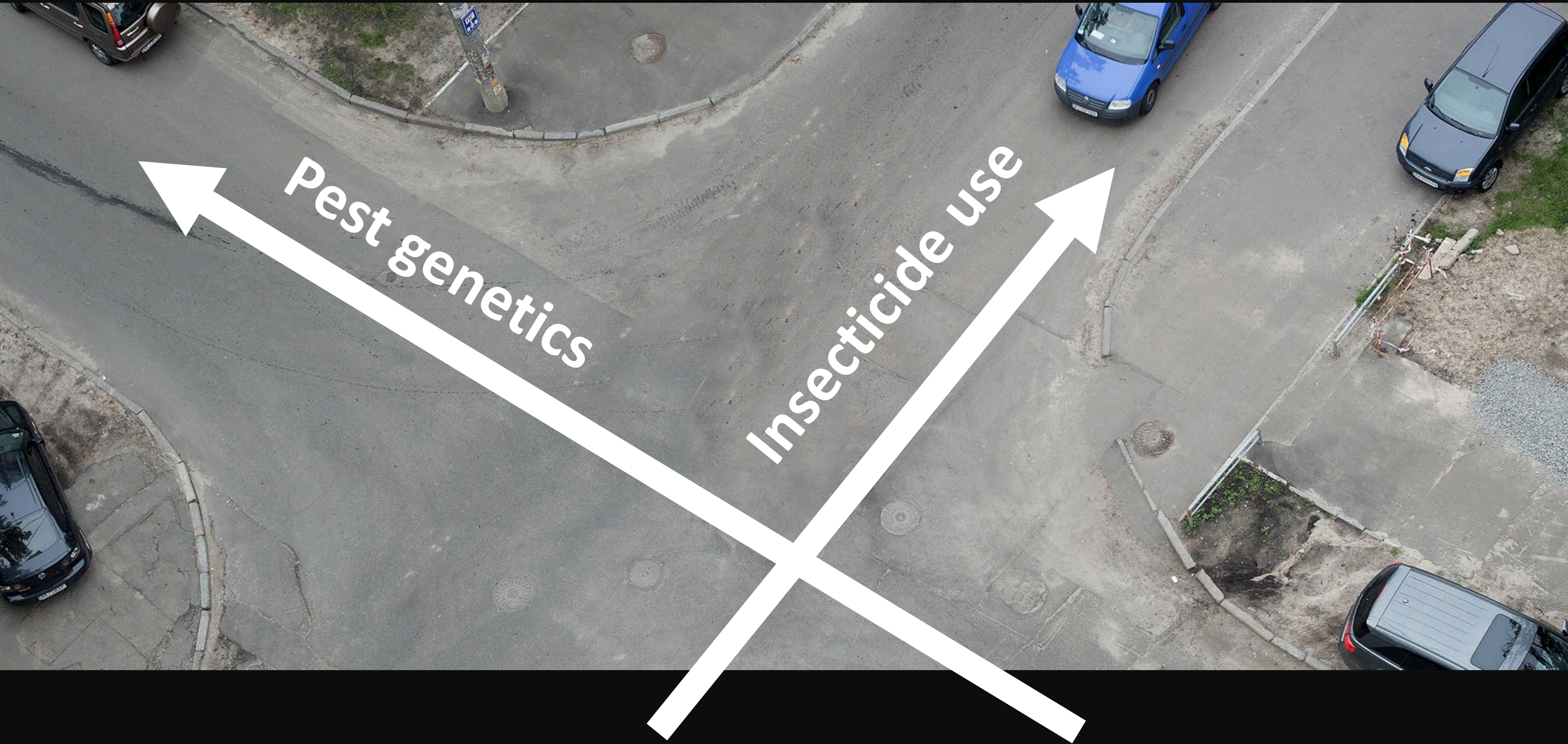

*only 4 of 5 blocks counted


EVERYTHING WILL CHANGE
EVERYTHING HAS CHANGED

Insecticide resistance

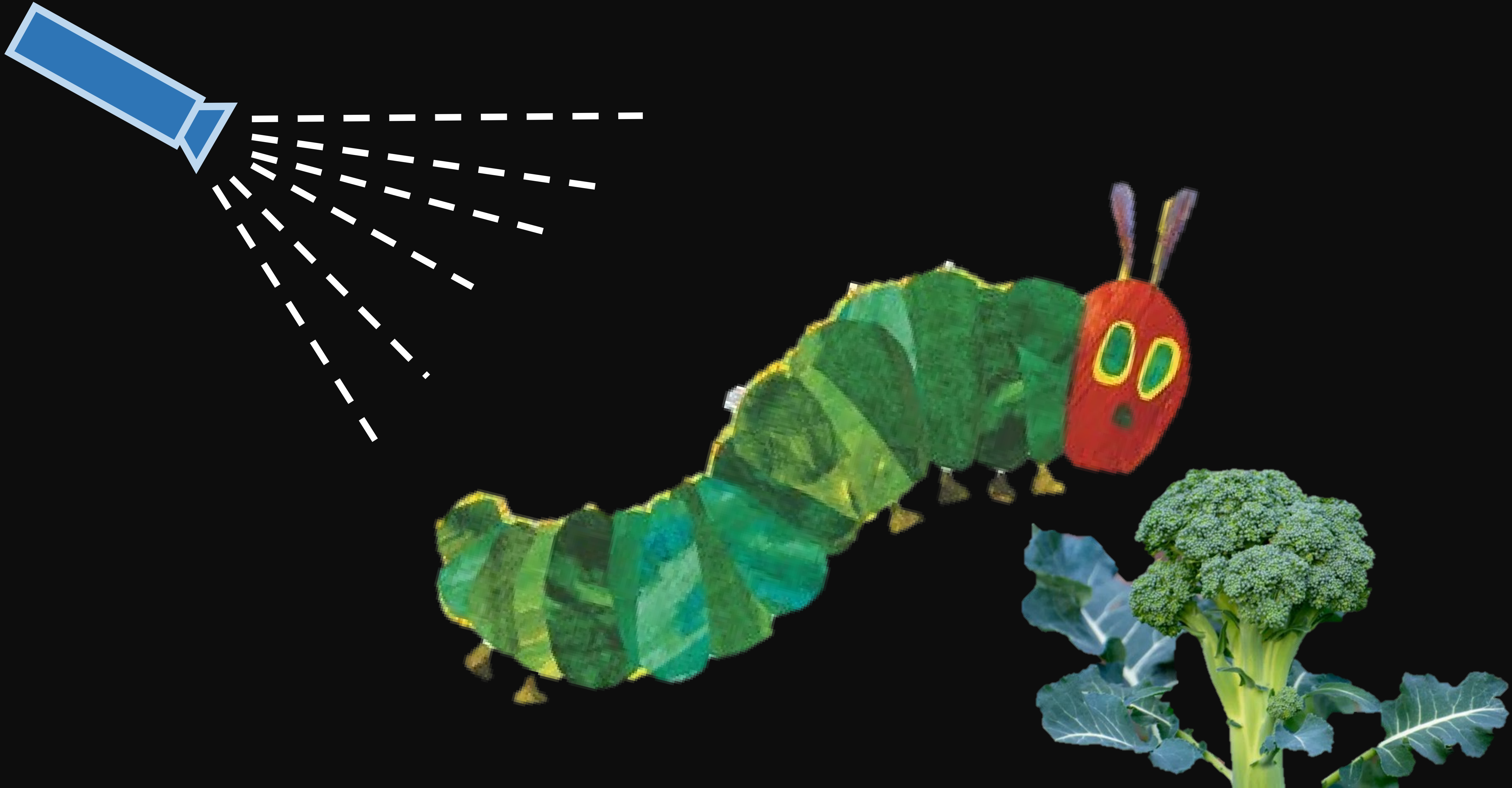
# Problem: Insecticide-resistant pests



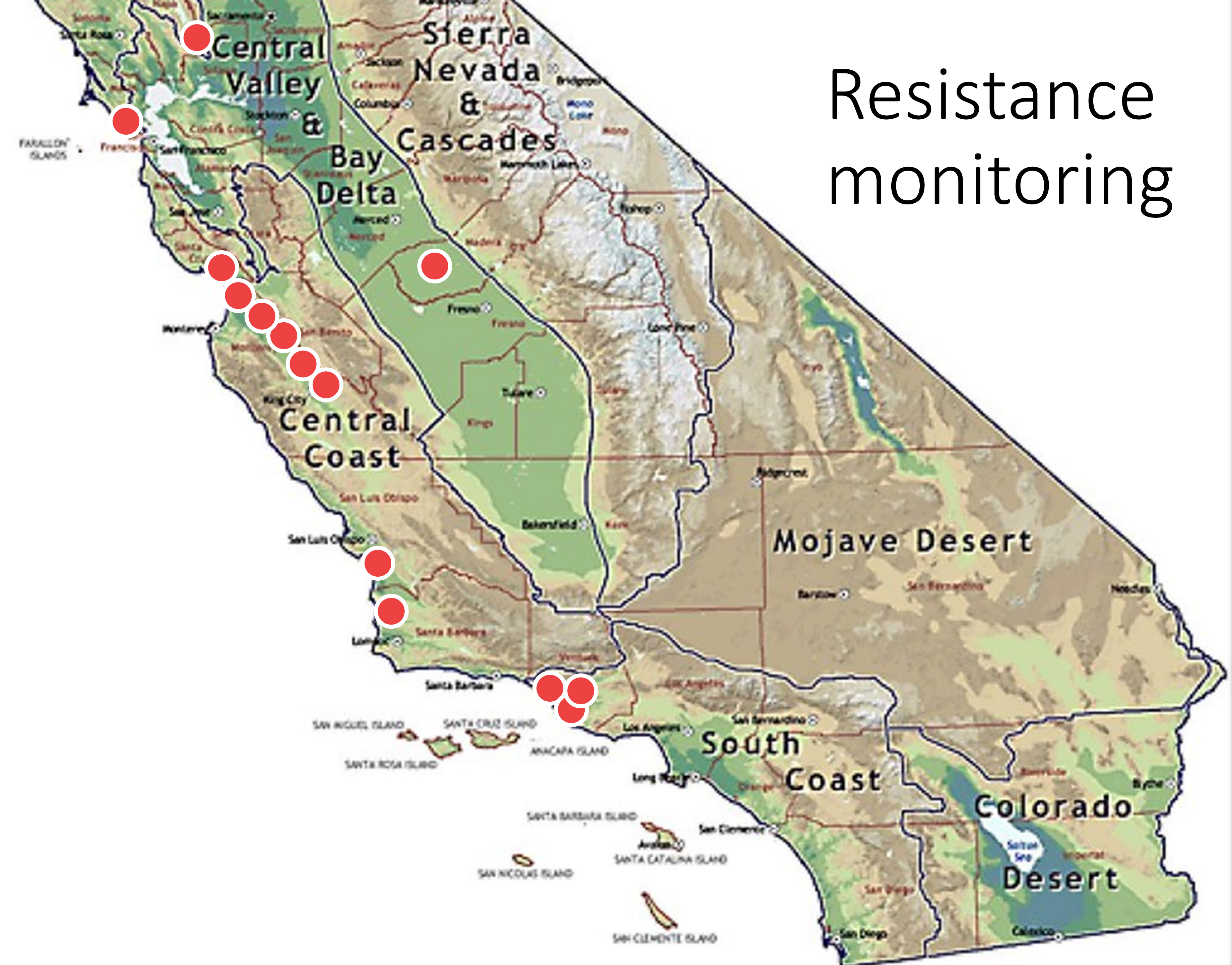

Pest genetics
Insecticide use

# Insecticide resistance

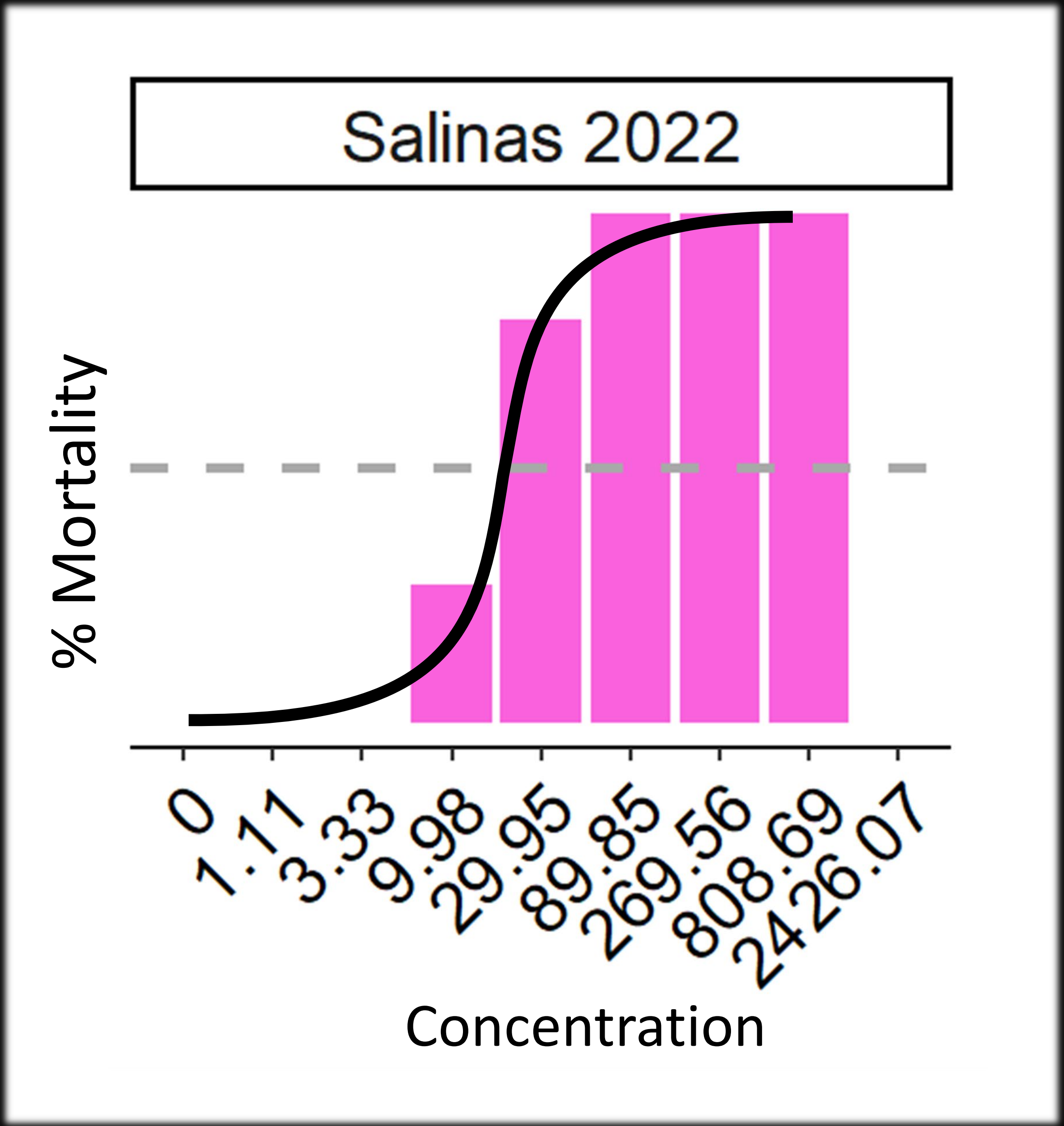

PEST MANAGER WAITING
FOR RESISTANCE TO SOLVE ITSELF

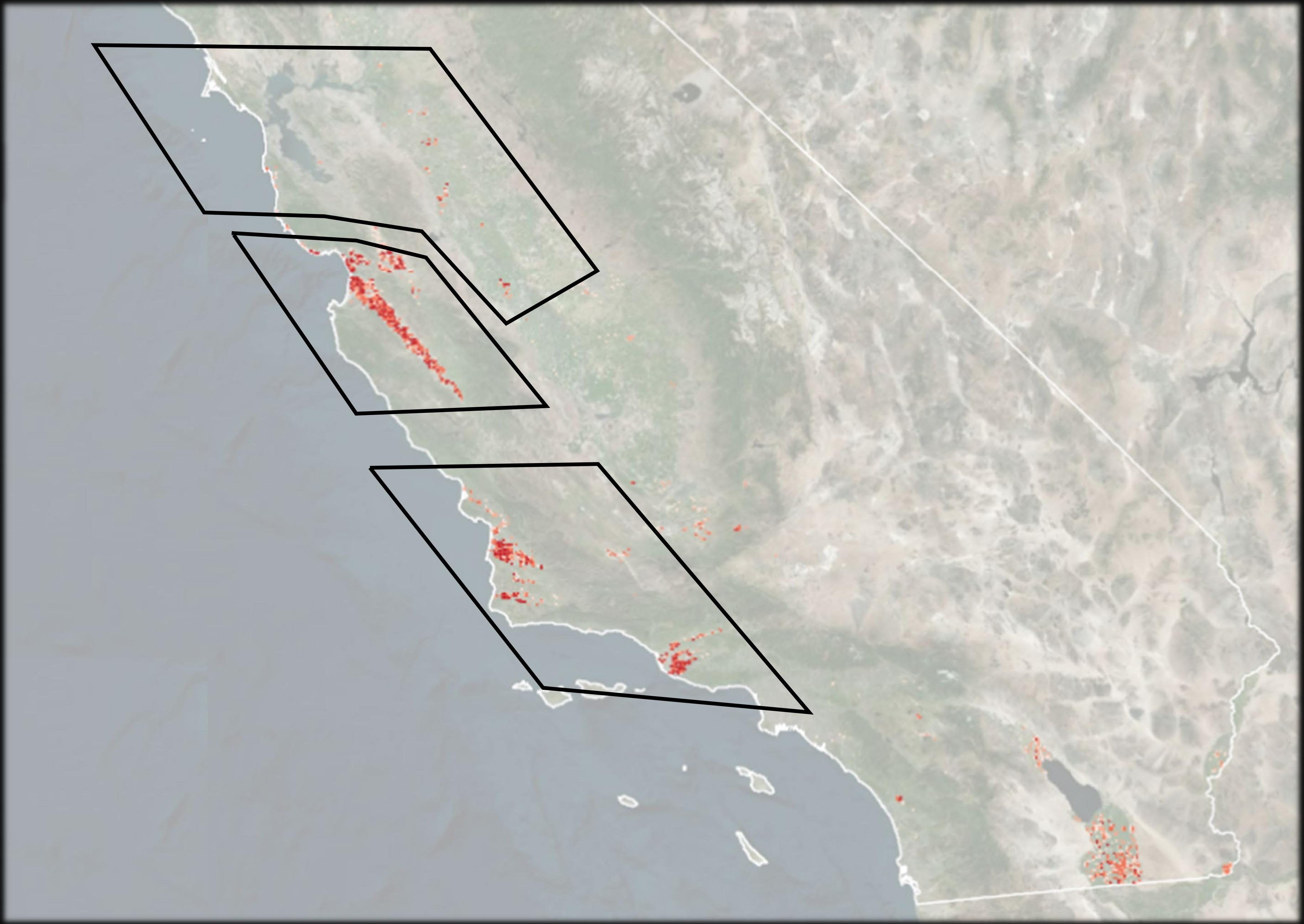


# Resistance monitoring

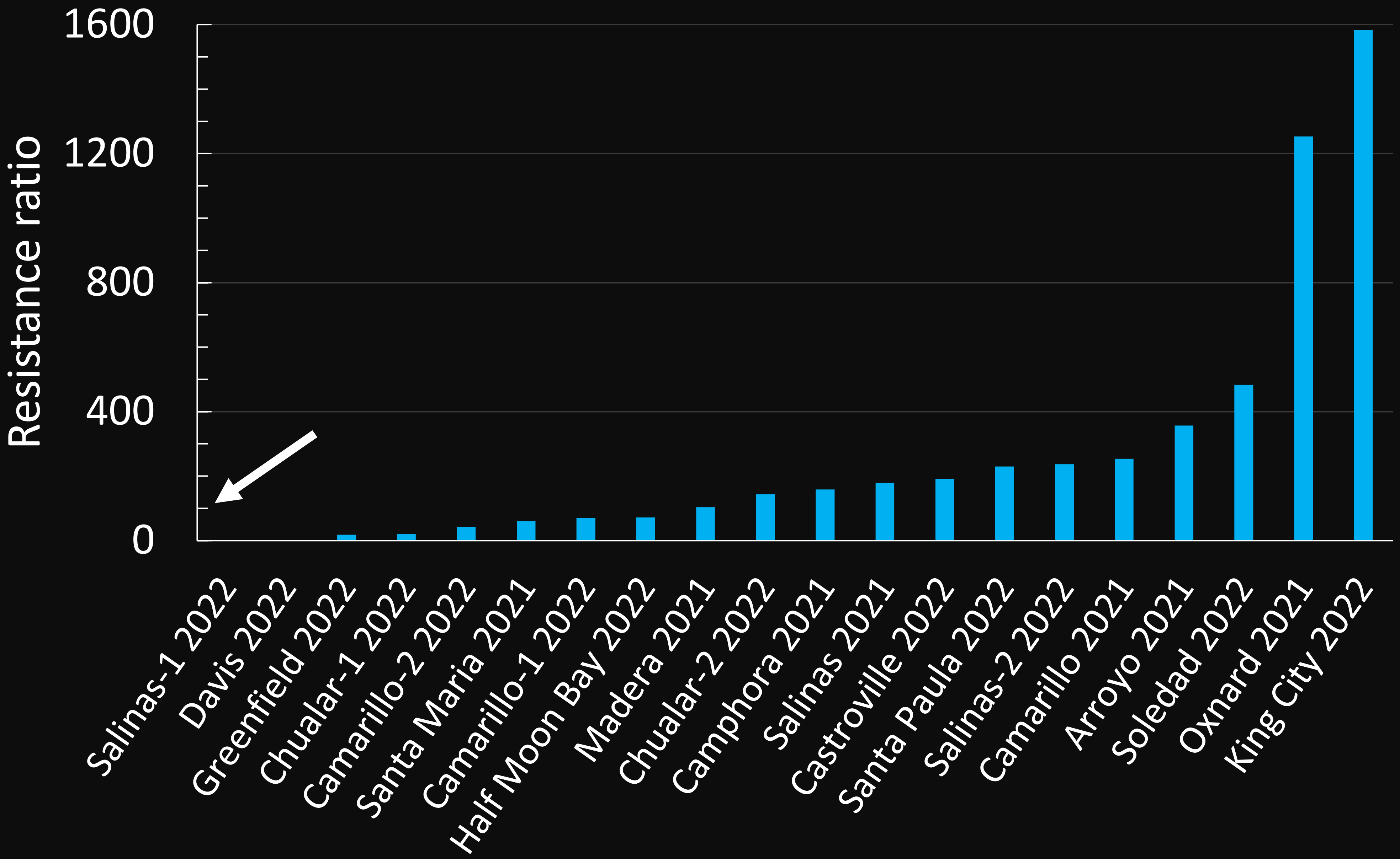


# Resistance monitoring – leaf dip assay

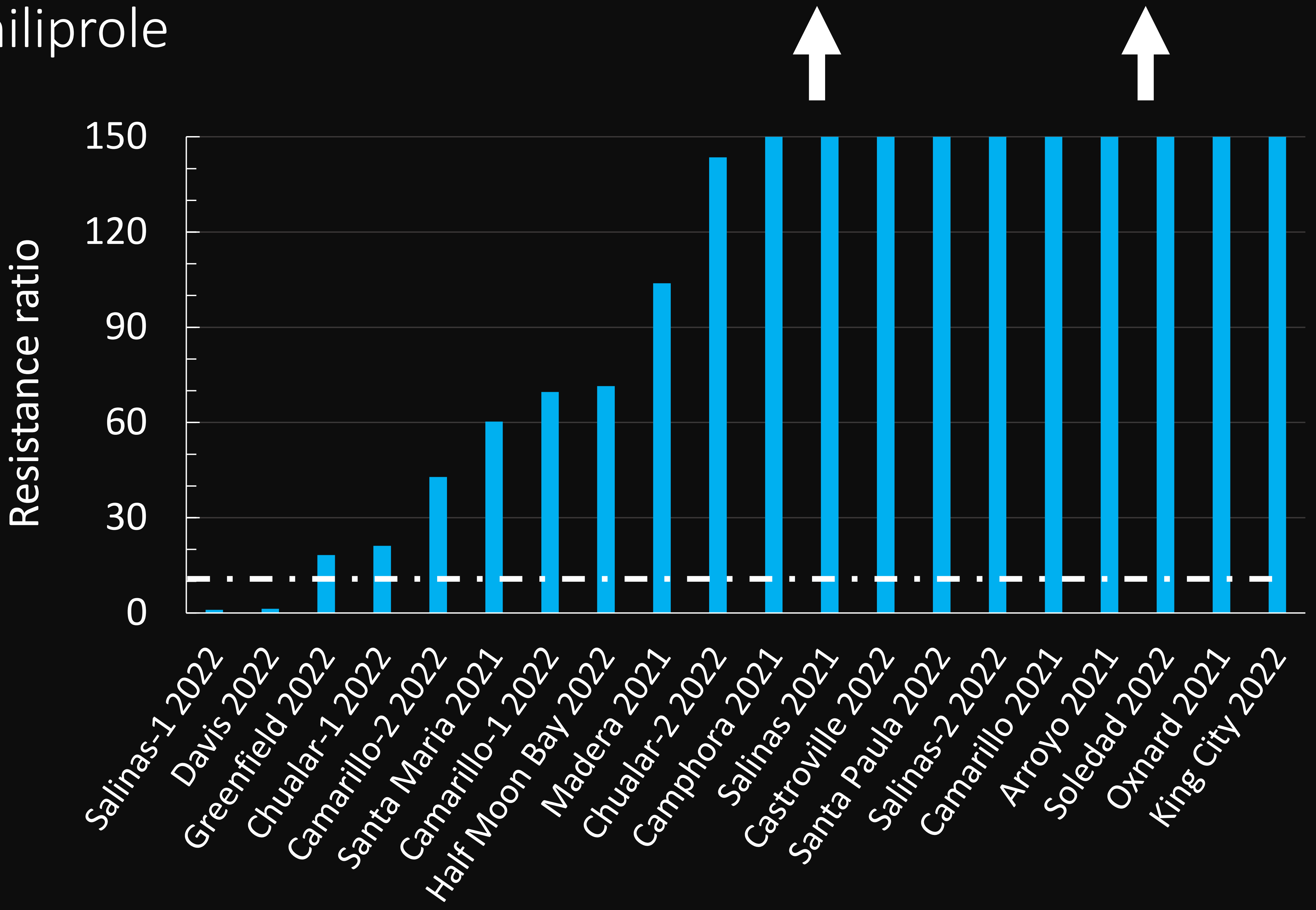

Salinas 2022
% Mortality
0
1.11
3.33
9.98
29.95
89.85
269.56
808.69
2426.07
Concentration



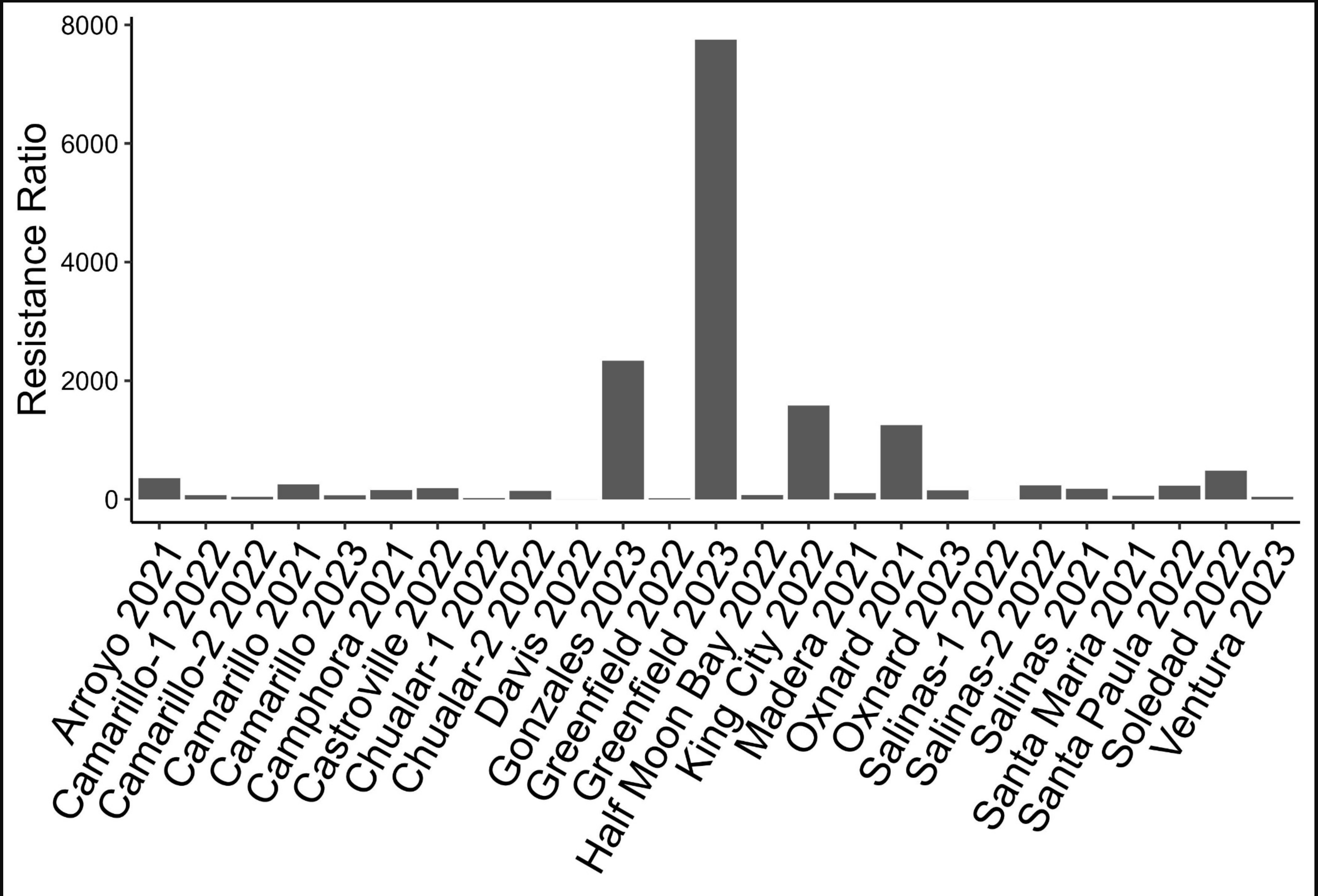
# Chlorantraniliprole
# Coragen
# (diamide)



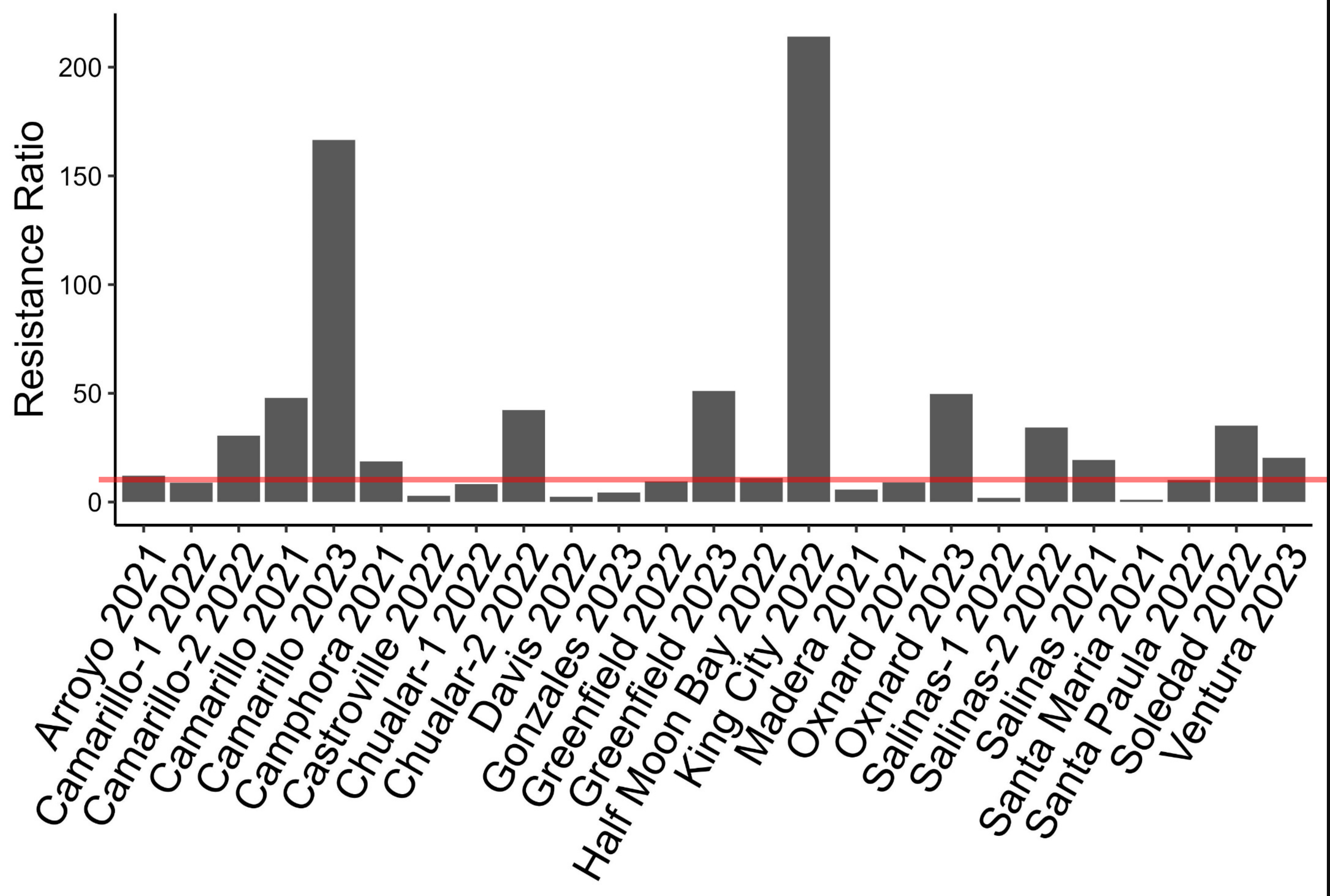
# Chlorantraniliprole
# Coragen
# (diamide)



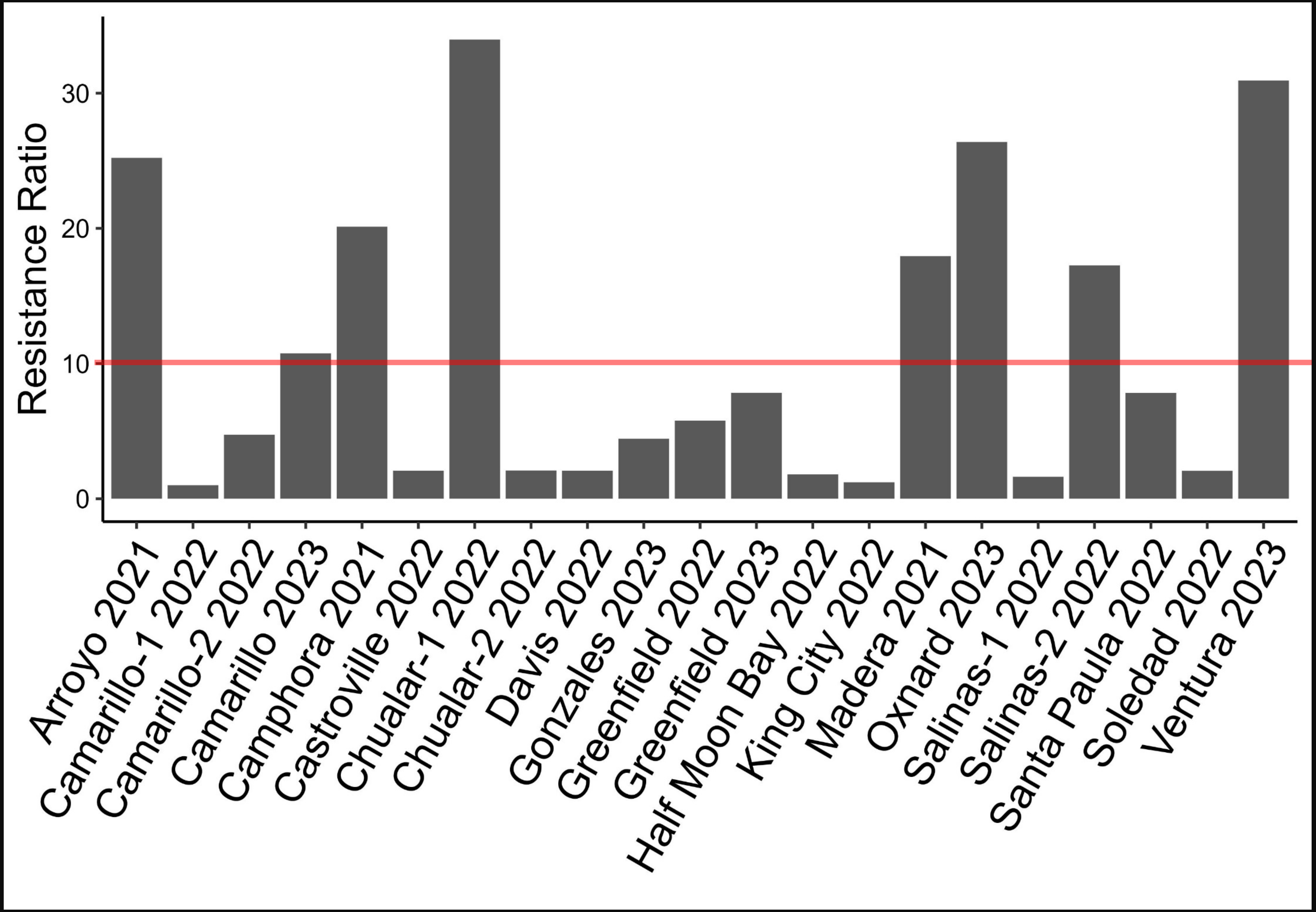
# Chlorantraniliprole
# Coragen
# (diamide)



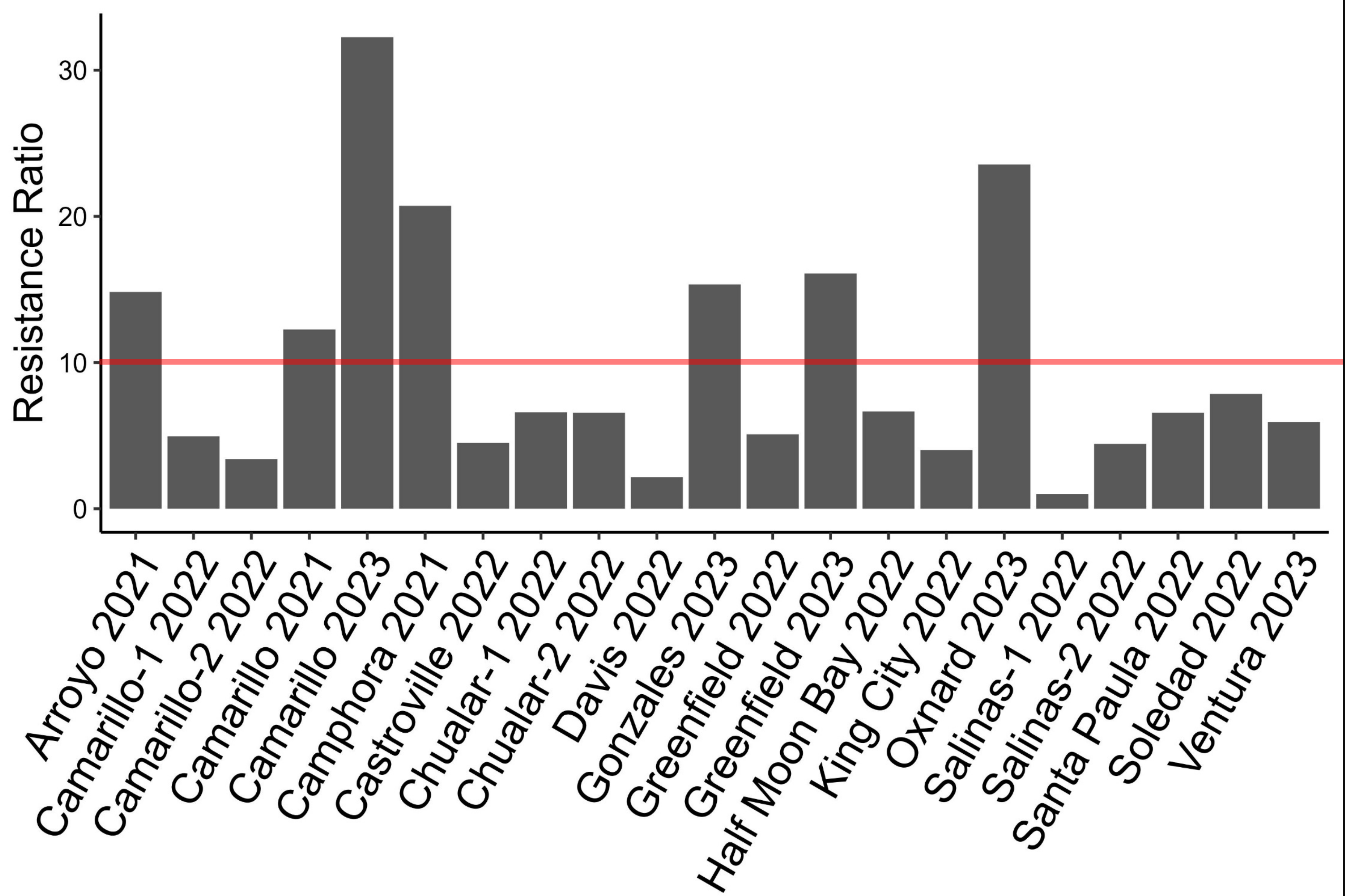
Cyantraniliprole
Exirel
(*Verimark*)
(diamide)



# Emamectin benzoate Proclaim



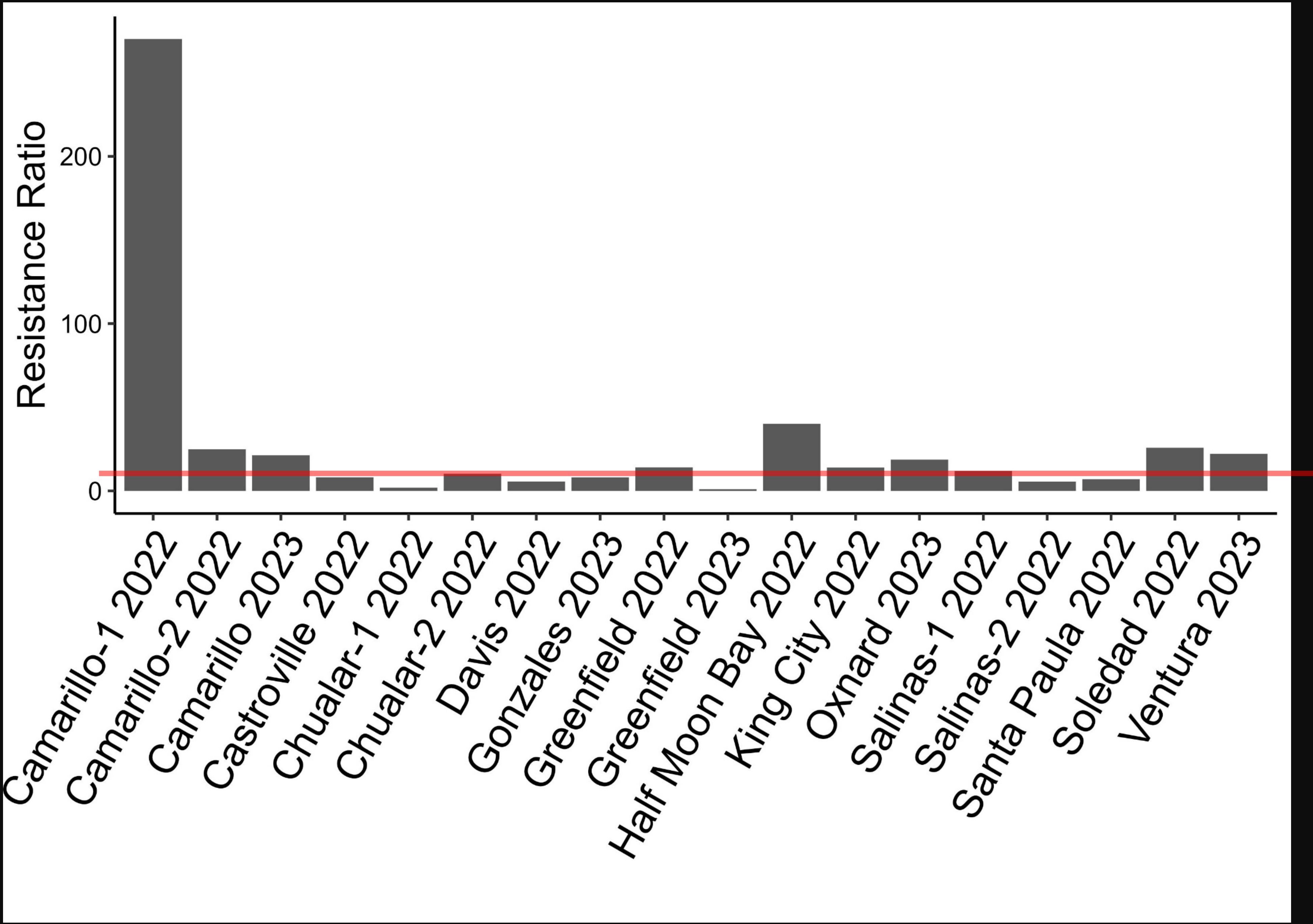
# Spinetoram
# Radiant
# (spinosyn)



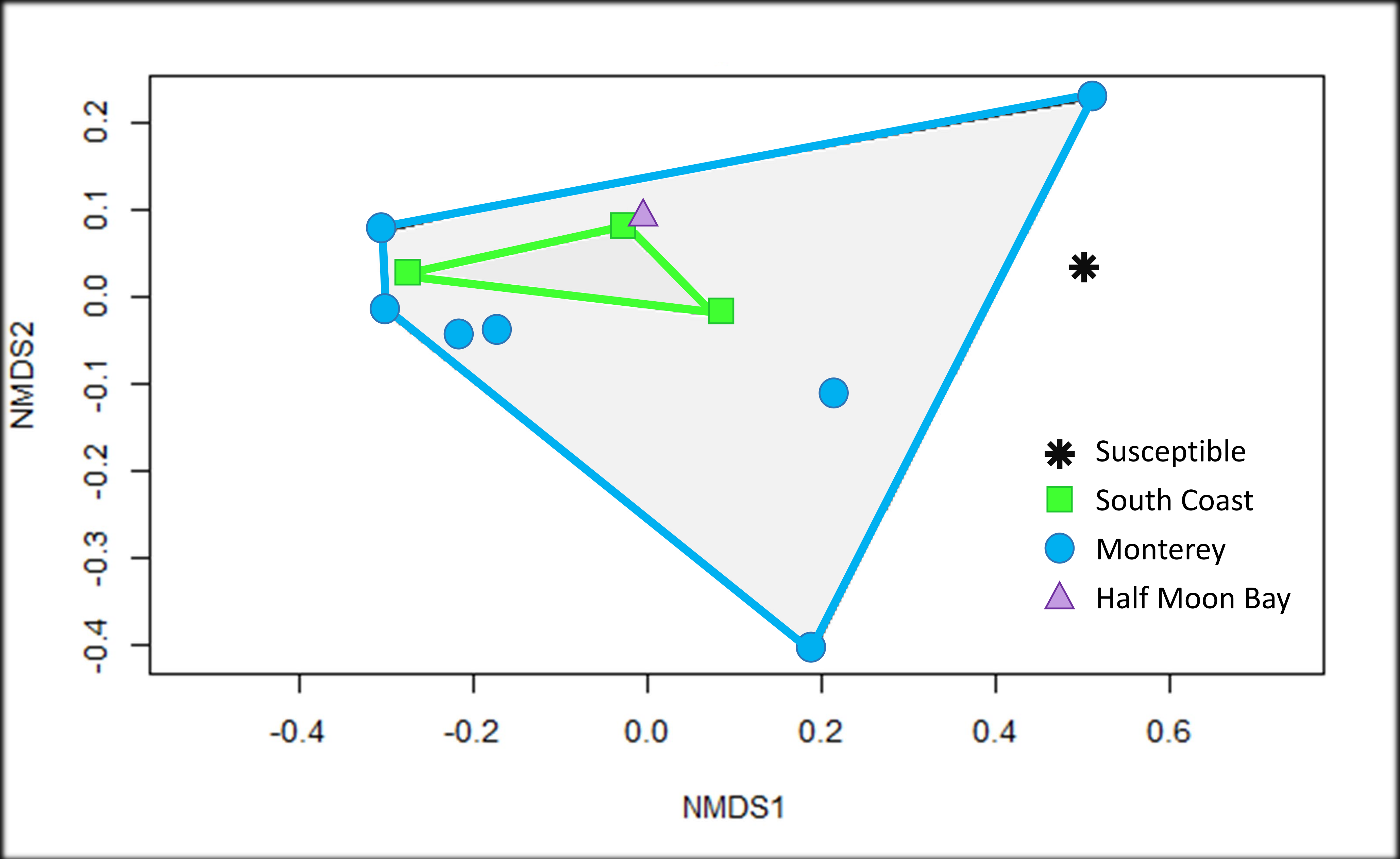
# Indoxacarb
# Avaunt

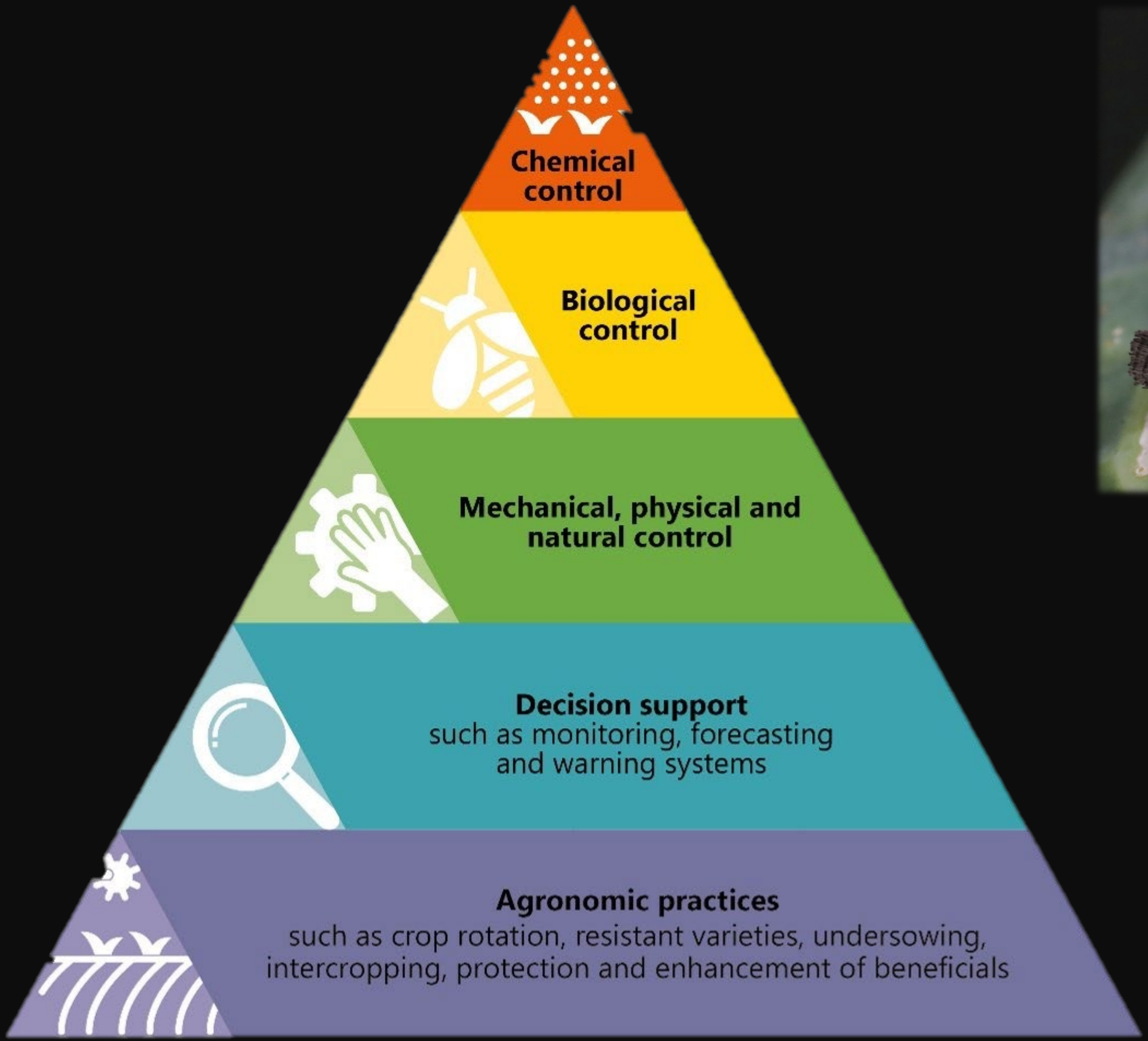
But....$LC_{50}$'s closer to label rate

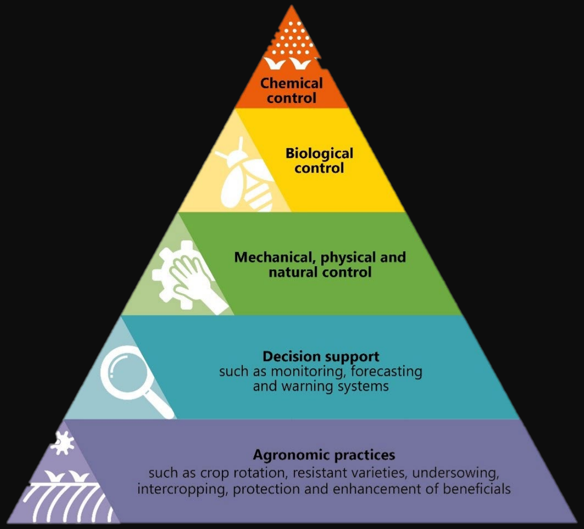
*Bacillus thuringensis/ Bt – aizawai* XenTari



# Patterns within populations across chemicals


0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
NMDS2
-0.4
-0.2
0.0
0.2
0.4
0.6
NMDS1
Susceptible
South Coast
Monterey
Half Moon Bay


Chemical control
Biological control
Mechanical, physical and natural control
Decision support
such as monitoring, forecasting and warning systems
Agronomic practices
such as crop rotation, resistant varieties, undersowing, intercropping, protection and enhancement of beneficials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Questions?