# Next generation of aphid biological control


HTA Grower Technical Workshop, 3rd June 2025

# Understanding variation in parasitoid susceptiblity in potato aphid and it's implications for biological control


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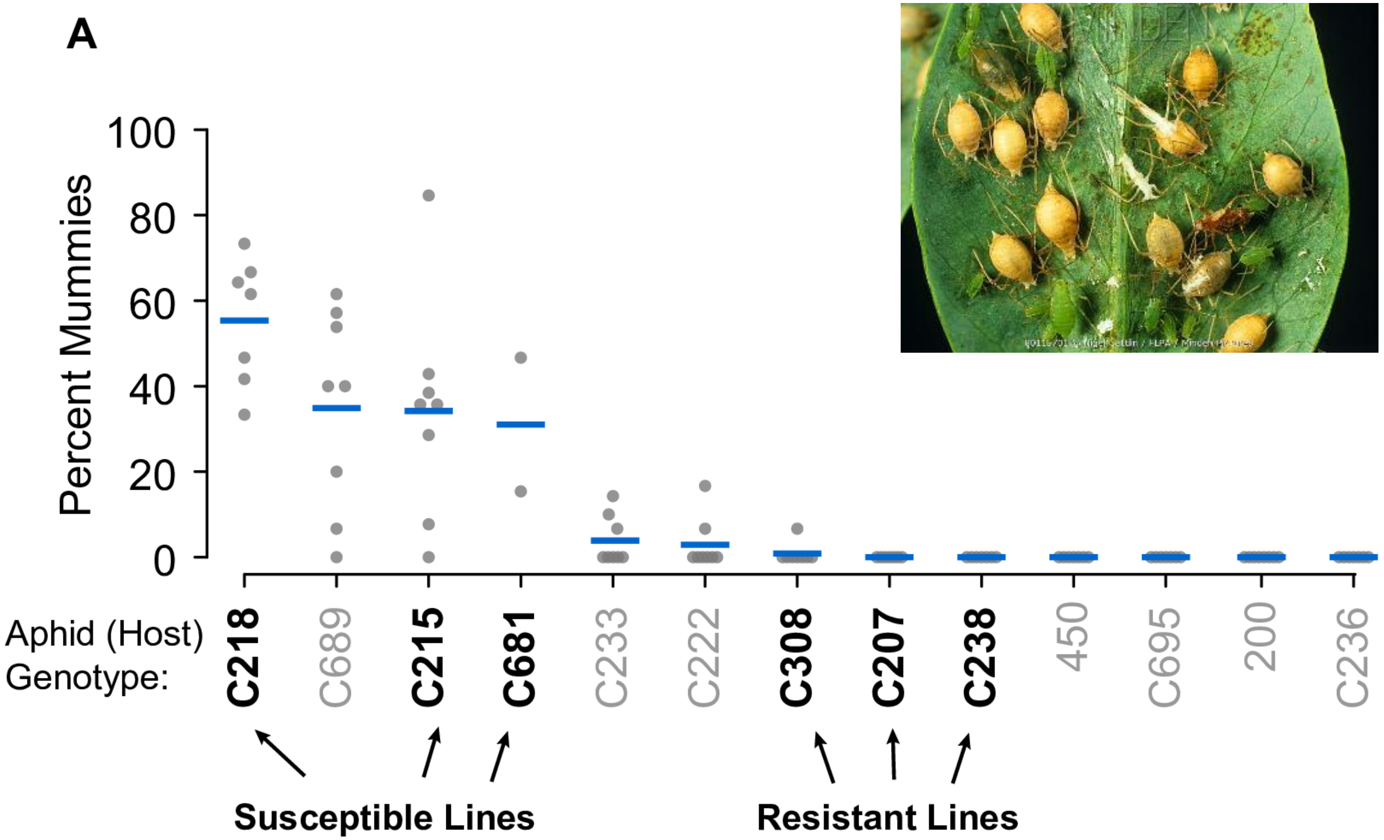
CTP FRUIT CROP RESEARCH

# Parasitoid resistance in aphids – how?

- First detected in *Acyrtosiphon pisum* (pea aphid).



# Parasitoid resistance in aphids – how?

- Complex trait.
- **Intrinsic resistance**: encoded in the aphid genome.
- Multiple traits provided by **secondary endosymbionts (SE).**
- Three SE have been described to provide parasitoid resistance.

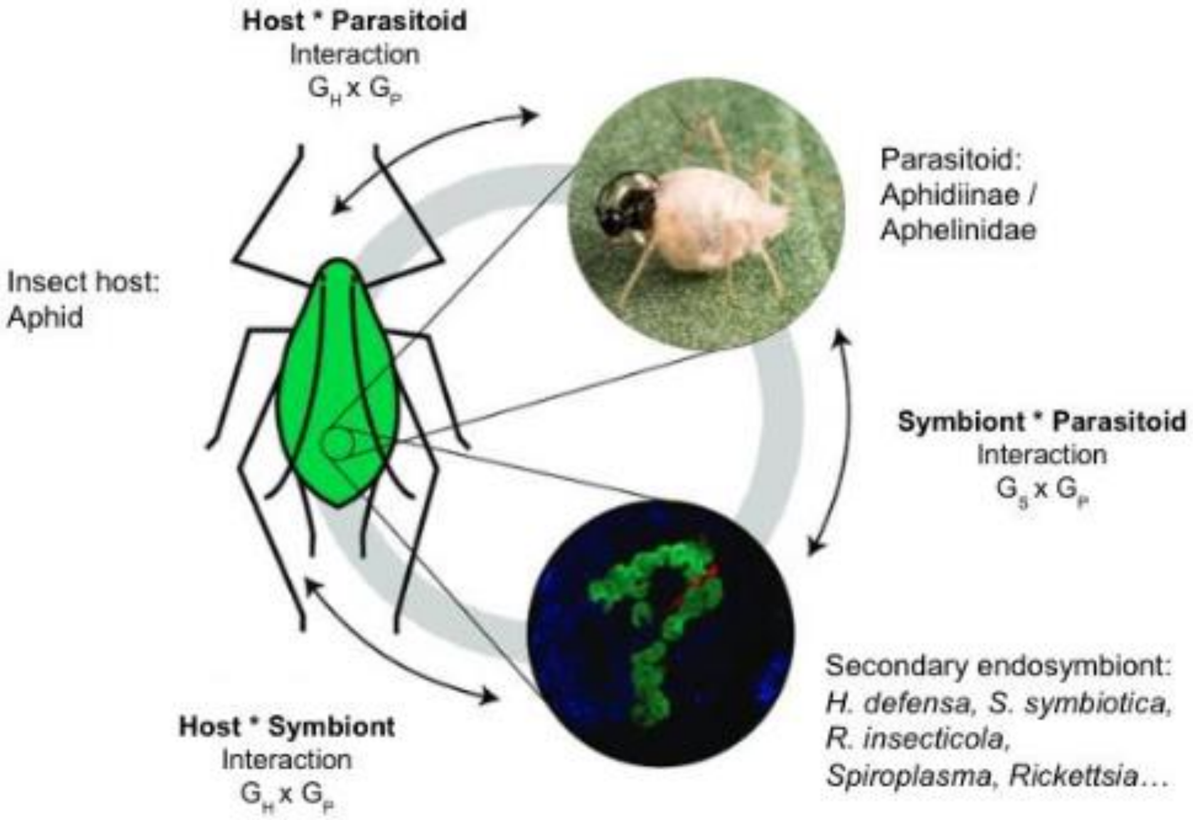
**Table 1. Summary of some host benefits associated with harbouring secondary symbionts.** '*' Even though *Buchnera* is not a secondary symbiont, it has also been linked to thermal tolerance.

| ***Phenotype*** | ***associated symbiont*** | ***reference*** |
|---|---|---|
| Aphid thermal tolerance | *Serratia symbiotica* | Montllor *et al.*, 2002 |
| | **B. aphidicola* | Dunbar *et al.*, 2007 |
| Parasitoid resistance | *Hamiltonella defensa* | Oliver *et al.*, 2003, Oliver *et al.*, 2005 & Ferrari *et al.*, 2004 |
| | *Regiella insecticola* | Vorburger *et al.*, 2010 |
| | X-type | Heyworth & Ferrari, 2005 |
| Reduced lady beetle survival | *H. defensa/S. symbiotica* | Costopoulos *et al.*, 2014 |
| Resistance to fungal pathogen | *R. insecticola* | Scarborough *et al.*, 2005 |
| | X-type | Heyworth & Ferrari, 2005 |
| Colour polymorphism | *Ca. Rickettsiella viridis* | Tsuchida *et al.*, 2010 |

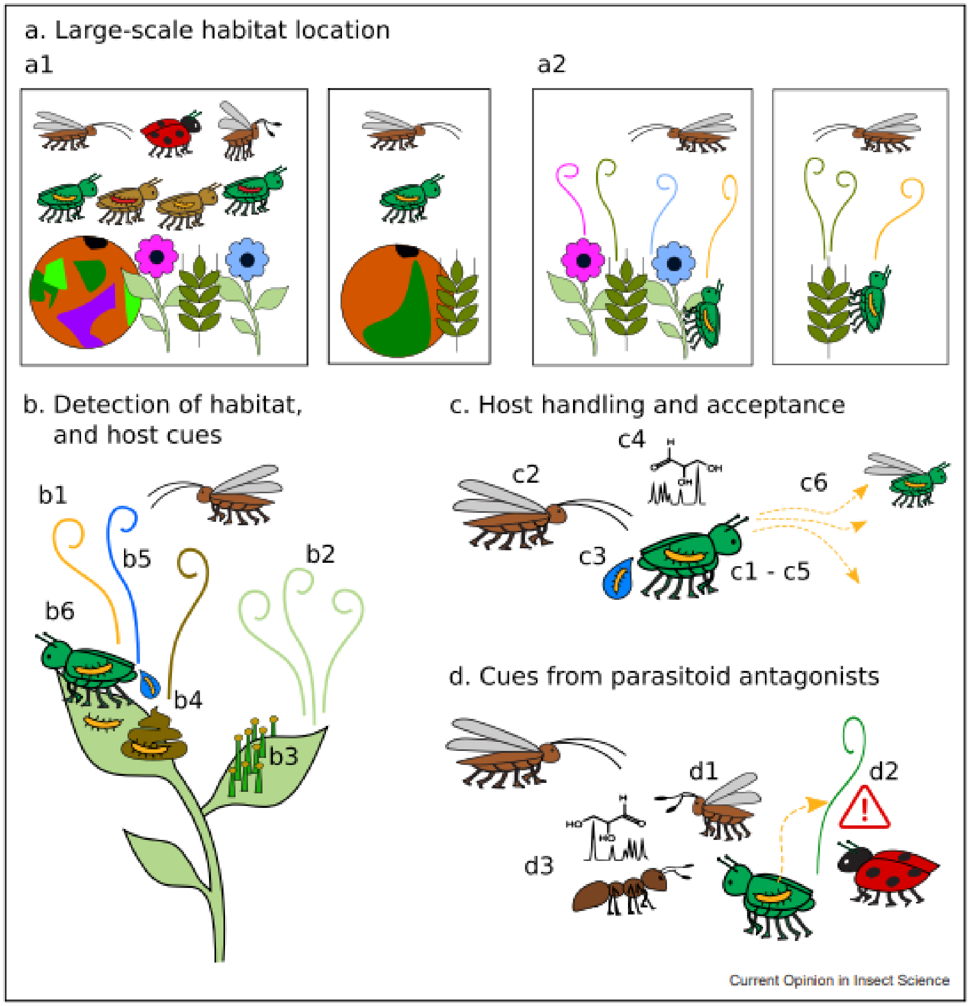
# The complexity of parasitoid resistance

- Specific interactions between aphid – parasitoid species.

- Genotype by genotype interactions between aphids- symbionts- parasitoids.



# Other impacts of secondary endosymbionts

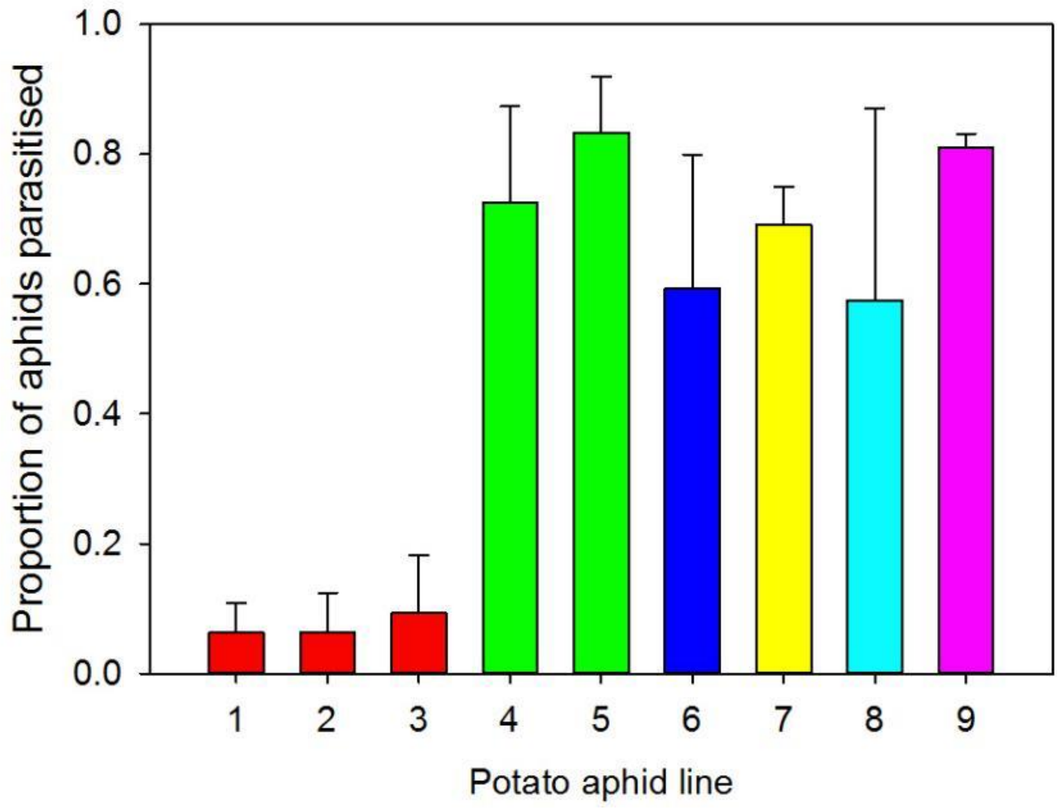



- Modulation of plant and host volatile chemical cues.
- Directly emanation of volatile cues.
- Modulation of plant defences by reducing HIPVs emissions or altering physical structure.
- Alteration of host emitted cues from frass, honeydew, body colour.
- Changes on host defensive behaviours and dispersion to avoid parasitism.
- Alteration of risk cues associated with parasitoid antagonists (modulating competition).

# The potato aphid (*Macrosiphum euphorbiae*)

One genotype from potato crops has been described as resistant to parasitism, associated with genotype.

| Genotype | Secondary endosymbionts present |
|---|---|
| ● 1 | *H. defensa* |
| ● 1 | *H. defensa* (+ APSE) |
| ● 1 | None found |
| ● 2 | *H. defensa* (+ APSE) |
| ● 2 | *H. defensa* (+ APSE) |
| ● 3 | None found |
| ● 4 | None found |
| ● 6 | None found |
| ● 7 | None found |



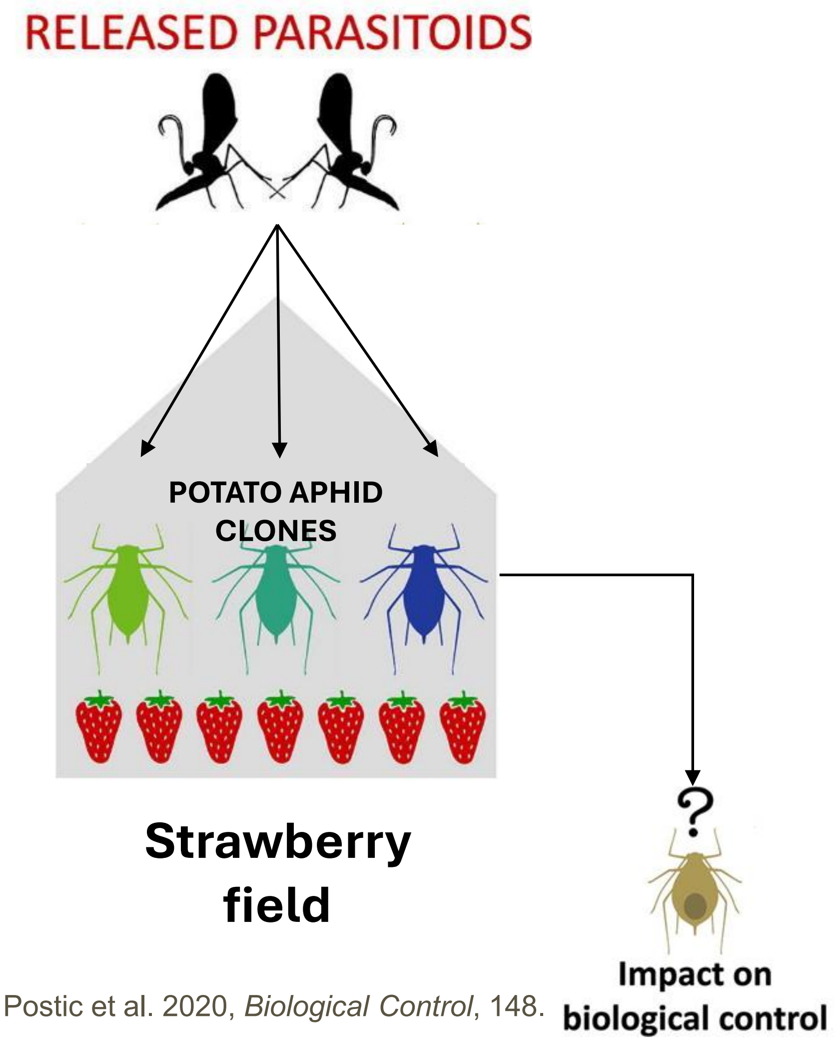

Adapted from Clarke, H.V., 2013. PhD thesis.

# The problem and the questions

- Early-season aphid control problems in strawberry

- Are there resistant clones of ***Macrosiphum euphorbiae*** infesting strawberries?

- Is parasitoid resistance affecting biological control and IPM strategies in strawberry crops in the UK?




Adapted from Postic et al. 2020, *Biological Control*, 148.

# How are we approaching this?

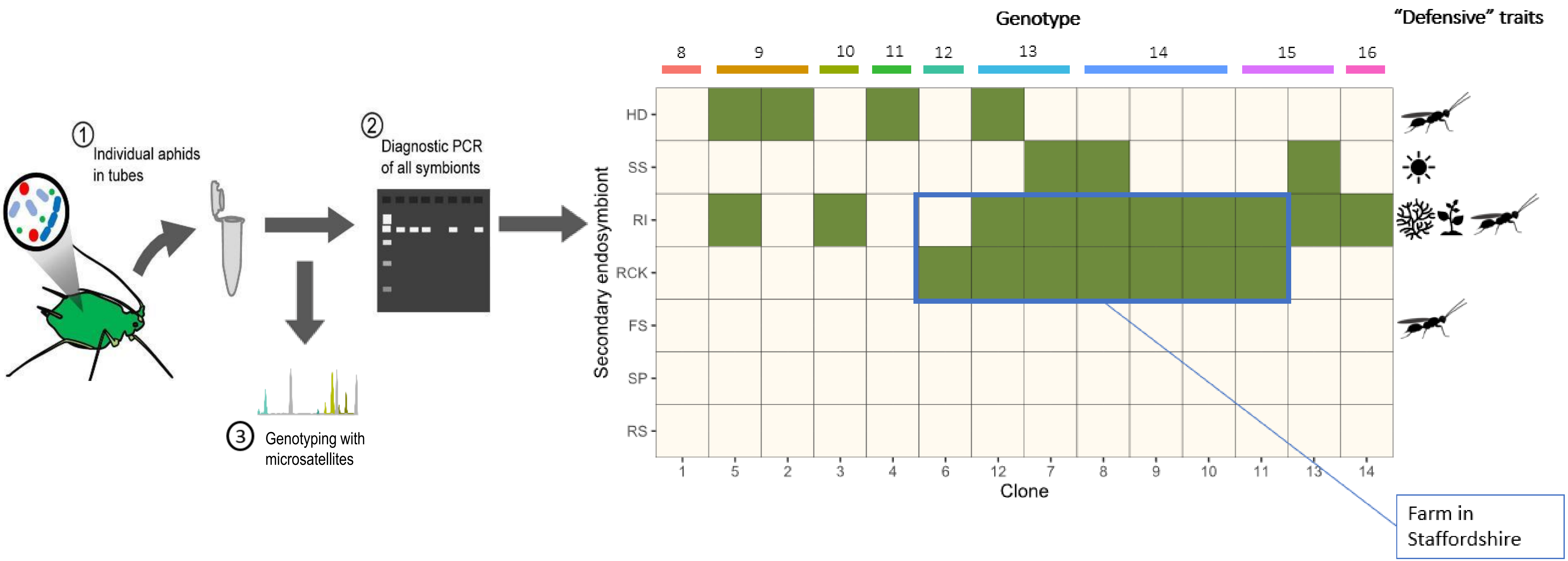

**Determine potato aphid clonal variation in strawberry crops in the UK**

**Understand the role of clonal variation in the interaction of the potato aphid with the parasitoid *Aphidius ervi***

Determine the genetic diversity of the main parasitoid species *Aphidius ervi* used against the potato aphid

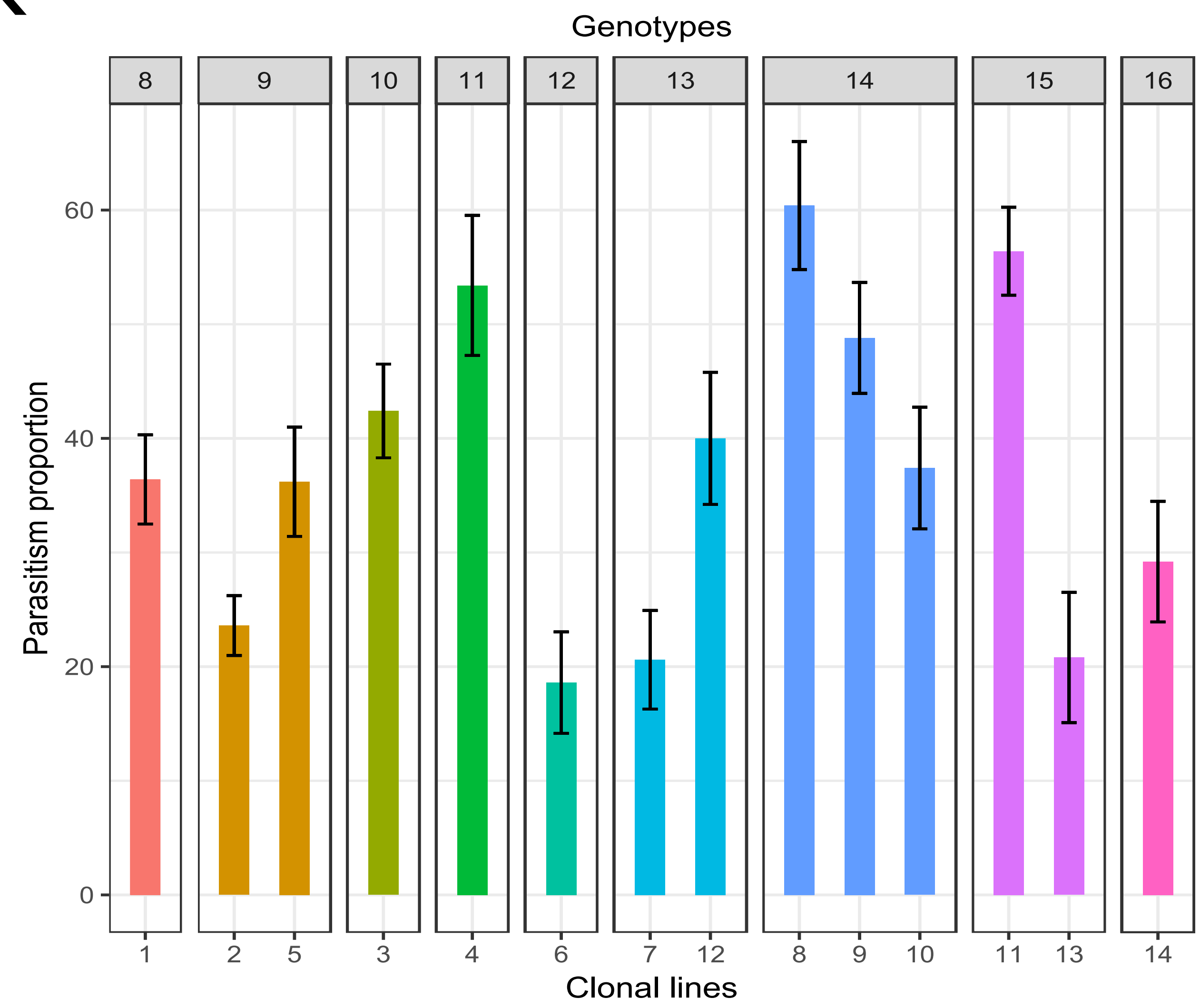
**Determine the effect of aphid clonal variation on parasitism efficacy in field conditions**

# 1. Potato aphid clonal variation in strawberry crops in the UK



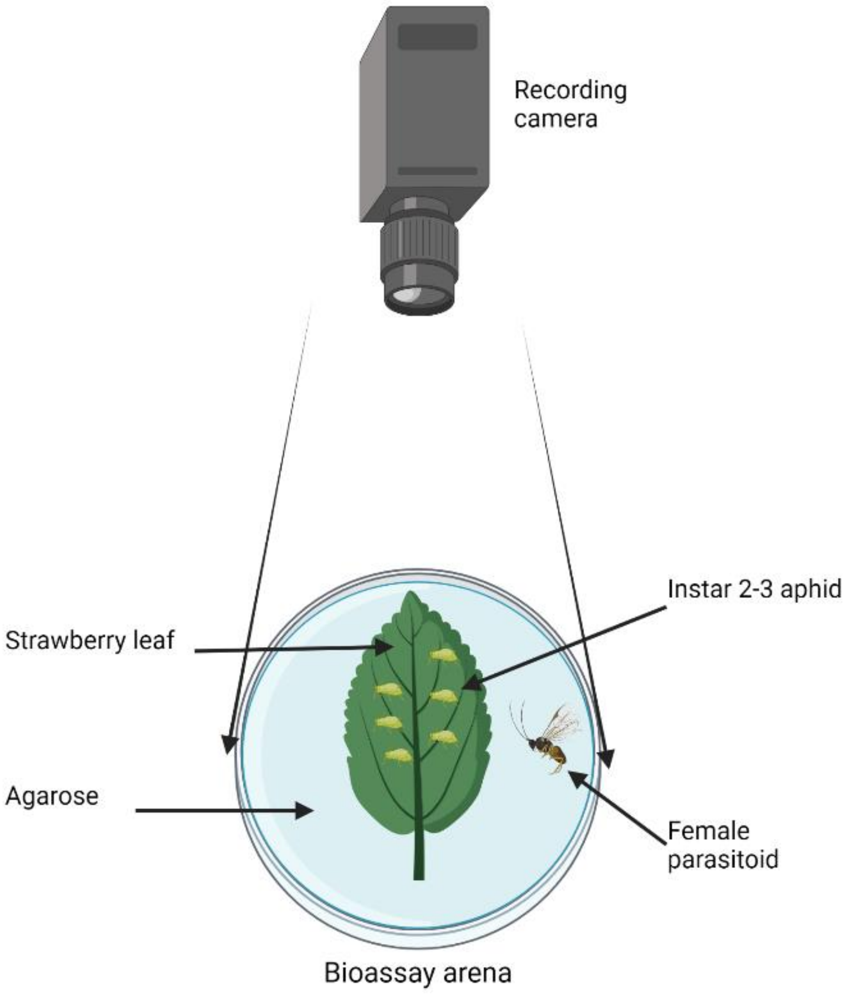
# 1. Potato aphid clonal variation in strawberry crops in the UK

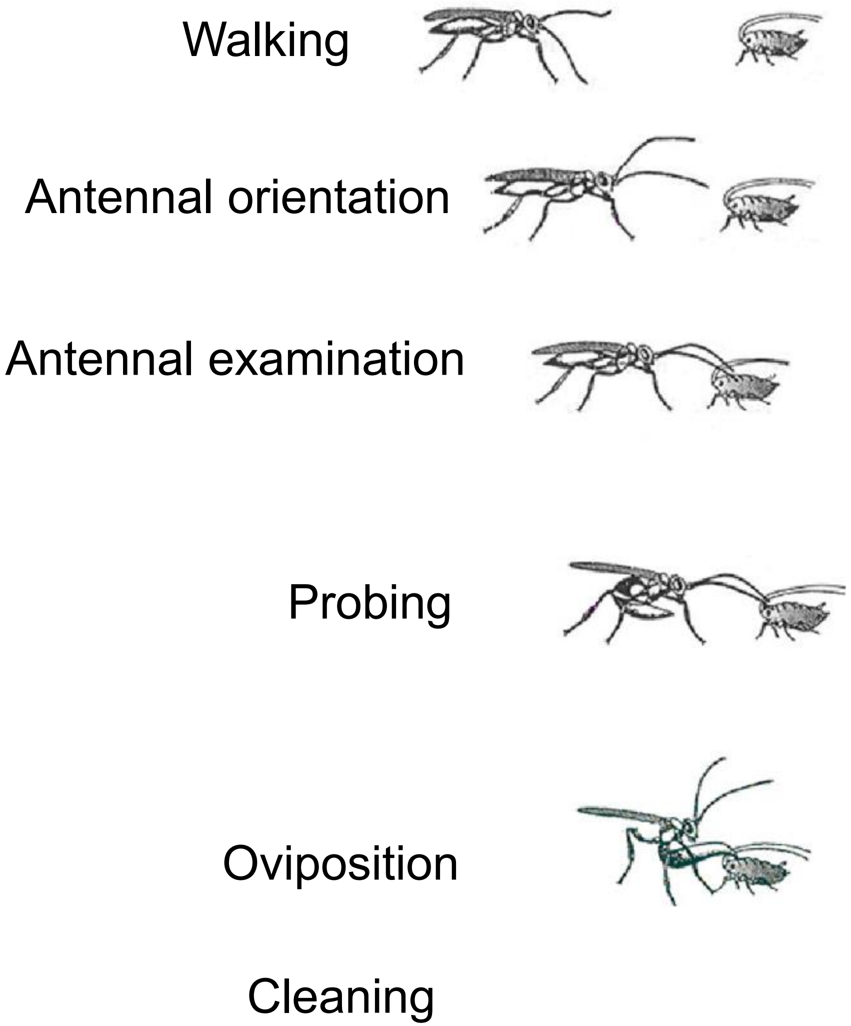
*Aphidius ervi*




30 nymphs x 10 replicates

# 2. The role of clonal variation in the interaction



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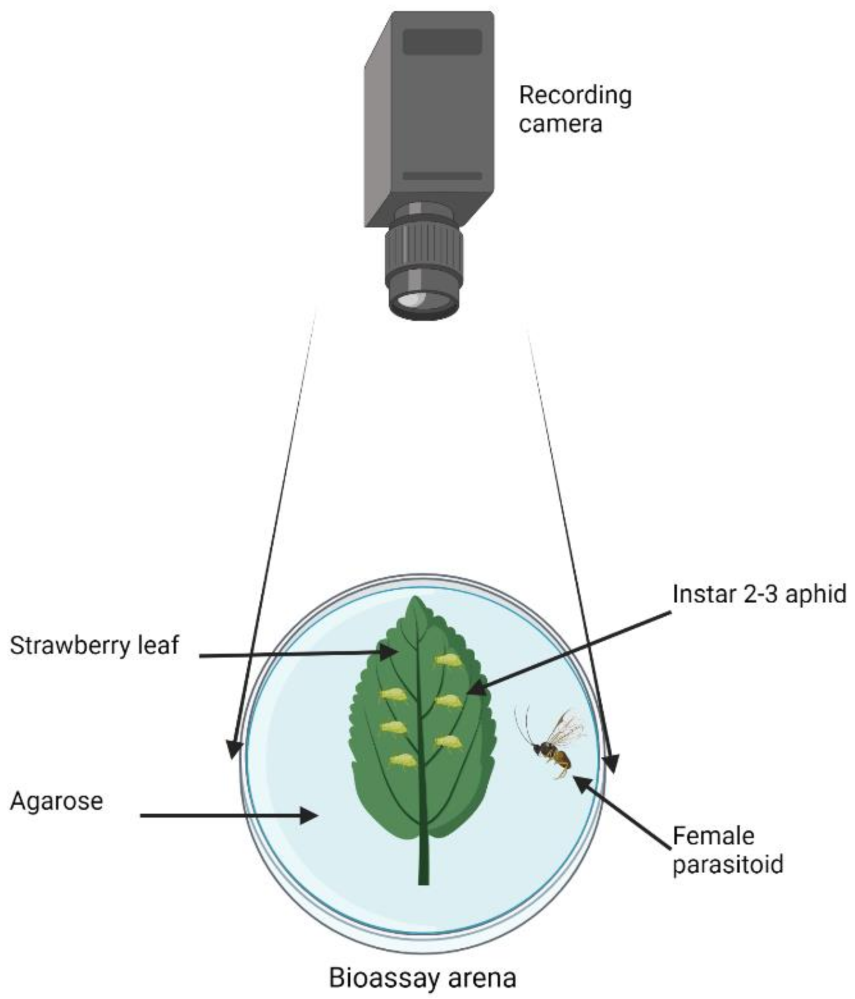
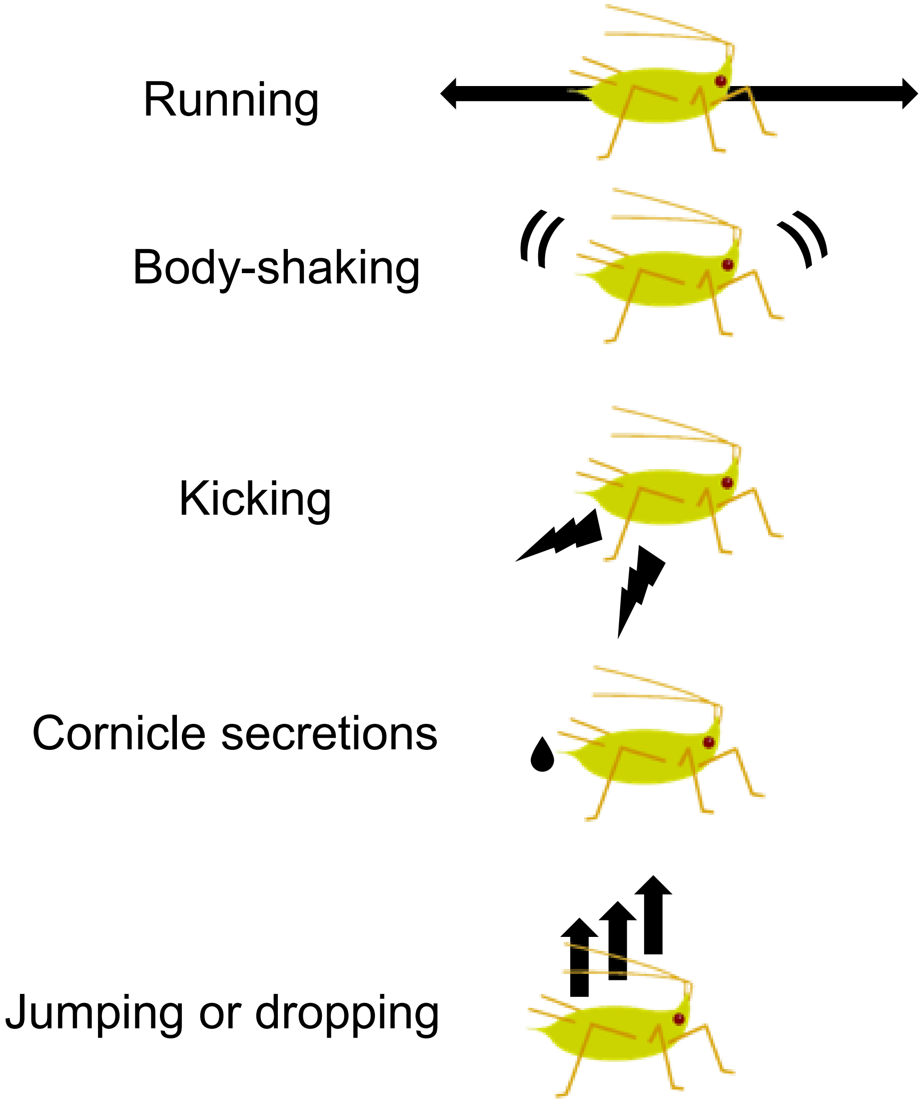
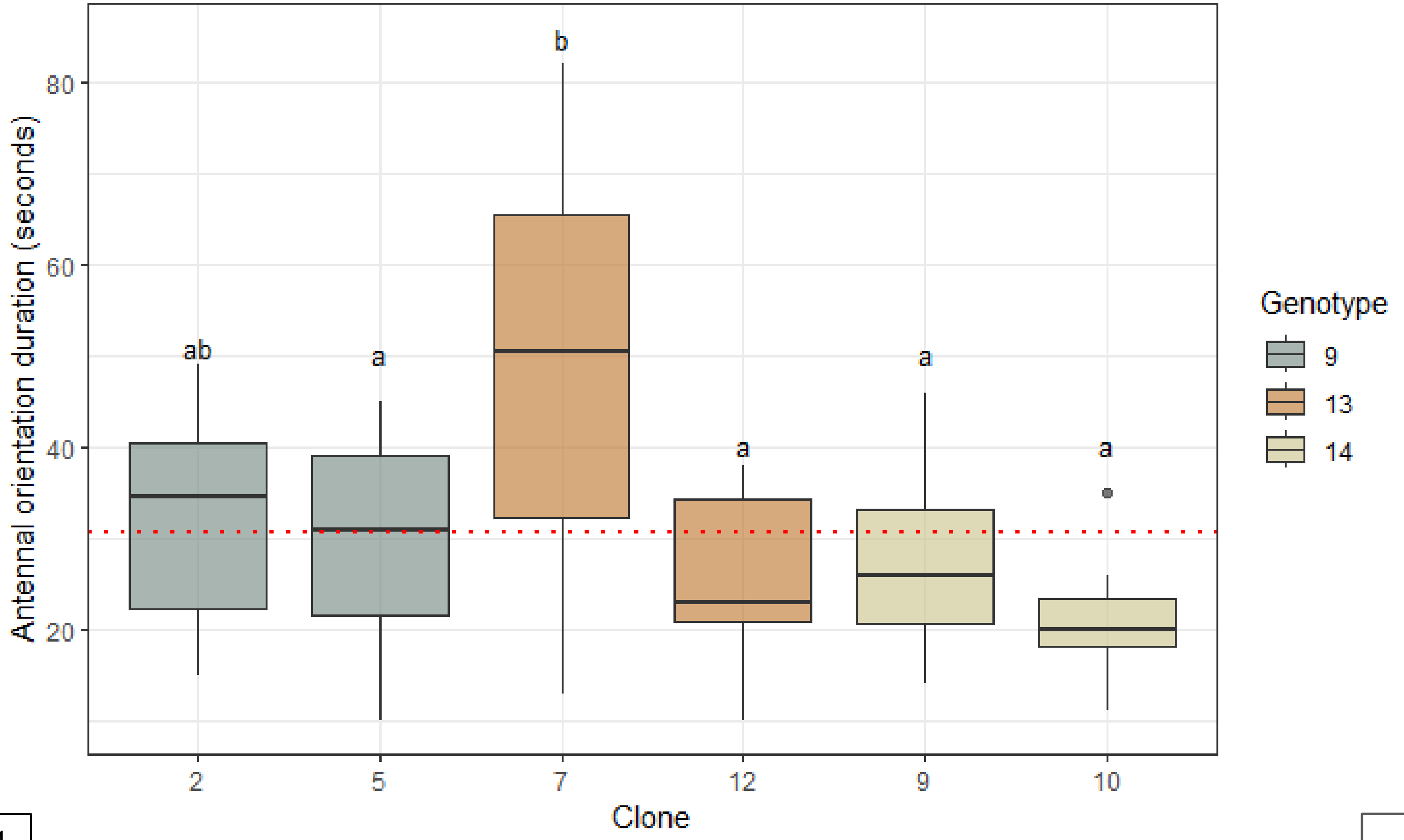


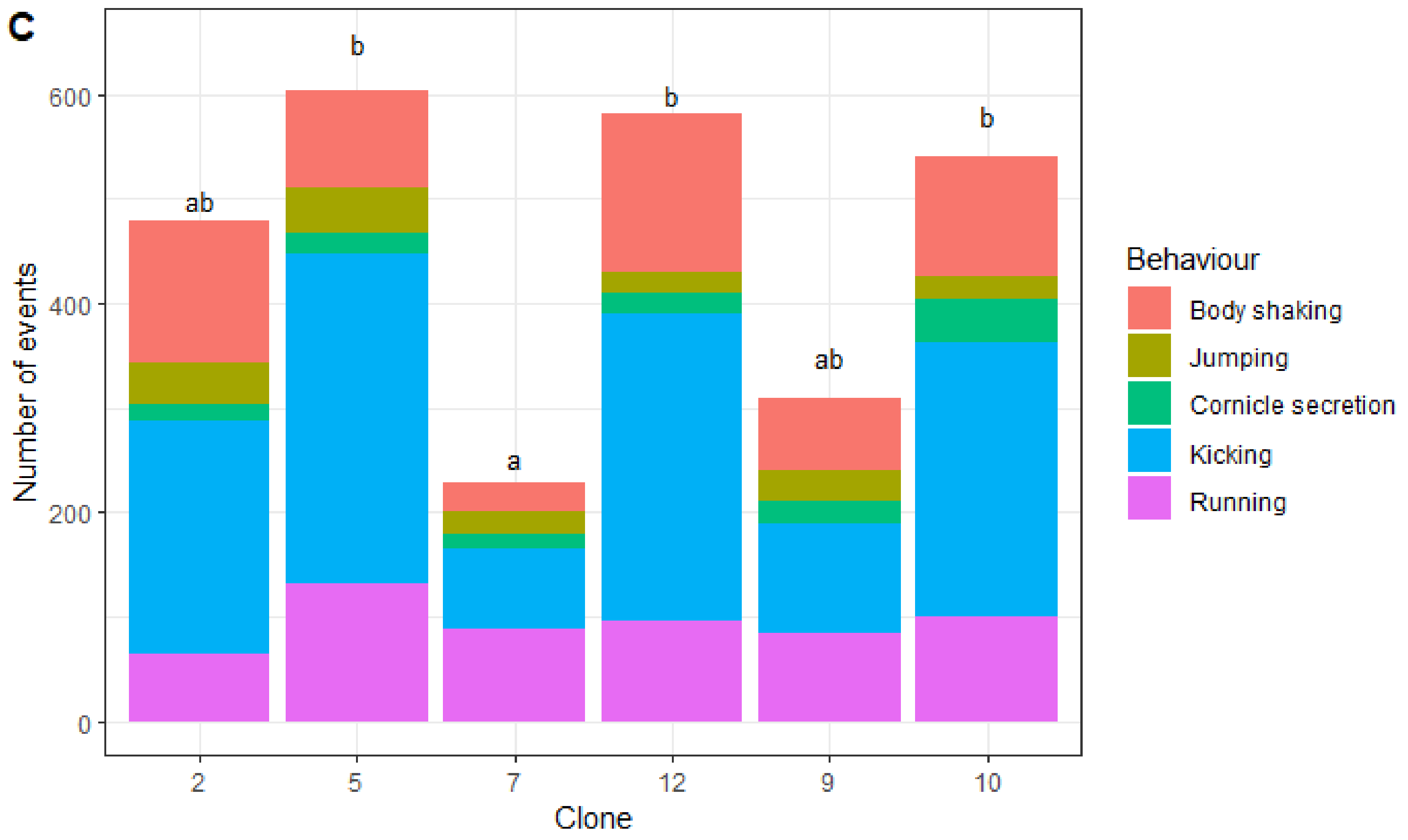
# Checking the role of genotype – parasitoid searching behaviour




Clonal line: *X*2 =5.87, *df*= 3, P <0.001
Genotype: : *X*2 =4.82, *df*= 2, P <0.05

GLM w/ gaussian dist. with EMM pairwise comparisons

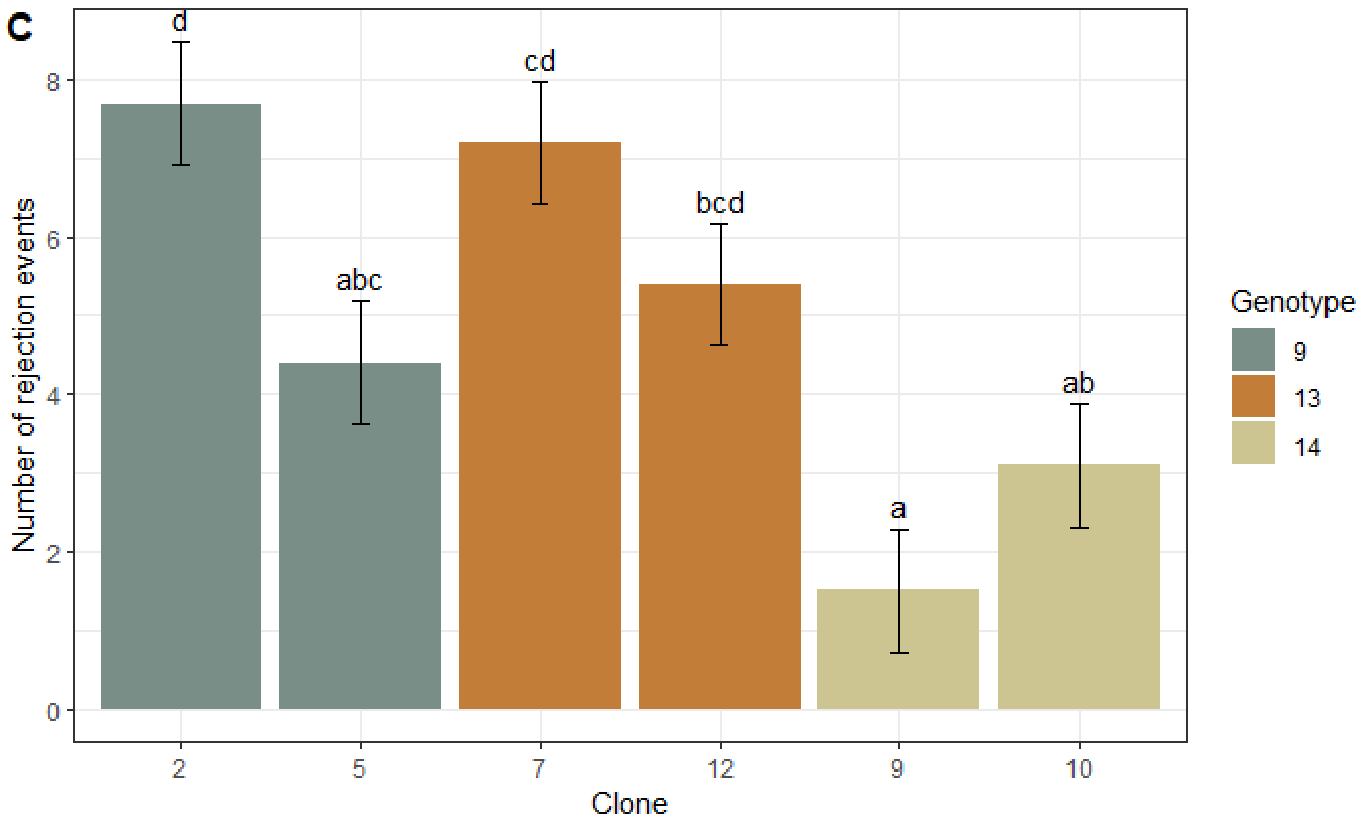
# Checking the role of genotype – aphid defensive behaviours




Clonal line: $X_2$ =19.7, *df*= 5, P <0.001
Genotype: : $X_2$ =2.2, *df*= 2, P > 0.05

GLM w/ gaussian dist. with EMM pairwise comparisons

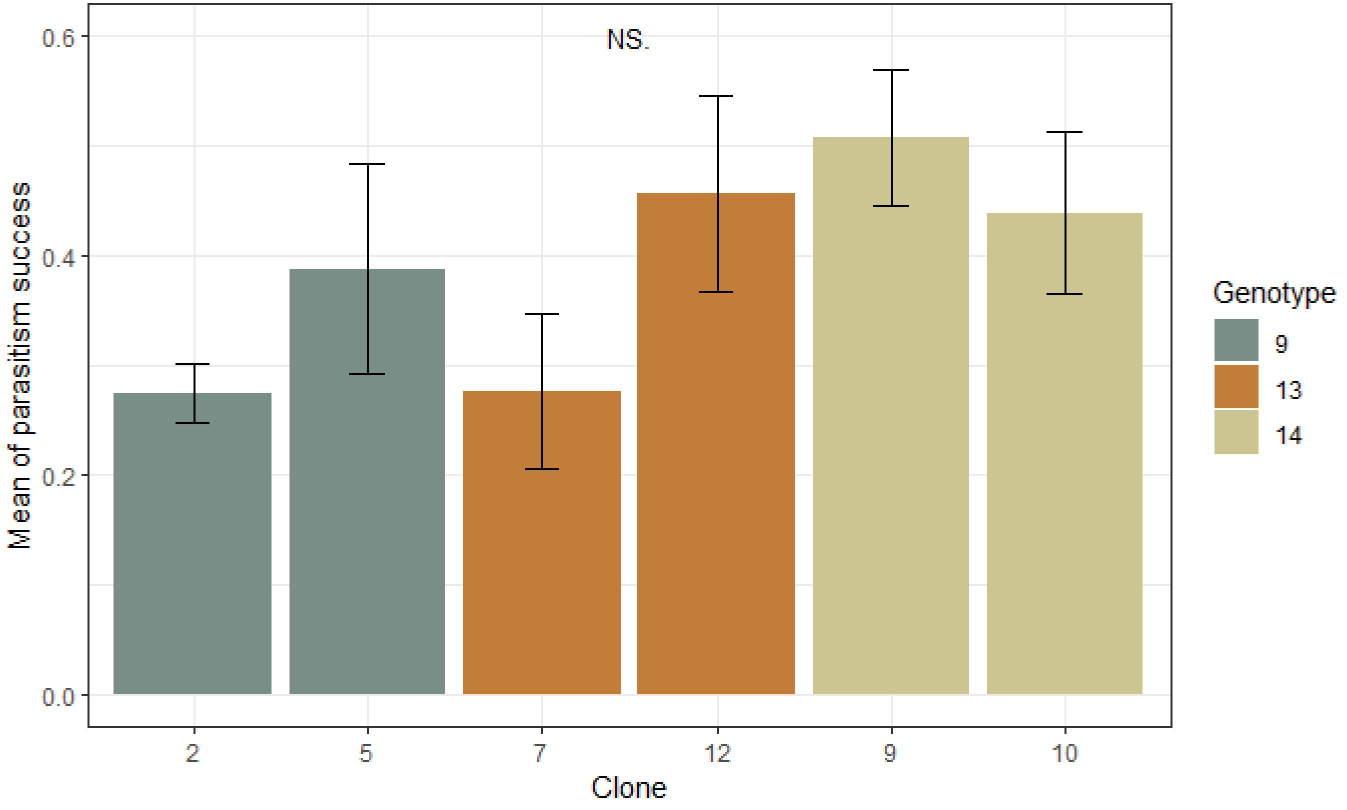
# Checking the role of genotype – rejections by parasitoids




Clonal line: *X*2 =6.02, *df*= 3, P <0.001
Genotype: : *X*2 =2.04, *df*= 2, P <0.05

GLM w/ gaussian dist. with EMM pairwise comparisons

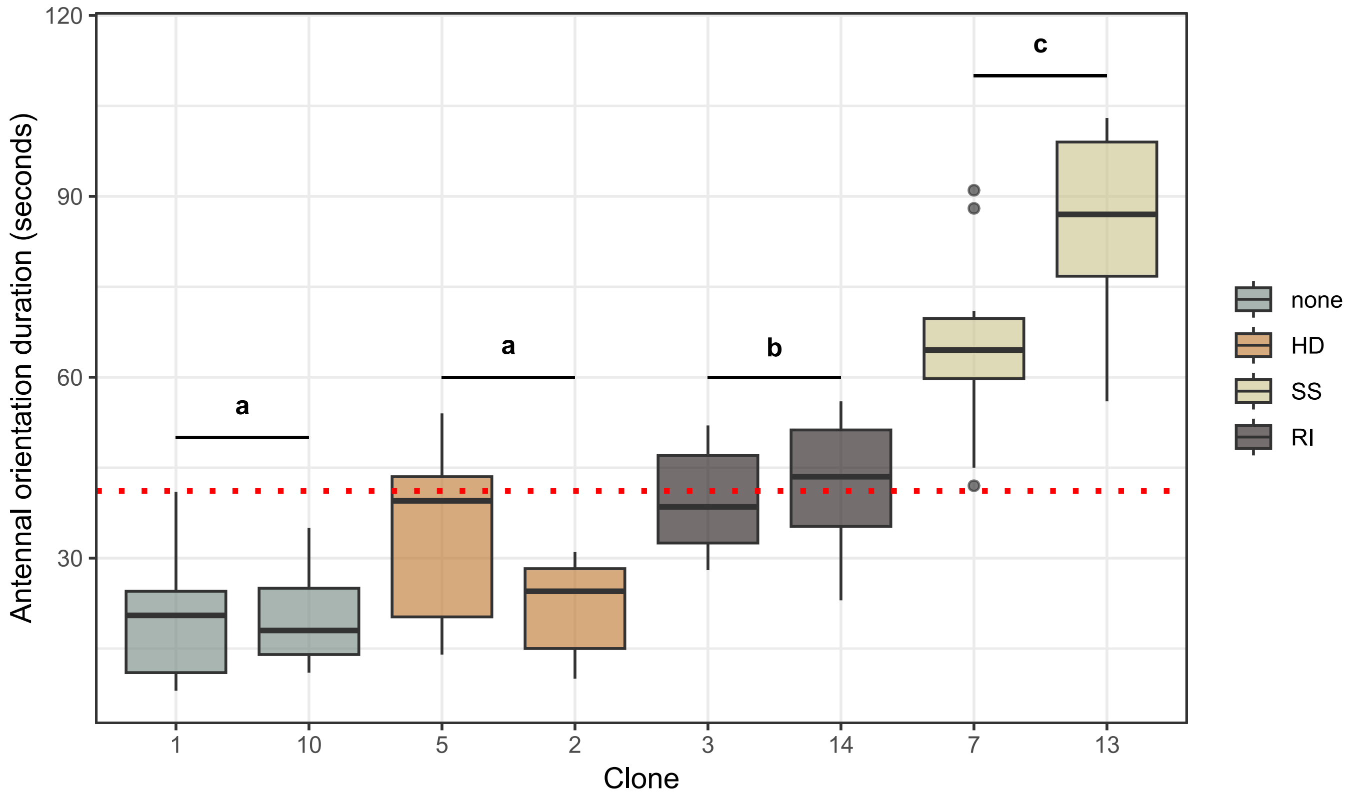
# Checking the role of genotype – parasitism success




Clonal line: *X2* =1.56, *df*= 3, P >0.05
Genotype: : *X2* =2.04, *df*= 2, P >0.05

GLM w/ gaussian dist. with EMM pairwise comparisons

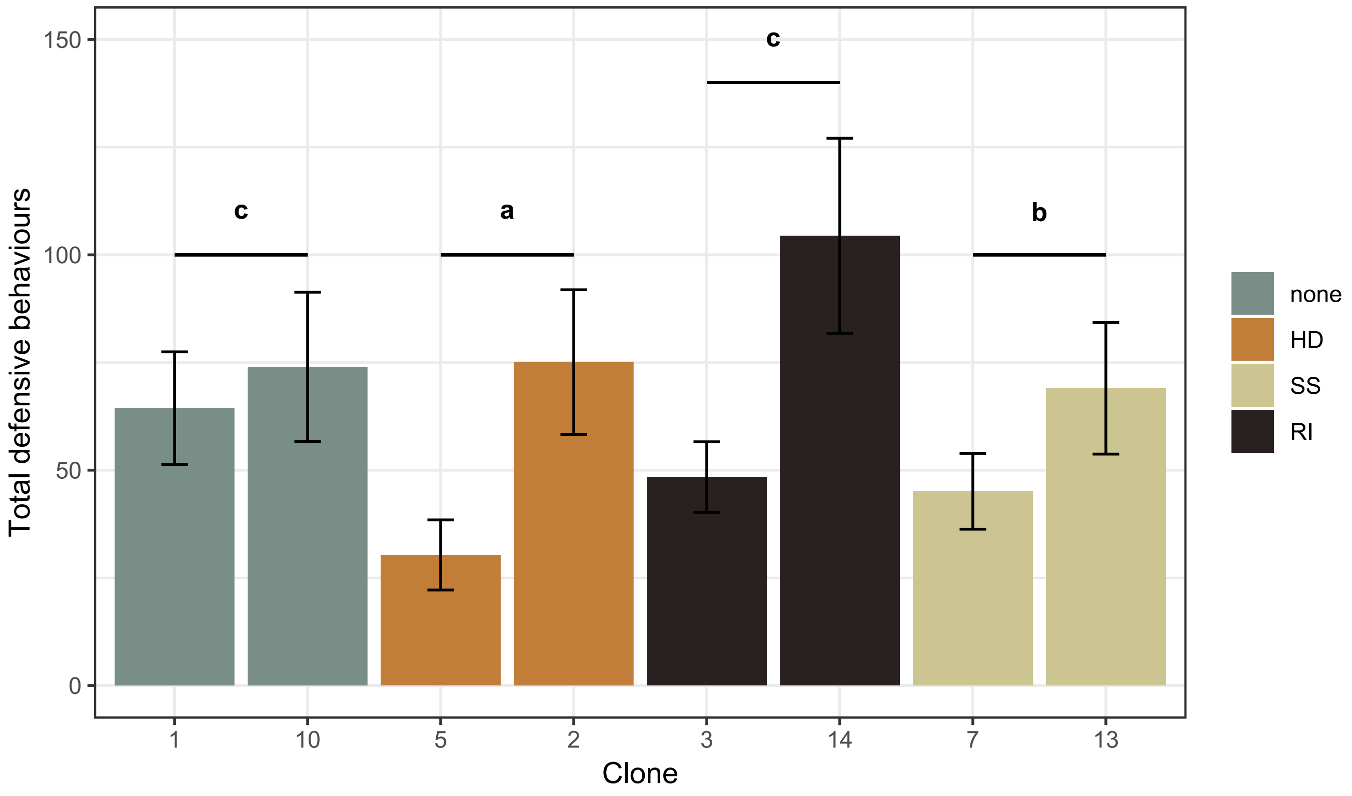
# Checking the role of endosymbiont infection–parasitoid searching behaviour




Clonal line: $X_2$ =19.1, *df*= 4, P <0.001
Endosymbiont : $X_2$ = 219, *df*= 3, P < 0.001

GLM w/ gaussian dist. with EMM pairwise comparisons

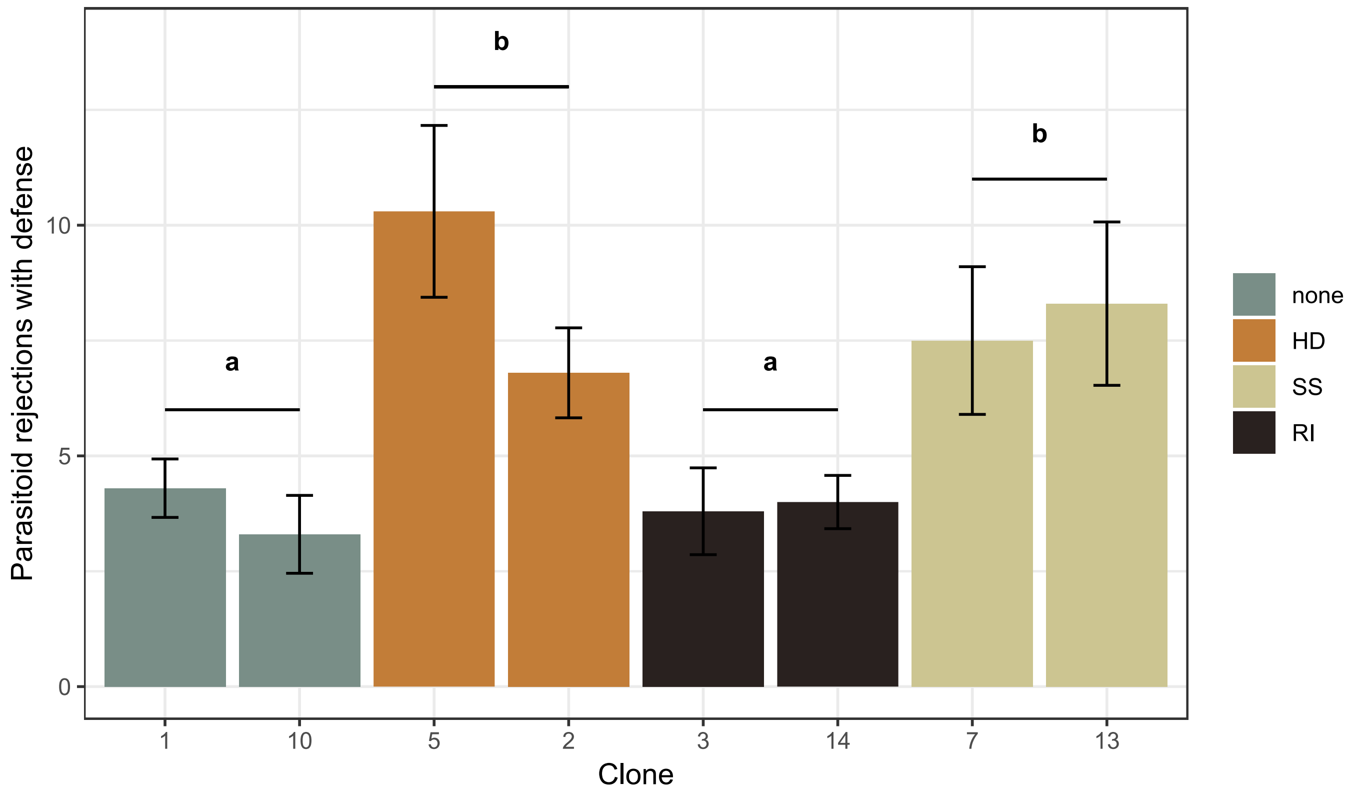
# Checking the role of endosymbiont infection– aphid defensive behaviours




Clonal line: $X_2$ = 111, *df*= 4, P <0.001
Endosymbiont : $X_2$ =463, *df*= 3, P <0.001

GLM w/ gaussian dist. with
EMM pairwise comparisons

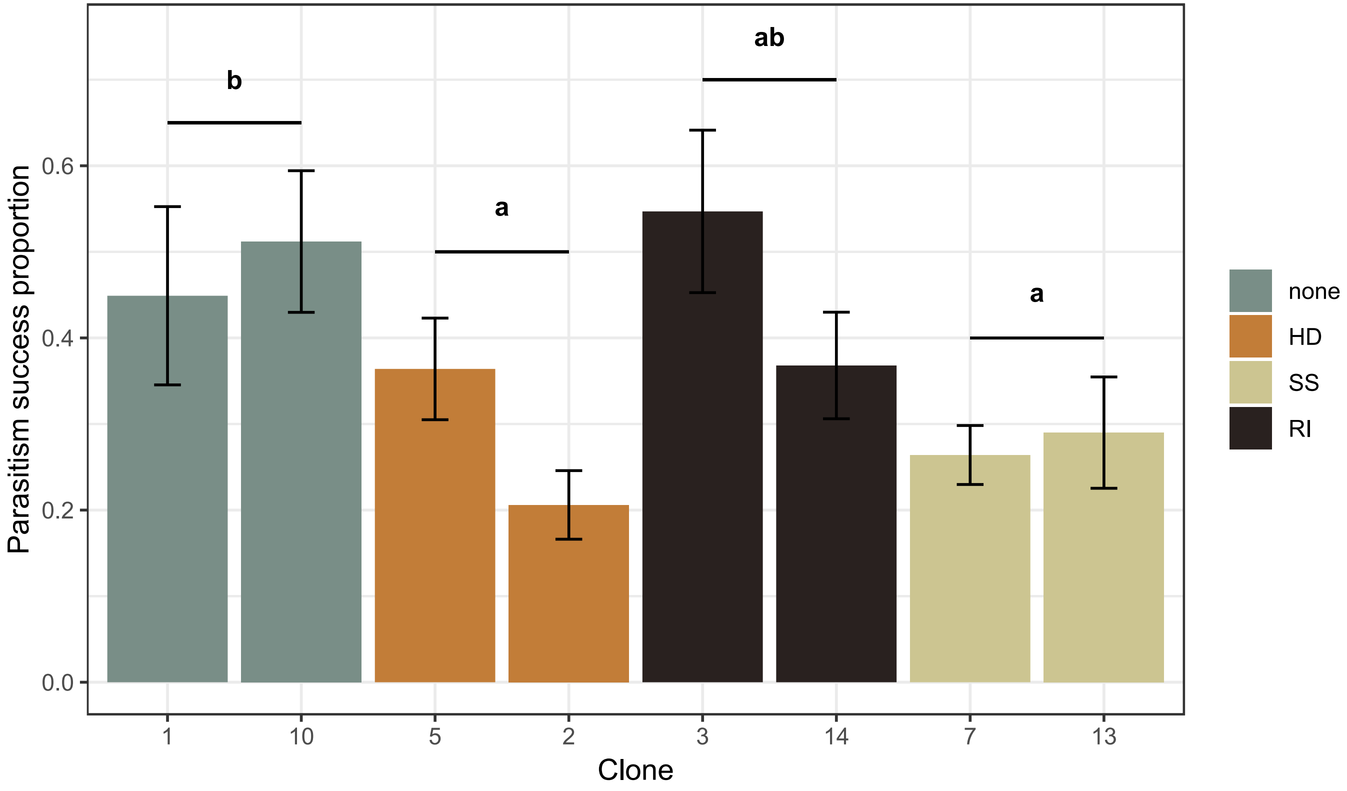
# Checking the role of endosymbiont infection – rejections by parasitoids




Clonal line: $X2$ =8.9, $df$= 4, P >0.05
Endosymbiont: $X2$ =66.4, $df$= 3, P < 0.001

GLM w/ gaussian dist. with EMM pairwise comparisons

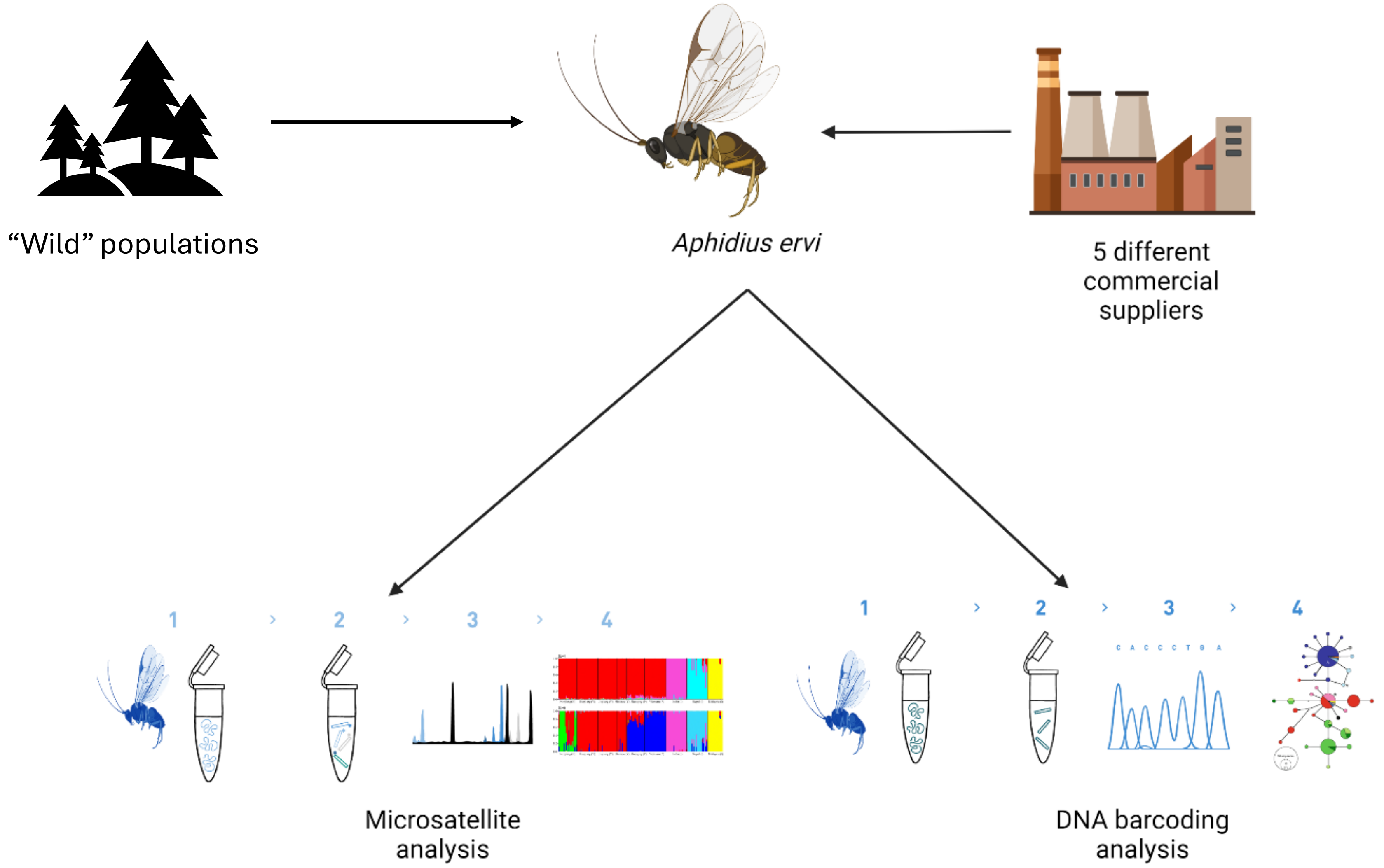
# Checking the role of endosymbiont infection – parasitism success

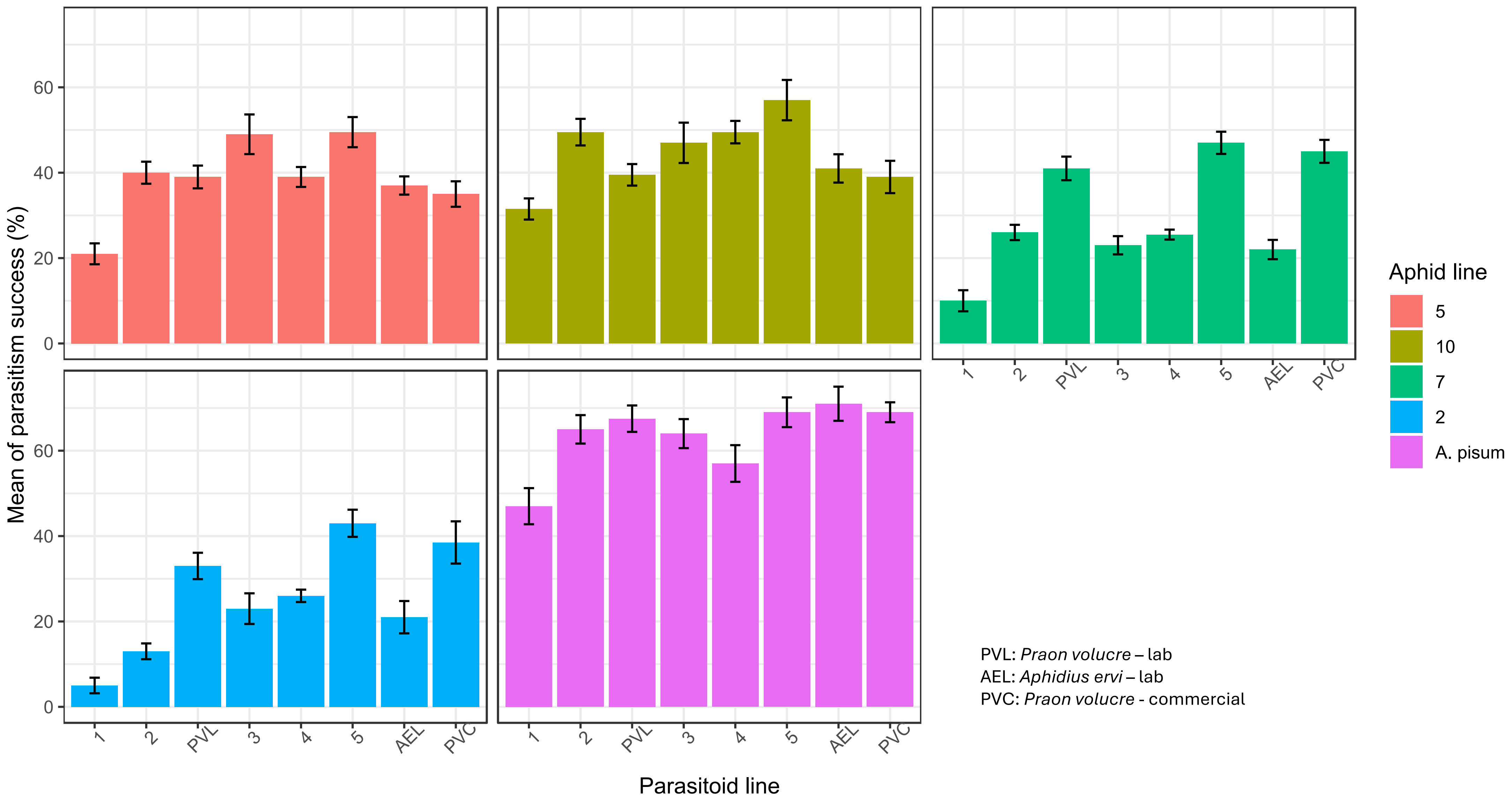



Clonal line: $X_2$ =6.06, *df*= 4, P >0.05
Endosymbiont : $X_2$ =14.2, *df*= 3, P <0.001

GLM w/ gaussian dist. with EMM pairwise comparisons

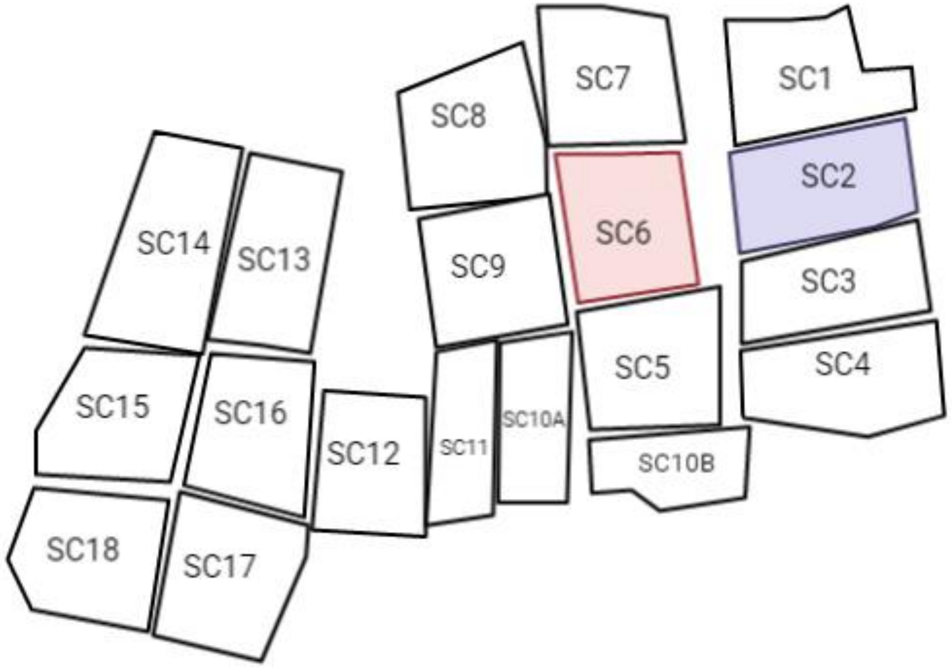
# 3. Genetic diversity of *Aphidius ervi*




Mean of parasitism success (%)
Parasitoid line
Aphid line
5
10
7
2
A. pisum
1
2
PVL
3
4
5
AEL
PVC
0
20
40
60
PVL: *Praon volucre* – lab
AEL: *Aphidius ervi* – lab
PVC: *Praon volucre* - commercial

# 4. The effect of potato aphid variation on field conditions

Farm view - selection of plots

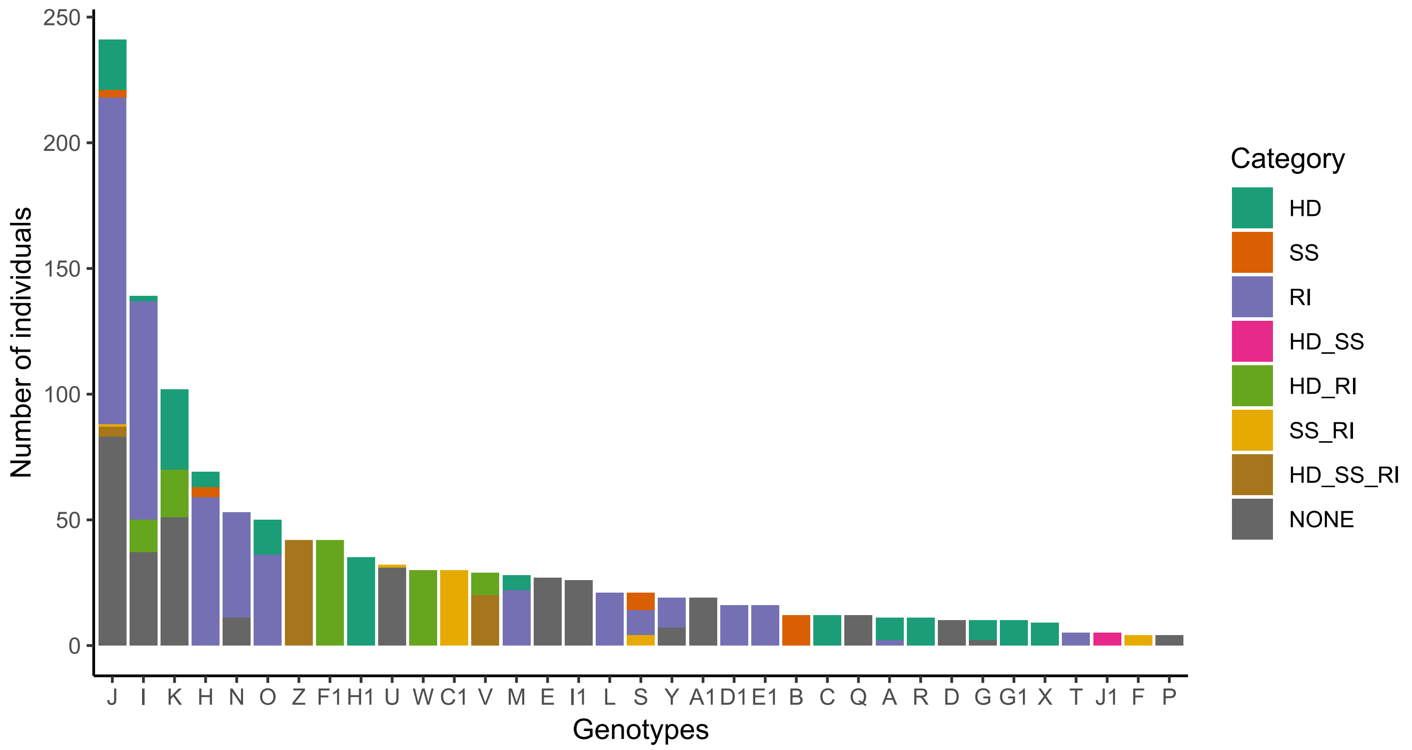




Over 2 seasons

# 4. The effect of potato aphid variation on field conditions

- α diversities
- β diversities
- Endosymbiont prevalence vs parasitism pressure
- Parasitism pressure correlations
- Effect of polytunnel size



# 4. Summary

- **Variation** on potato aphid susceptibility to *Aphidius ervi* in the UK.

- **Limited** aphid genotype effect on parasitoid searching behaviour, aphid defensive behaviour and parasitism success. **BUT significant effect** of endosymbiont infection status.

- Importance of **genetic diversity** on parasitoid populations.

- Importance of understanding the aphid-parasitoid **dynamics** in field conditions.

# ACKNOWLEDGMENTS

Dr. Tom Pope, Dr. Joe Roberts, Dr. Ali Karley, Dr. Francis Wamonje, Dr. Michelle Fountain, Dr. Bethan Shaw, Harriet Duncalfe, Gaynor Malloch, Danielle Henderson-Holding.

# FUNDING

**Enhancing Biological Pest Control:**

Learning Mechanisms and Olfactory Conditioning in Parasitoid Wasps

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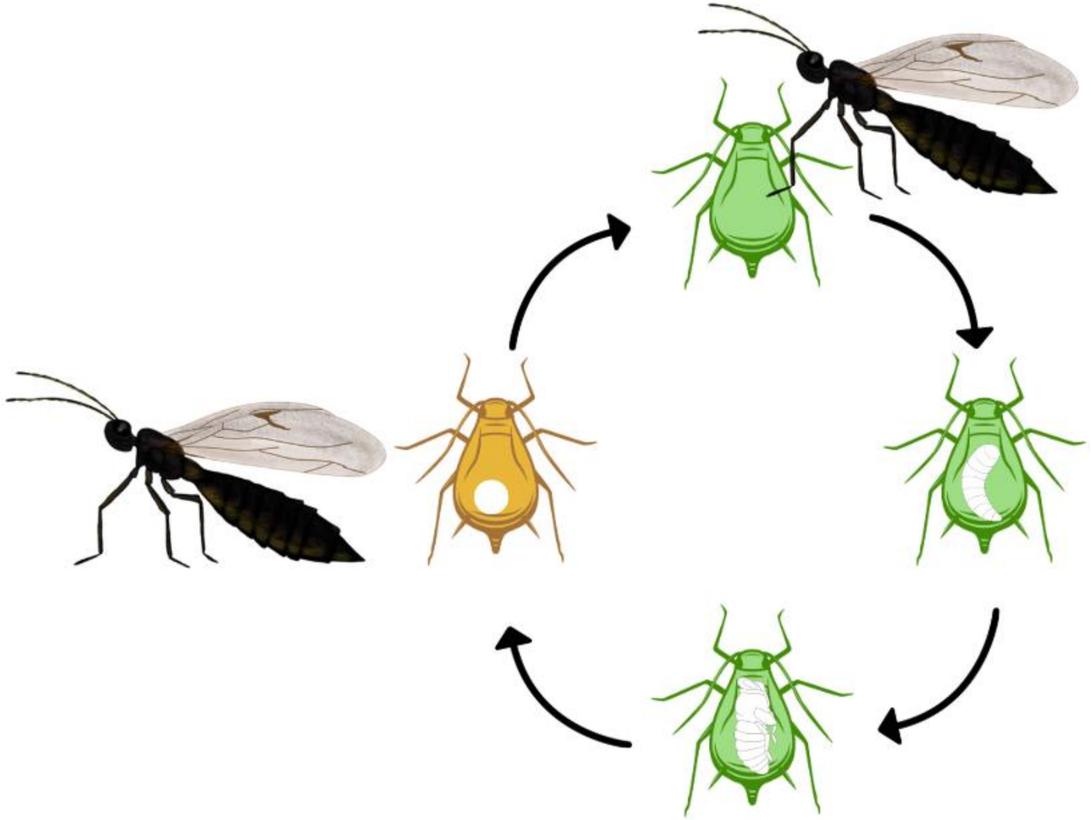
# Background

- Parasitoid wasps are mass reared and commonly used in augmentative biocontrol programs to regulate aphid populations



# Parasitoid foraging behaviour

**Host searching behaviour:**

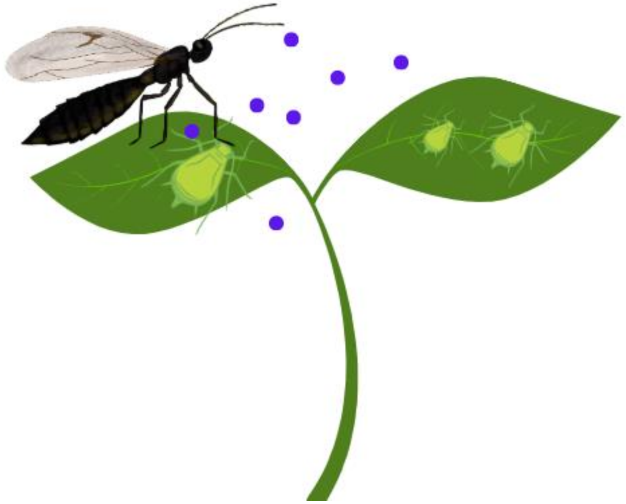
**Host habitat location**

Herbivore-induced plant volatiles (HIPVs)

# Parasitoid foraging behaviour

## Host searching behaviour[2]:

**Host habitat location** → **Host location**



Herbivore-induced plant volatiles (HIPVs)

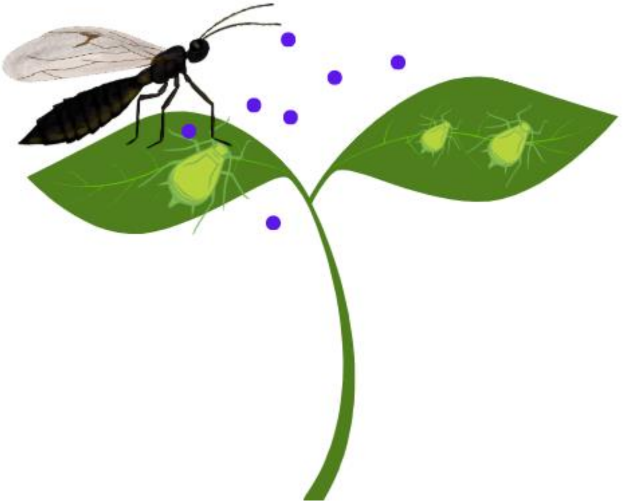
HIPVs and host-originating chemical cues

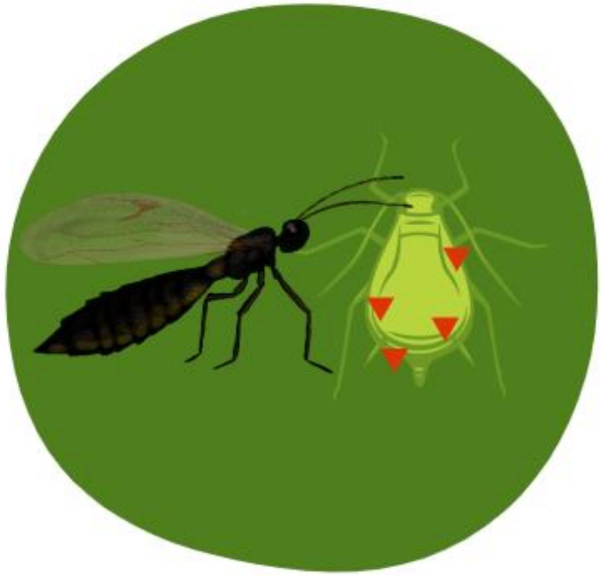
2. Vinson, S.B. (1976) 'Host selection by insect parasitoids', *Annual Review of Entomology*, 21(1), pp. 109–133. doi:10.1146/annurev.en.21.010176.000545.

# Parasitoid foraging behaviour

## Host searching behaviour:

**Host habitat location** → **Host location** → **Host acceptance**





● ◆ ▼ Herbivore-induced plant volatiles (HIPVs)

● HIPVs and host-originating chemical cues

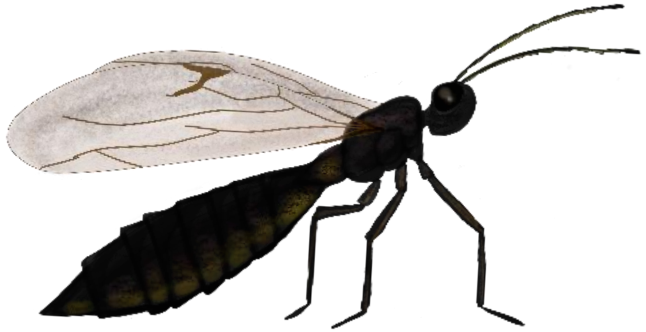
▼ Chemical cues directly derived from the host

# Parasitoid foraging behaviour and learning

## Parasitoid behavioural responses to chemical cues

- **Innate**
  - Fixed responses
- **Learned**
  - Associative learning

"The process that produces an adaptive change in an individual's behaviour as the result of experience"[3]



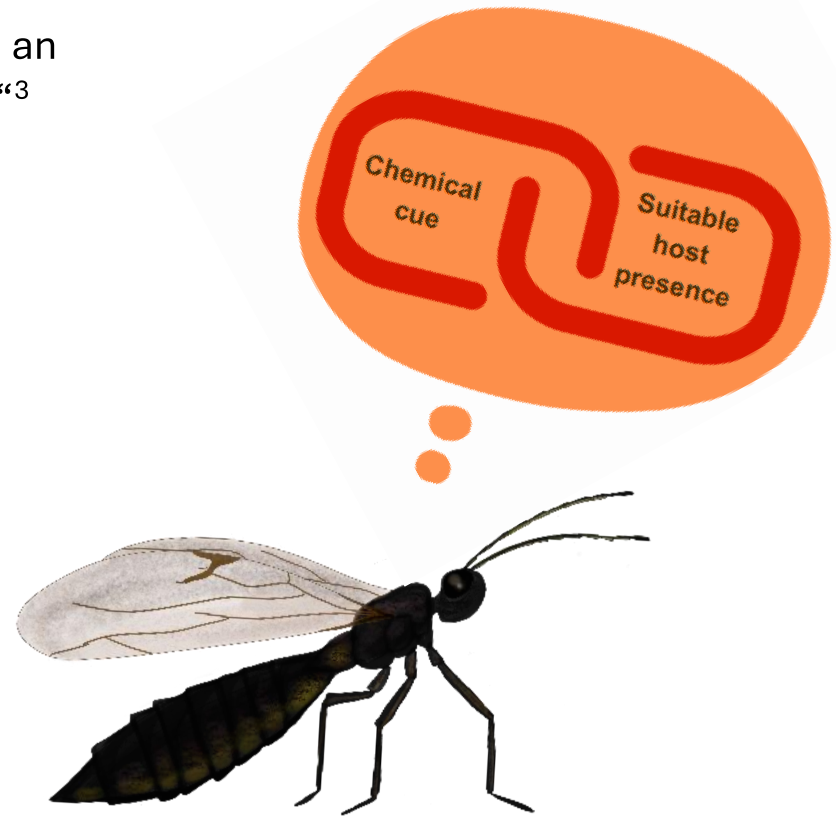
# Parasitoid foraging behaviour and learning

## Parasitoid behavioural responses to chemical cues

- **Innate**
  - Fixed responses
- **Learned**
  - Associative learning

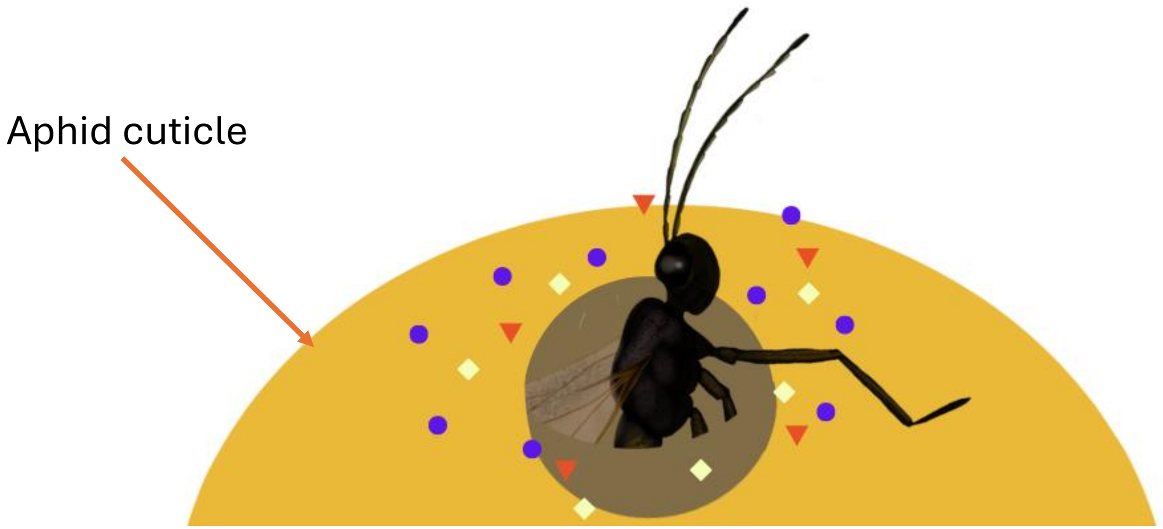
"The process that produces an adaptive change in an individual's behaviour as the result of experience"[3]

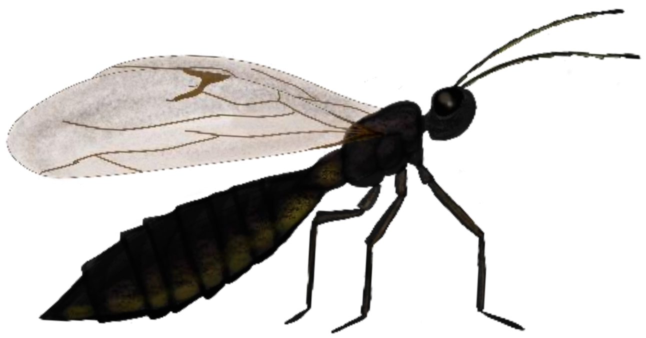
"The establishment through experience, of an association between two stimuli or between a stimulus and a response"



# Parasitoid foraging behaviour and learning

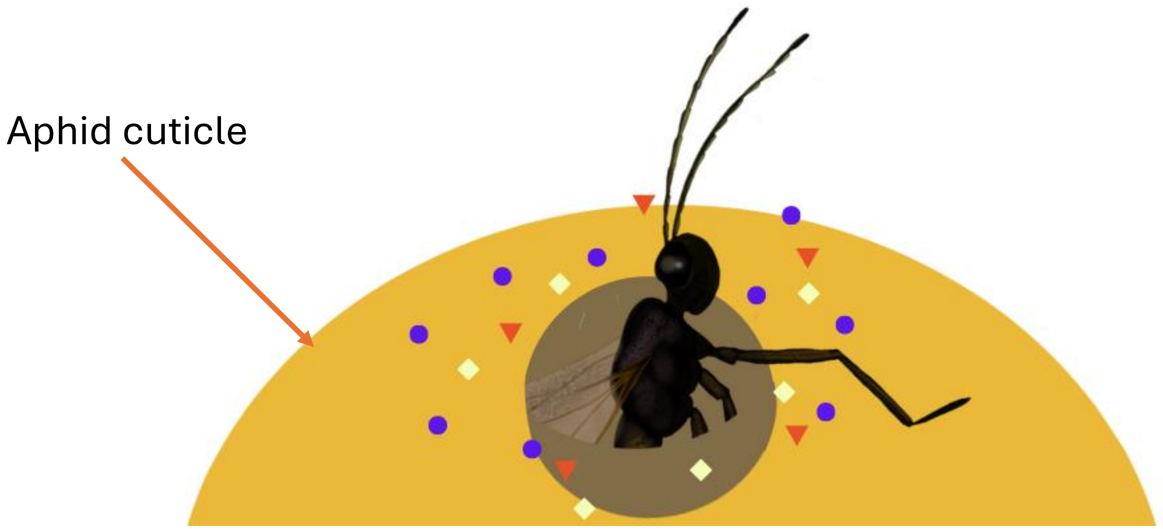
**Naïve wasps**

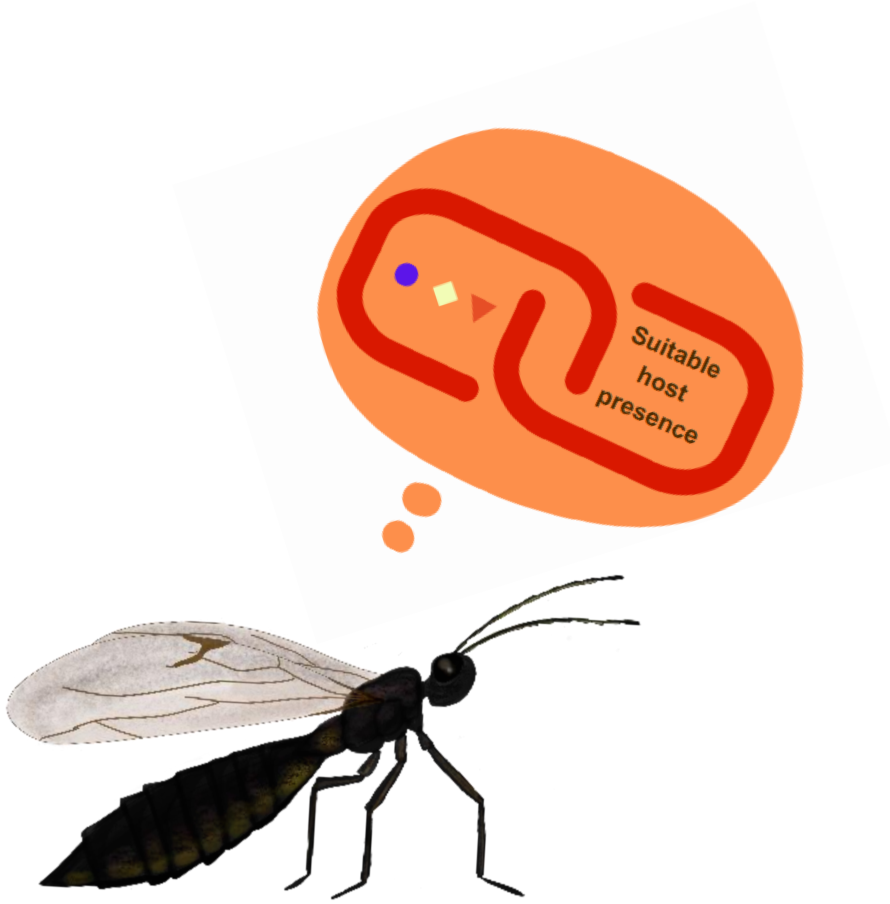


# Parasitoid foraging behaviour and learning

**Naïve wasps**

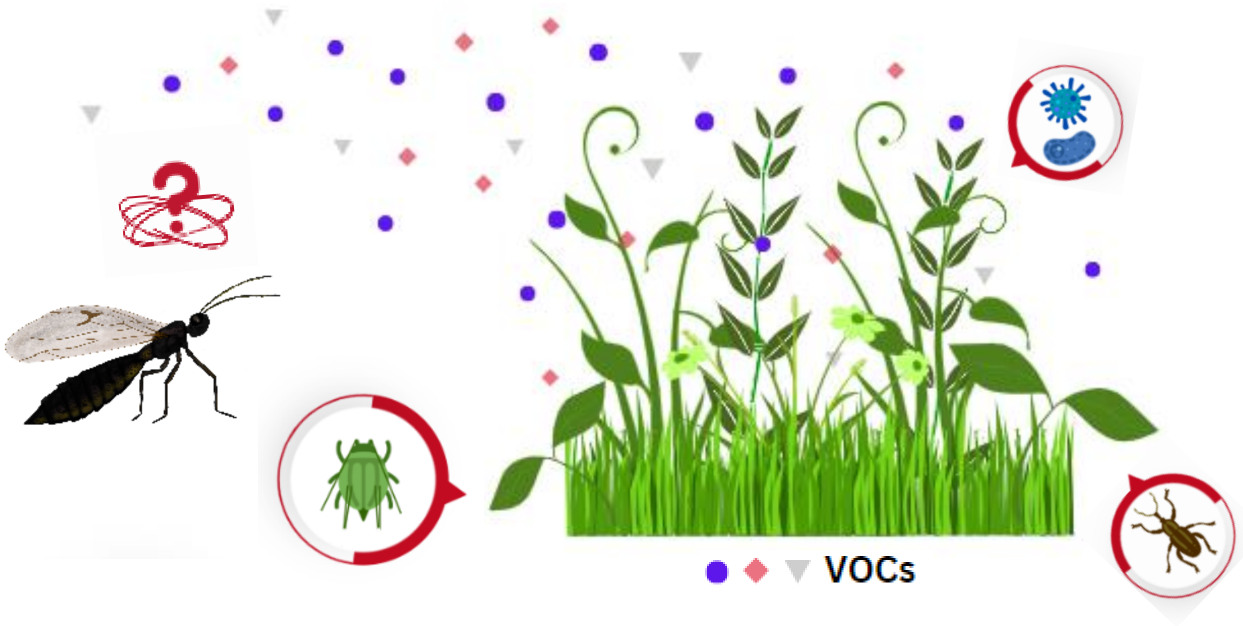


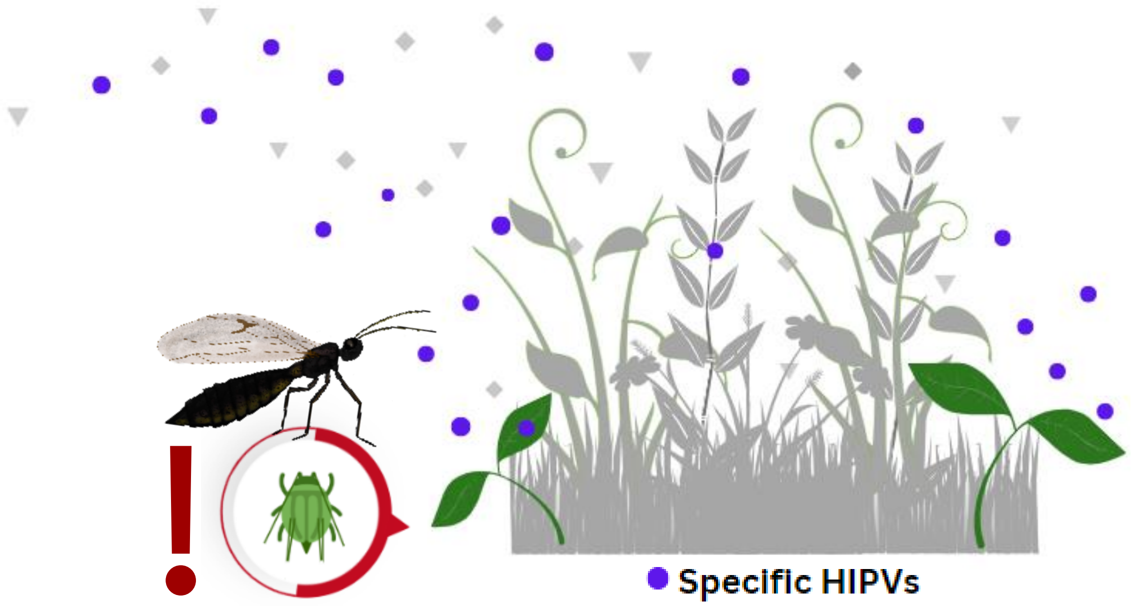
## Applying parasitoid olfactory conditioning

- The training of commercially reared parasitoids to respond specifically and/or more strongly to cues involved in the target pest system using the learning mechanisms

**Before Conditioning**



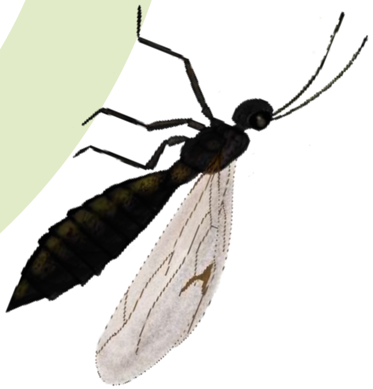

**After Conditioning**



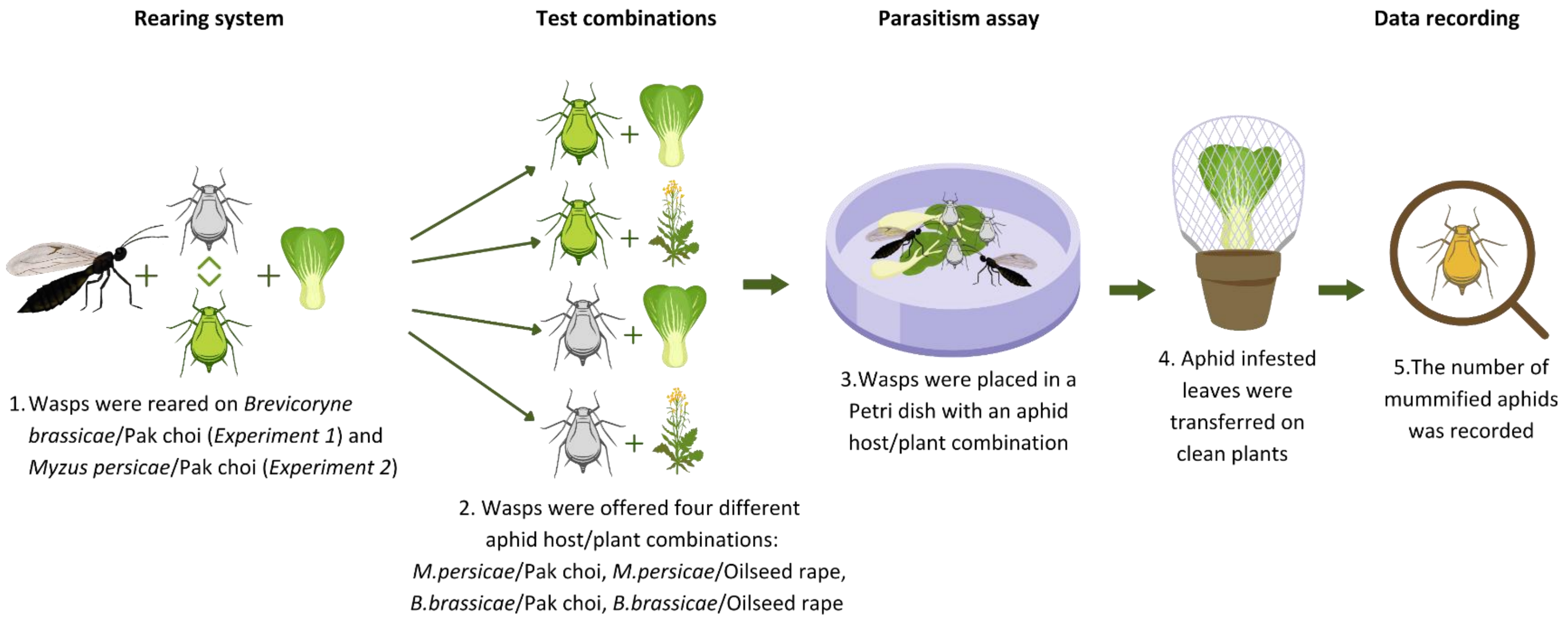
## Project Aim and Objectives:

Explore how insect learning can be used to improve the efficiency of parasitoids as biological controls in sustainable crop protection

- Characterise chemical cues associated with host-searching behaviour
- Determine the learning abilities of commercially available parasitoids
- Develop mass-rearing techniques that incorporate parasitoid learning
- Evaluate the impact of improved parasitoid learning on biological control efficacy under semi-field conditions

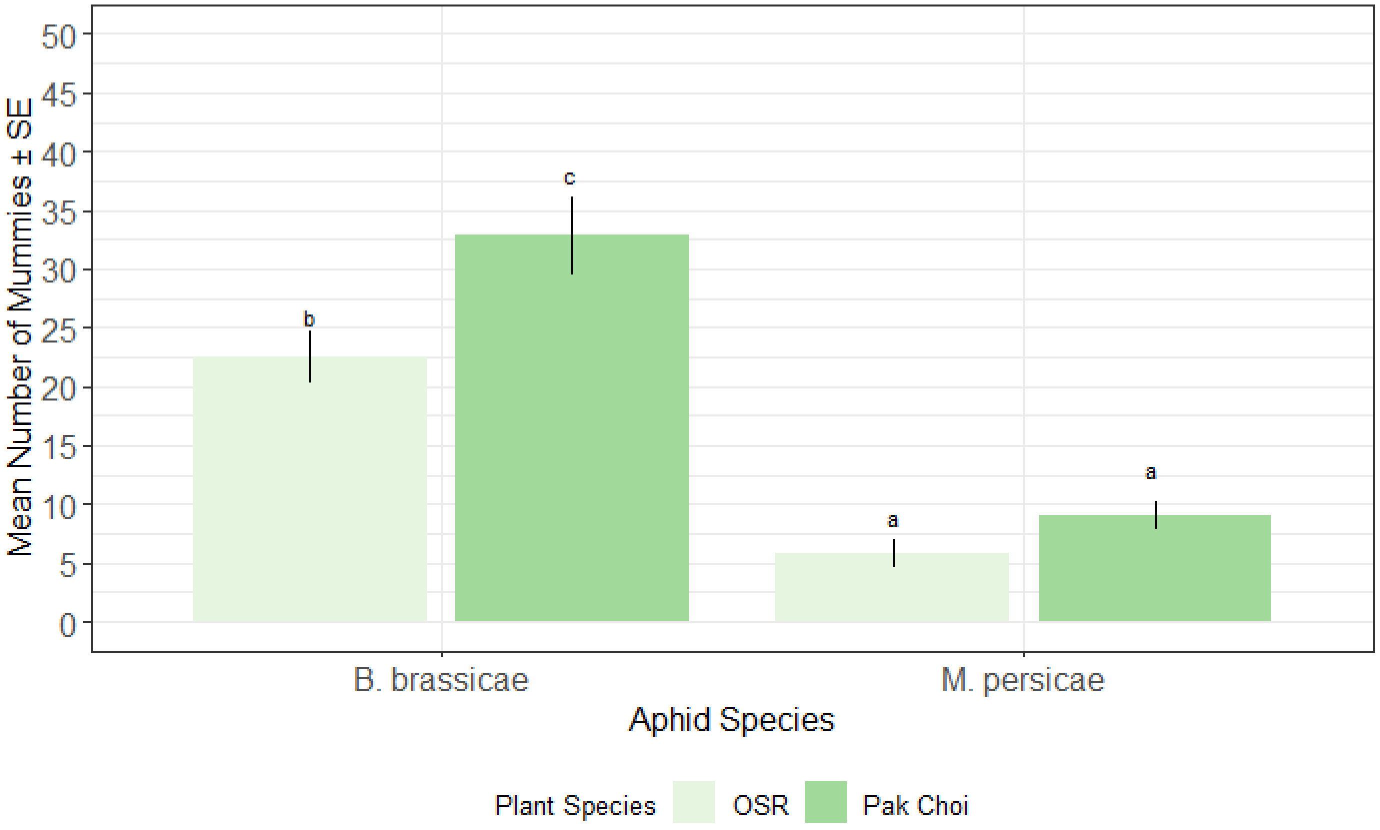


# Initial experiments

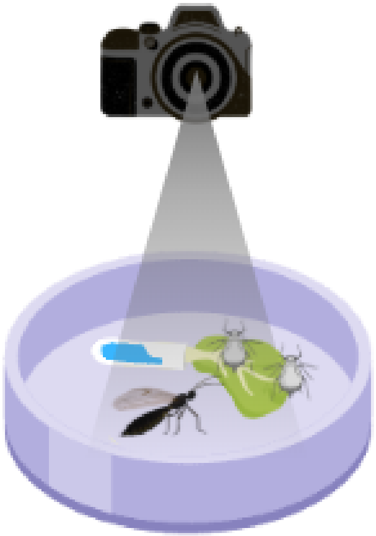


# Experiment 1 – wasps reared on *B. brassicae* / Pak choi

# Experiment 2 – wasps reared on *M. persicae* / Pak choi



# Future work



- Parasitoid behavioural observation experiments
- Start working with commercially available parasitoids e.g., *A. colemani*
- Experiments in a larger scale

# Thank you for listening!

## Supervisory Team

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