

## Final Report

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### Student Project No. SF/TF 170/a

**Title:** Attacking the clones: understanding aphid pest resistance to biological control.

Understanding potato aphid resistance to parasitoids.

Laura Marcela Martinez-Chavez

Harper Adams University, Edgmond, Shropshire, TF10 8NB

#### Supervisors:

**Tom W. Pope<sup>1</sup>, Joe Roberts<sup>1</sup>, Alison J. Karley<sup>2</sup>, Francis Wamonje<sup>3</sup>.**

<sup>1</sup> Harper Adams University, Newport, Shropshire, TF10 8NB, UK

<sup>2</sup> The James Hutton Institute, Invergowrie, Dundee, DD2 5DA, UK

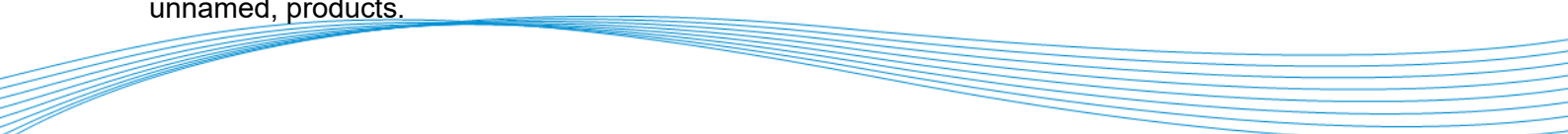
<sup>3</sup> NIAB, East Malling, West Malling, Kent, ME19 6BJ, UK

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# 1. Industry Summary

The potato aphid (*Macrosiphum euphorbiae*) is an economically important pest of strawberry crops in the UK. The presence of this aphid and the honeydew it produces can affect plant photosynthesis by promoting fungal growth (sooty moulds), affecting fruit formation and its marketability. Integrated pest management in strawberry crops is focused on the use of biological controls for different pests and the minimal use of synthetic chemical insecticides. In the case of aphids, individual or a mix of six aphid parasitoid species are currently used in both protected and outdoor crop environments. However, there has been an increase in the frequency of reports of early-season control problems of potato aphids in strawberry crops. Parasitoid resistance in aphids has been reported for different species including the potato aphid in potato crops in the UK, however, aphid resistance to parasitoids has not been confirmed to be a problem in strawberry crops. Aphid resistance to parasitoids can be genetically encoded or a trait conferred by facultative bacteria living inside the insects. The main objective of this project is to understand the role of potato aphid clonal diversity on its interactions with parasitoids used in biological control programmes in strawberry crops. The specific objectives of this project were:

- 1) Determine the clonal diversity of the potato aphid attacking strawberry crops in the UK.
- 2) Understand the role of aphid genetics and secondary endosymbiont composition on shaping the potato aphid-*Aphidius ervi* interaction.
- 3) Determine the genetic diversity of the main parasitoid species (*Aphidius ervi*) used against potato aphid, as supplied by different biological control companies, to understand whether genetic diversity can be used to overcome aphid resistance to this parasitoid species.
- 4) To test under commercial crop conditions whether genetic variation in the potato aphid and the endosymbionts they carry confers resistance to released parasitoids, by assessing how the aphid-endosymbiont-parasitoid community dynamic fluctuates through the season.

In terms of results, first, parasitism assays were completed using the 14 aphid clonal lines. Data from these parasitism bioassays showed significant differences in parasitoid susceptibility between the 14-potato aphid clonal lines, with two lines from Staffordshire where a parasitism proportion <20% to the parasitoid *A. ervi* provided by a commercial supplier was recorded. Subsequently, a more detailed assay with two clonal lines per genotype was undertaken to understand the role of aphid genotype in determining the role of potato aphid clonal variation in shaping its interaction with the parasitoid *A. ervi*. The results showed no effect of genotype on parasitism proportions, nor for parasitoid acceptance for oviposition. However, an effect of genotype on aphid defensive behaviours such as cornicle secretions was described and differences in parasitoid cleaning time were also recorded. A second assay with two clonal lines per endosymbiont infection status (i.e

*Hamiltonella defensa*, *Serratia symbiotica*, *Regiella insecticola*, no infection) showed an effect of endosymbiont infection status on parasitism proportion, acceptance and oviposition. An effect of infection status was recorded for aphid defensive behaviours, certain parasitoid searching behaviours, parasitoid acceptance and parasitism success. With potato aphid clonal lines infected with *Hamiltonella defensa*, *Serratia symbiotica* recording lower overall parasitism efficiency by *A. ervi*. These results show that the interaction between the potato aphid and *A. ervi* is predominantly shaped by endosymbiont infection, however the interaction is complex.

In terms of the parasitoid *Aphidius ervi* itself, it has been established that there was a low genetic diversity in the wasps supplied at the beginning of the season by commercial companies in the UK. There was also, low genetic differentiation between the different commercial suppliers. This can influence the effectiveness of parasitoid populations against aphid populations with variation in traits such as parasitoid susceptibility. The parasitism assessment of the *A. ervi* populations against different clonal lines of potato aphid, showed that for variation in parasitism proportion was recorded depending on the source of *A. ervi*. However, a stronger variation was noted when the parasitoid interacted with previously described “resistant” clonal lines, with less genetically diverse parasitoid populations doing worse than more genetically diverse ones.

Finally, the results from the 2023-2025 field survey have shown that there is a high intraspecific diversity of the potato aphid attacking strawberry crops. It is important to notice that most of the genotypes showed low abundances and poor representation throughout the year. However, 9 genotypes were deemed of importance as it was present throughout the survey period with high relative abundances. In terms of secondary endosymbionts, a mix of uninfected aphids and single and multiple endosymbiont infections were found throughout the season with a dominance of *Regiella insecticola* at the end of all seasons. However, only evidence of a weak link between endosymbiont infection with parasitism pressures was found, and a moderate relationship between potato aphid genotypes and parasitoid community  $\beta$  diversities was also described.

Key findings and conclusions:

- There is genetic diversity of *Macrosiphum euphorbiae* infesting strawberry crops grown in the UK.
- Different clonal lines of *Macrosiphum euphorbiae* are infected by single, double or triple infections of secondary endosymbionts including: *Hamiltonella defensa*, *Serratia symbiotica*, *Regiella insecticola*, *Rickettsia* sp.
- Different clonal lines of *Macrosiphum euphorbiae* collected from strawberries in the UK have shown variability on their susceptibility to the parasitoid *Aphidius ervi* provided by a commercial supplier.

- The genetic background of *Macrosiphum euphorbiae* influences certain aphid defensive behaviours and has an effect in some parasitoid host searching behaviours but it is not a factor in the variability of *Aphidius ervi* (provided by a commercial supplier) acceptance or success.
- Infection of *Macrosiphum euphorbiae* with certain secondary endosymbionts influences some aphid defensive behaviours, parasitoid host searching behaviours, *A. ervi* acceptance and success to (provided by a commercial supplier).
- There is little genetic differentiation between *Aphidius ervi* wasps supplied by different commercial suppliers.
- *A. ervi* source has an effect on its parasitism success on different clonal lines of *M. euphorbiae*.
- There is high genotypic diversity and endosymbiont infection statuses among aphids attacking strawberry crops.
- Under field conditions, potato aphid endosymbiont infection has a weak link with parasitism pressures.
- Under field conditions, potato aphid genotype can affect parasitoid community turnover in the season.

This project will benefit strawberry growers, any other agricultural sectors where biological control agents are used for pest control (especially aphids) and biological control companies. This is because the main findings can be translated to any context where pests are suppressed by natural enemies (especially parasitoids), as what is described here is not an isolated problem associated with strawberry crops. In addition, the information provided in this document could be the base for a step change in mass-rearing programs and quality control assurance in the commercial production of biological controls. The key takeaways for from this project are:

- Potato aphid populations are highly intraspecifically diverse in terms of genotypes and endosymbiont associations in strawberry crops.
- Intraspecific variation in potato aphid populations is linked to variations in parasitism success by *Aphidius ervi*, although the effect on other parasitoid species has been seldomly explored.
- Endosymbiont infection of potato aphid can modulate aphid defensive behaviour and parasitoid searching behaviour, with implications for parasitoid acceptance.
- Endosymbiont infection of potato aphid can be associated with lower levels of physiological susceptibility to the parasitoid *A. ervi*.
- The genetic diversity of populations of the parasitoid *A. ervi* is negatively affected by commercial mass-rearing practices.
- *A. ervi* populations attacking potato aphid in strawberry crops are more closely related to natural populations instead of commercially supplied individuals.
- *A. ervi* source and its genetic diversity can affect parasitism success of different potato aphid populations. Especially when resistant pest's populations are present.
- The evaluation of other commercially supplied natural enemies' success and genetic diversity is advocated.

- Field sampling is crucial to understanding the role of potato aphid intraspecific variation on parasitism success under real life conditions.
- The integration of pest intraspecific variation into the design and implementation of IPM programs is highly recommended.
- Local variation of pest populations should be explored for tailored and more efficient IPM programs.
- Field findings highlight the need for monitoring aphid population structure and symbiont prevalence when planning parasitoid releases.
- Increased understanding of the ecological complexity influencing biological control outcomes contributes to reduced pesticide reliance and more resilient control systems for strawberry crops and other agricultural sectors.