Studentship Project: Annual Progress Report
10/2020 to 03/2021

Student Name:	**Becca McGowan**	**AHDB Project Number:**	
Project Title:	**The Biology & Integrated Management of the Bean Seed Fly**		
Lead Partner:	University of Warwick & PGRO		
Supervisor:	Rosemary Collier & Rob Lillywhite		
Start Date:	October 2019	**End Date:**	September 2023

1. Project aims and objectives

Project Aim: Establish an integrated pest management strategy for control of the Bean Seed Fly (*Delia platura* & *Delia florilega*)

Objectives:

1. Establish a Bean Seed Fly culture to provide insects for experimental work
2. Investigate the impact of temperature on Bean Seed Fly development and diapause
3. Identify effective trapping methods for monitoring Bean Seed Fly
4. Create and validate a Bean Seed Fly forecasting model
5. Assess the efficiency of different cultural strategies for reducing crop damage by Bean Seed Fly

2. Key messages emerging from the project

- Bean Seed Fly diapause differs from closely related pest species such as Cabbage Root Fly (*Delia radicum*) and Onion Fly (*Delia antiqua*)
- A lure which releases volatiles may make blue sticky traps more selective for Bean Seed Fly
- The spring emergence of Bean Seed Fly can be forecasted using a day-degree model
- Controlling sowing timing in relation to cultivation may reduce Bean Seed Fly damage in the crop

3. Summary of results from the reporting year

Objective Two: Investigate the impact of temperature on Bean Seed Fly development and diapause

Experiment One: Do wild Bean Seed Fly at Warwick Crop Centre enter diapause?
Methods
Pots containing medium for Bean Seed Flies to lay their eggs have been placed in a field at Warwick Crop Centre every two weeks from 01/09/20. After a 2-6 day period, these pots have been placed in cages subject to the environmental conditions. Once the eggs are estimated to have developed into pupae (267 day-degrees. Estimated from research by Throne and Eckenrode, (1986)), the pupae are filtered from the pots. Pupae are placed at 20°C and the time until flies emerge is recorded.

It is known that non diapausing Bean Seed Fly pupae take on average 15 days at 20°C to develop into adult flies (Throne and Eckenrode, 1986). It was assumed that flies emerging after 15 days were in diapause.

Results
This experiment is ongoing and seven batches of pots containing Bean Seed Flies which were laid between 01/09/20 – 12/11/20 have been assessed. In four batches, more than 50% of pupae emerged before 15 days at 20°C suggesting they were not in diapause. These eggs were laid between 01/09 – 04/09, 29/09 – 02/10, 13/10 – 19/10 and 26/10 – 30/10. In two batches less than 50% of pupae emerged before 15 days at 20°C. These eggs were laid between 18/09 – 22/09 and 09/10 – 13/10. In the batch placed between 10/11 – 12/11, no pupae were found. These results are suggesting that a proportion of Bean Seed Fly are not going into diapause.

Additionally there is further emergence occurring after 15 days at 20°C. Related species such as the Cabbage Root Fly require a period at a cold temperature (e.g. between 0 – 10°C) to complete diapause (Collier and Finch, 1983). If the Bean Seed Fly pupae were in diapause, it is expected that they require a period of time at a cold temperature to complete diapause. As Bean Seed Fly are emerging after 15 days at 20°C, their overwintering behaviour seems to differ from Cabbage Root Fly.

Experiment Two: When do wild Bean Seed Fly at Warwick Crop Centre complete diapause?
Methods
Previous data monitoring Bean Seed Fly annual activity at Warwick Crop Centre shows their activity decreases after October. Five batches of pots containing medium for Bean Seed Flies to lay their eggs have been placed in a field at Warwick Crop Centre between 09/20 – 10/20. After a 2-6 day period, these pots have been placed in cages subject to the environmental conditions. Once the eggs were estimated to have developed into pupae (267 day-degrees. Estimated from research by Throne and Eckenrode, (1986)), sub-samples (15 pots) were filtered every two weeks for pupae from each batch. Pupae are placed at 20°C and the time until flies emerge is recorded.

It is known that non diapausing Bean Seed Fly pupae take on average 15 days at 20°C to develop into adult flies (Throne and Eckenrode, 1986). It was assumed that flies emerging after 15 days were in diapause.

Results
In eggs laid between 01/09 – 04/09, more than 50% of sub-samples of pupae filtered on 23/09 and 06/10 emerged in 15 days of being placed at 20°C suggesting the majority of pupae were not in diapause. In eggs laid between 18/09 – 22/09, in sub-samples of pupae filtered on 27/10, 09/11 and 23/11, less than 50% of pupae emerged in 15 days of being placed at 20°C. In sub-samples of pupae filtered on 10/12, 21/12, 07/01 and 19/01, more than 50% of pupae emerged in 15 days of being placed at 20°C. If the pupae were in diapause, these results suggest they completed diapause from 10/12.

This experiment is ongoing. Results are still being recorded and analysed.

Objective Three: Identify effective trapping methods for monitoring Bean Seed Fly
Experiment One: Are more Bean Seed Flies caught on blue sticky traps with a lure attached than blue sticky traps without a lure?
In different sampling sites at Warwick Crop Centre over three sampling periods, Bean Seed Fly counts on blue sticky traps containing a volatile lure were compared to blue sticky traps containing no lure. Samples are in the process of being identified and the data is being analysed.

Objective Four: Create and validate a Bean Seed Fly forecasting model
Experiment One: Can accumulated day-degrees be used to estimate emergence of the spring emerging generation of Bean Seed Fly at Warwick Crop Centre?
Methods
Using previous water trap data collected at Warwick Crop Centre, for each year the start (date from an increase in Bean Seed Fly counts) and peak (date of the largest Bean Seed Fly count) of the emerging generation was estimated. The corresponding accumulated degree days were calculated and averaged using soil and atmospheric temperatures. Three methods of calculating day-degrees were used. A threshold temperature of 3.9°C a was used from a biofix date of 1st January per year.

To test the relationship between accumulated degree days and the estimated percentage emergence of the emerging generation of Bean Seed Fly, logistic, log-logistic and variations of these models were fitted to the data using non-linear least squares regression. Models using 3 and 4 parameters were fitted and 'Method 1' for calculating degree days was used. These models have been used previously to model the emergence of Bean Seed Fly and other dipteran species (Broatch et al., 2006; Pearl and Reed, 1920; Rowley et al., 2017; Son et al., 2007).

Results
Using soil temperature, on average (6 years of data), Bean Seed Fly started to emerge at 207 (±58) day-degrees and their first peak occurred at 275 (±52) day-degrees. A significant relationship was found between accumulated day degrees and estimated percentage emergence of the spring emerging generation of Bean Seed Fly at Warwick Crop Centre using soil ($P<0.001$, residual SE = 22.993) and air temperatures ($P<0.05$, residual SE = 26.016). Estimates for 10 – 100% emergence of the spring generation of Bean Seed Fly can be calculated from the functions for these curves.

Objective Five: Assess the efficiency of different cultural strategies for reducing crop damage by Bean Seed Flies
Experiment One: Are more Bean Seed Flies caught in water traps in a bed recently cultivated than a bed which has not been recently cultivated?
Methods
In four sampling sites, during two sampling periods, water traps were placed in beds which were recently cultivated and not recently cultivated. Bean Seed Fly counts were taken daily from each water trap prior to and after cultivation.

Results
For the first samping period, Bean Seed Fly counts were increased in beds recently cultivated compared to beds not recently cultivated, the day after cultivation. This increase was observed at all sites. Statistical tests are currently being applied.

4. Key issues to be addressed in the next year

Objective Two: Investigate the impact of temperature on Bean Seed Fly development and diapause:

1. An experiment mimicking Autumn and Winter environmental temperatures on Bean Seed Flies in the culture
2. Repeats of experiments one and two between Sept 2021 – April 2022
3. Analysis of results from experiments one and two

Objective Three: Identify effective trapping methods for monitoring Bean Seed Fly

1. Complete identification of the samples (currently stored at <0°C)
2. Analyse the data from 2020
3. Potentially investigate sticky trap positioning on the effectiveness of catching Bean Seed Flies

Objective Four: Create and validate a Bean Seed Fly forecasting model

1. Model validation (compare the predicted dates of spring emergence with observed dates of spring emergence)
2. Carry out the non-linear least squares regression with a more commonly used calculation of day degrees

Objective Five: Assess the efficiency of different cultural strategies for reducing crop damage by Bean Seed Flies

1. An experiment to test the timing of cultivation and covering the crop with a protective netting on crop damage by Bean Seed Flies
2. Repeat of experiment one with the addition of measuring egg laying

5. Outputs relating to the project

(events, press articles, conference posters or presentations, scientific papers):

Output	Detail
Growers Meeting (Dec 2019)	**Powerpoint presentation introducing the project and it's aims to growers.**
AHDB Crops PhD Conference (Jan 2019)	**Flash presentation introducing the project.**
Growers Meeting (Dec 2020)	**Powerpoint presentation updating growers on the progress and current findings of the project.**
AHDB Crops PhD Conference (Jan 2021)	**Poster presentation highlighting some key findings and the benefit of the project to levy payers. The poster was 'highly commended.'**
Plants & Crop Theme Seminar (Feb 2021)	**Powerpoint presentation providing an overview and current findings of the project to members of the School of Life Sciences, University of Warwick.**

6. Partners (if applicable)

Scientific partners	
Industry partners	PGRO
Government sponsor	