# Development of near real-time weather-based insect pest forecasting system for Alberta

**Swaroop Kher and Daniel Itenfisu**

Alberta Government

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Lethbridge

Alberta Canola Producers Commission

# Introduction

- **Insect Pest Management: A key issue**

- **Effective implementation of Pest Management Strategies:**
  – Time of occurrence of key pest stages
  – Knowledge of pest phenology

- **Weather-based Pest Phenology Models:**
  – Can predict pest development
  – Use of Near-Real Time (NRT) Weather data provides greater precision in the prediction

# Alberta Pest Modeling Project

- **The project brings two disciplines together**
  - **Pest Management**
  - **Agro-meteorology and modleling**

- **Project Partners:**
  - Alberta Agriculture and Forestry
    - Engineering and Agroclimatic Services Branch
    - 170+ AF standard weather stations plus ~230 provincial stations
  - Alberta Canola Producers Commission (ACPC)

- **Approach:** Integrating NRT quality controlled weather data with pests and crops phenology data

# The Alberta Agriculture Weather Station Network

- Owns and operates 170 + standard Near Real Time weather stations,
- Have developed and implemented a NRT weather data quality program and reporting (via ACIS),
- Also makes use of 230+ other provincial NRT reporting weather stations data
- Developed a weather based operational agricultural risk management models that support AF programs (Drought, irrigation, crop Insurance, crop report, grass fire, *weather based pest prediction* )

# Current and Historical Alberta Weather Station Data Viewer

***Brought to you by the Alberta Climate Information Service (ACIS)***

weatherdata.ca

- About ACIS
- Data Disclaimer
- News
- Glossary
- Reference Documents

**Weather Data**

- Weather Station Data Viewer
- Historical Weather Data
- Weather Station Summary
- Almanac

**Maps**

- Weather Conditions Map
- Climate and Atlas Maps
- Weather Radar Imagery

**Irrigation (IMCIN)**

- About IMCIN
- IRRI-Cast
- AIMM Software
- AIMM Climate Files
- AIMM Crop ET Data

**Forecasts**

- Weather Forecast
- Disease Forecasting

**Reports**

- Moisture Situation Updates
- Weekly Crop Water Use

**Geographic Region**

Alberta ▼

Questions and

**Show Directions**

**Legend**

- Available for all selected stations
- Not available for some selected stations
- Not available for any selected stations
- Station with data available through ACIS
- Station with all requested elements available
- Selected station with all requested elements available
- Selected station with one or more requested elements not available
- Station with one or more requested elements not available

**Popular** | **Elements** | **Derivatives** | **Normals** | **Almanac**

Clear Selection    Clear All Tabs    Definitions

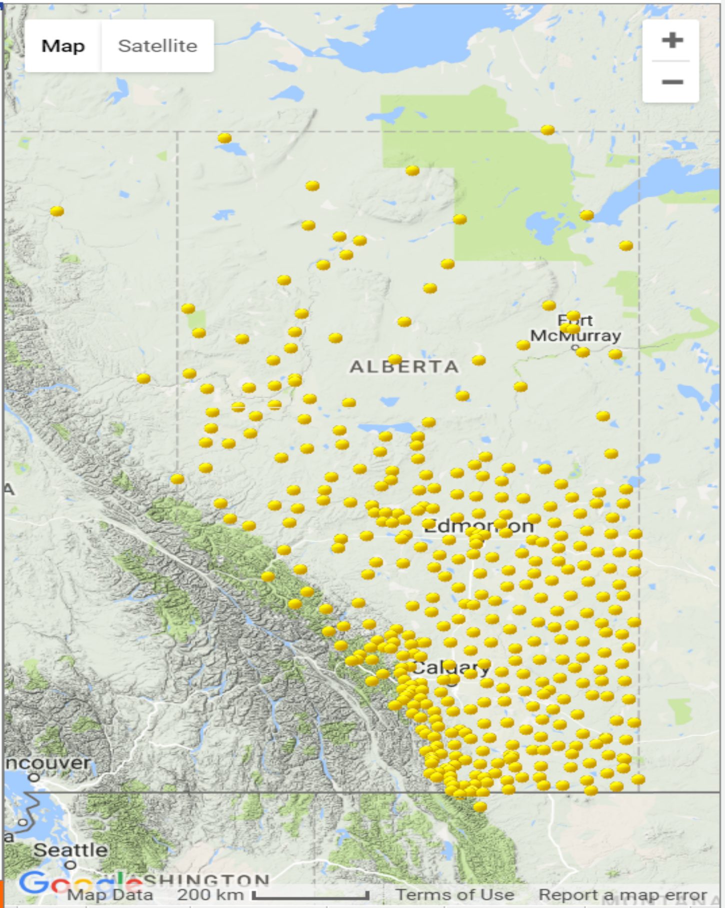
| | Observed | Normal |
|---|---|---|
| Precipitation (mm) | ☐ | |
| Accumulated Precipitation (mm) | ☐ | ☐ |
| Temperature (°C) | ☐ | ☐ |
| Minimum Temperature (°C) | ☐ | ☐ |
| Maximum Temperature (°C) | ☐ | ☐ |
| Relative Humidity at 2m (%) | ☐ | |
| Wind Speed at 2m (km/h) | ☐ | |
| Wind Direction at 2m (deg) | ☐ | |
| Wind Speed at 10m (km/h) | ☐ | |
| Wind Direction at 10m (deg) | ☐ | |
| Corn Heat Units | ☐ | ☐ |
| Potato Heat Units | ☐ | ☐ |
| Growing Degree Days (5°C) | ☐ | ☐ |
| Reference Evapotranspiration (mm) | ☐ | |
| Frost Probability 0°C (%) | | ☐ |

**Please select station and element**

**Include Flags:** ☑ Completeness ☑ Source ☑ Comments

**Period:** Daily ▼ **Precip Unit:** mm ▼

**Select Station(s):** Select Station ▼




AB | Peace | Northern | Central | Southern | IMCIN

**Selected Stations (up to 5 max.)** ❌

# The Alberta year round soil water and energy balance model outputs

Daily:

- Crop phenology
- Evapotranspiration
- Soil moisture(spring wheat, pasture)
- Snow accumulation
- Drought indices
- Grass fire indices
- ....................

# Project Objectives

1. The project aims to develop and implement a provincial near real time (NRT) weather-based crop insect-pest monitoring/prediction model for producers and industry stakeholders

2. Development and implementation of on-farm weather monitoring systems to collect NRT weather data parameters

3. Extensive phenology surveys for the target pest species with data collection with respect to crop hosts and natural enemies

4. Integration of tritrophic pest models with soil water and energy balance model

5. Development of web-based decision support system for pest management in Alberta

# Project Objective

- In the weather based pest prediction modeling : the project looks beyond the traditional use of daily degree-days accumulation – much into the pest/insect physiological time.

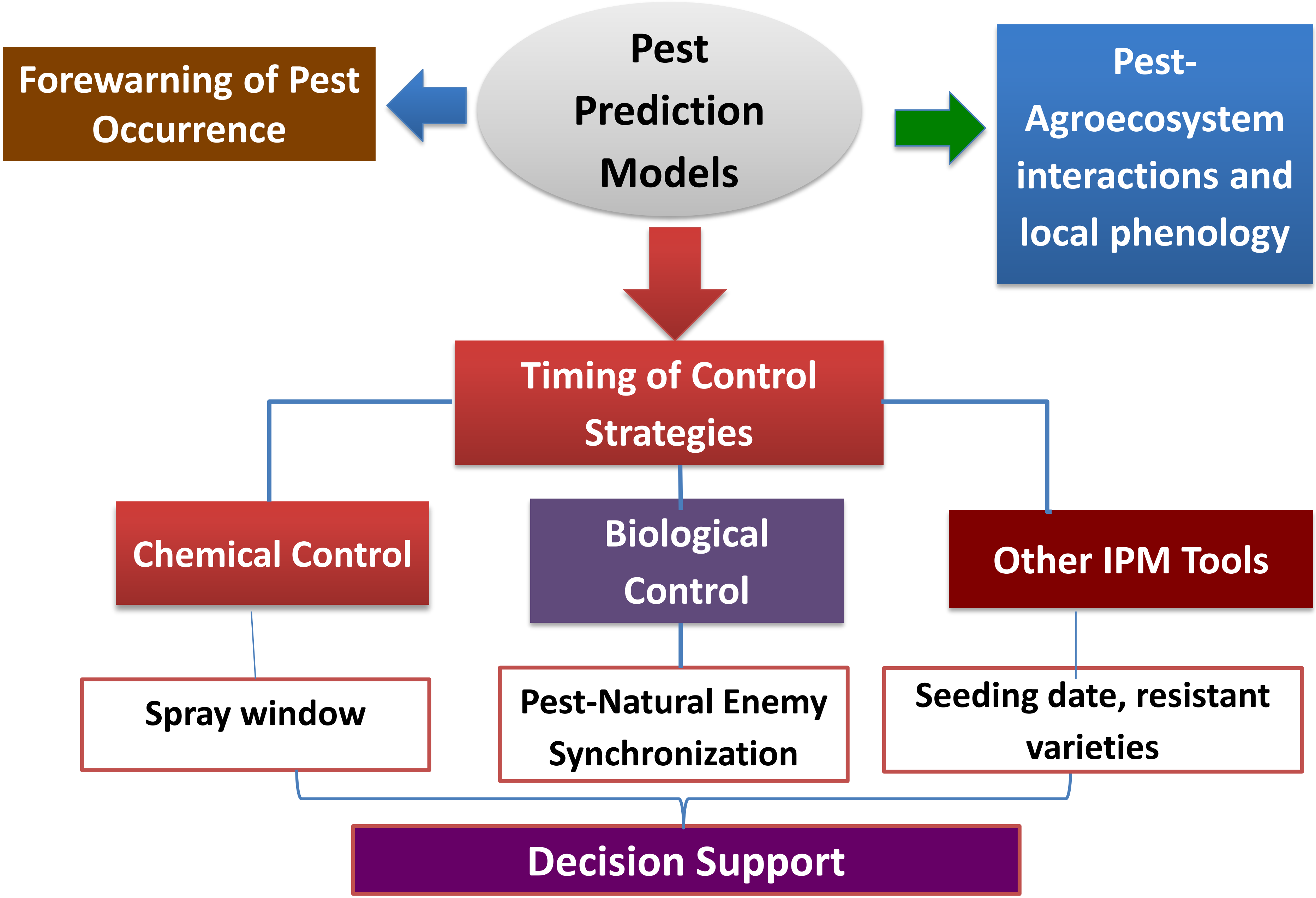
# Project Objectives

Improved Insect Phenology Monitoring

On-site NRT weather monitoring

Improvement of current models

# Phenology Models: Potential Applications



# Project Components

2014, 2015, 2016

## Literature Component

- Pest Bioecology
- Existing Models
- Management tactics
- Pest phenology
- Diapause Needs
- Sampling strategies

## Field Component

- Trap based monitoring
- Field Surveys
- Sampling Strategies

## Weather Component

- ACIS weather data
- Portable weather stations

## Lab Component

- Survey Sample sorting
- Staging
- Data Entry
- Soil Core Processing

## Model Component
## GDD Based Insect Phenology Models

- Data Processing
- SAS Coding
- Model testing and Validation

Alberta Government

# Cropping Systems

- Canola
- Wheat
- Alfalfa

# Insect Species

- **Bertha Armyworm:**
  - Yield losses in amounts of $14 million
  - Costs for insecticidal applications amounted to $3.4 million

- **Wheat Midge:**
  - yield losses of over $30 million CAD
  - Degradation of kernel quality

- **Alfalfa Weevil:**
  - 60-100% losses and defoliation of first cutting

# Insect-Crop-Natural Enemy Interactions

*Bathyplectus curculionis*

Alfalfa Weevil System

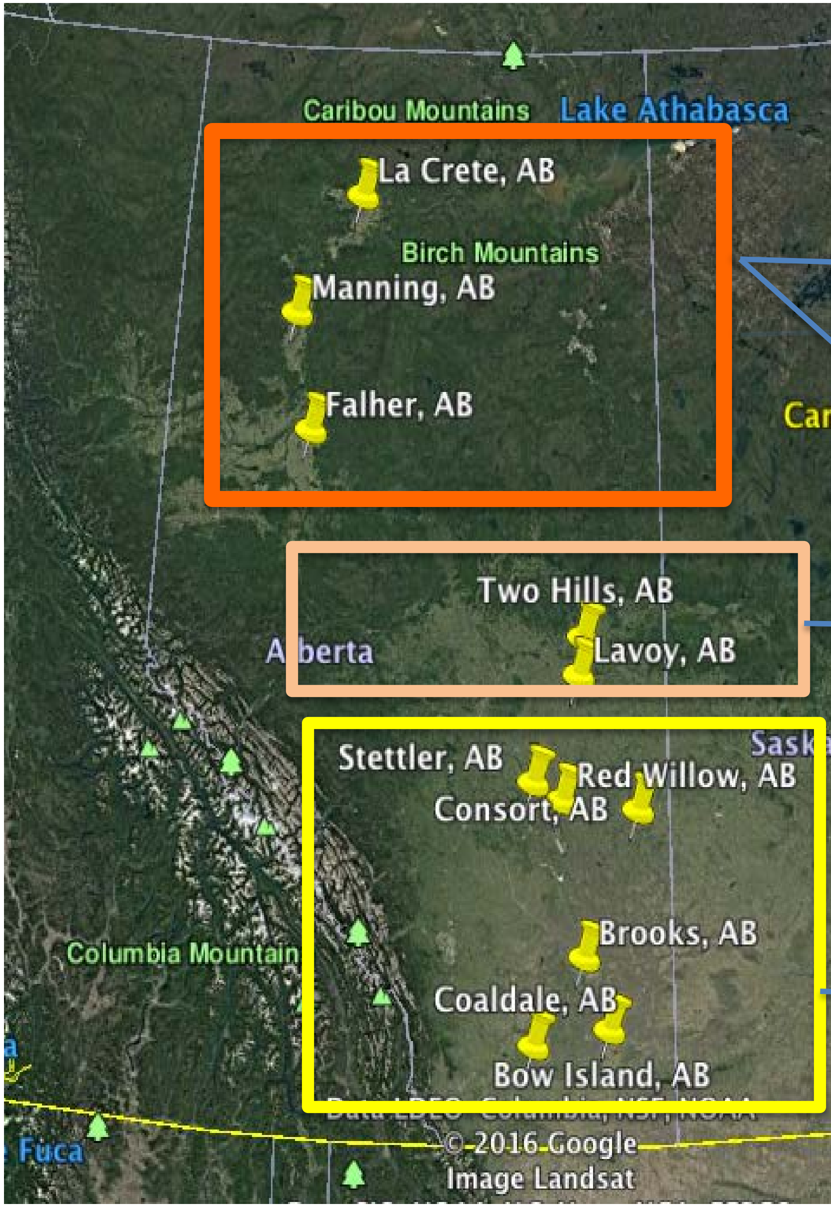
*Macroglenes penetrans*

Wheat Midge System

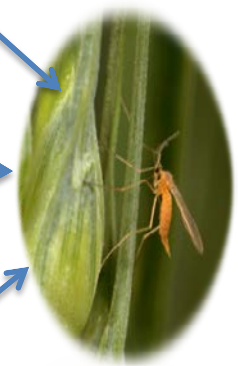
*Banchus flavescens*

Bertha Armyworm

# Study Area




**Bertha Armyworm: 20 Sites**



**Wheat Midge: 25 Sites**

**Alfalfa weevil: 15 Sites**

# Pest Project: Weather Component

- **2014-2016:**
  - **<u>Six weather stations: hourly weather data</u>**
  - Two stations for each model insect species

**Temperature**

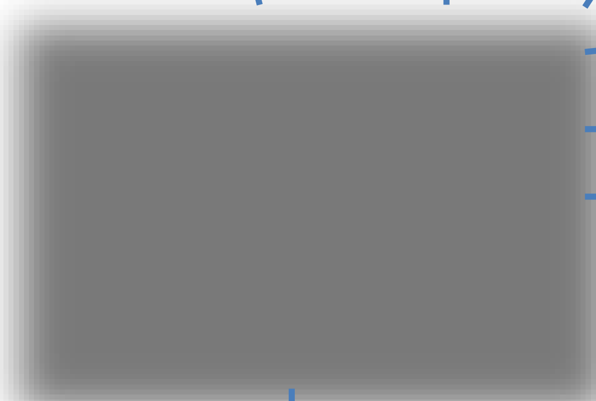
**R.H**

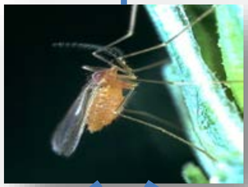
**Soil Temperature**

**Precipitation**

**Solar Radiation**

**Wind Speed**





Irrigated Site

Dryland Site

**Central Alberta + South**

Irrigated Site

Dryland Site

**Central Alberta + Peace**

Irrigated Site

Dryland Site

**Mainly South Alberta**

# Weather Station Site Selection

- On-site weather monitoring
- Proximity to ACIS network stations
- Comparison between on-site field data and nearby sites

# On-site Weather Monitoring

Portable Weather Station

Hobo-based Weather Station

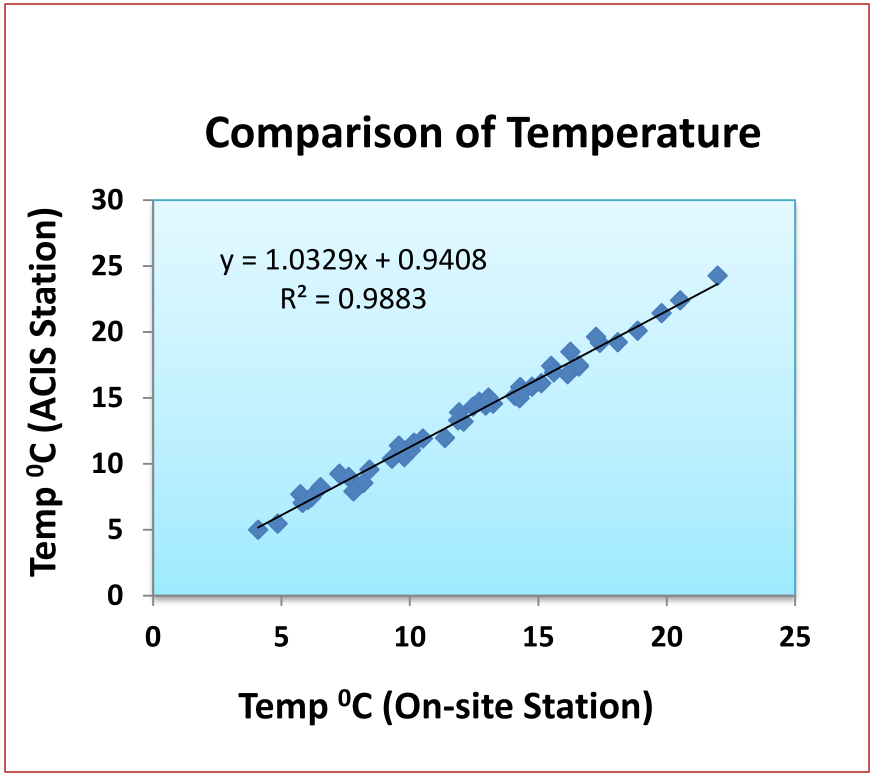
# Modeling Thresholds

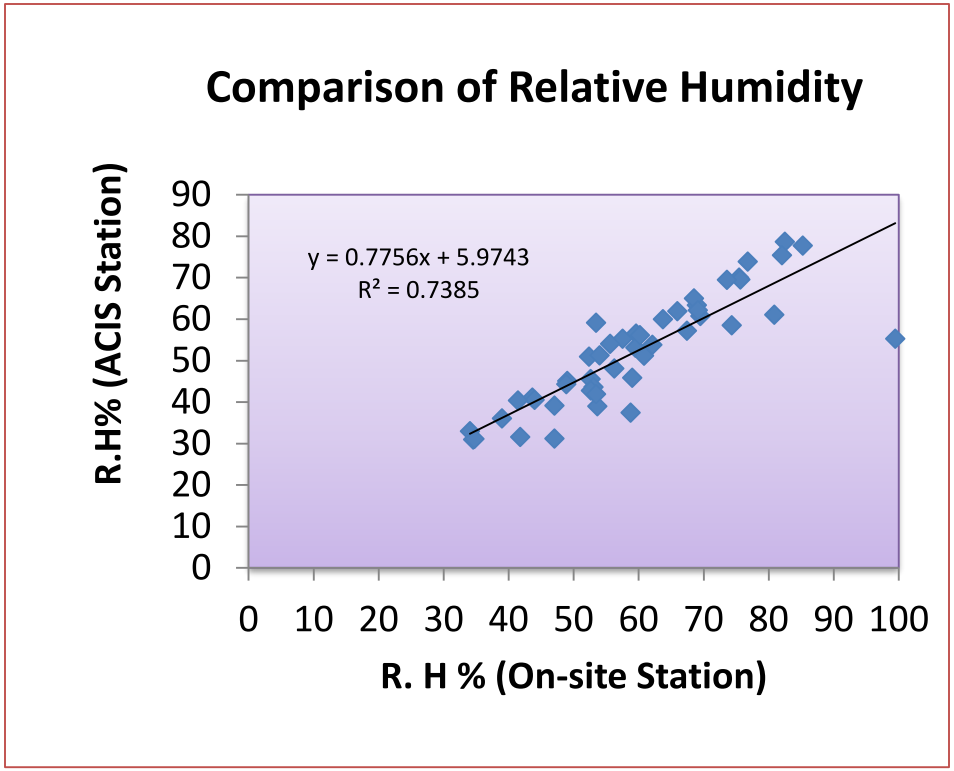
- **Wheat Midge:**
  - Post-diapause development: $6^0$ C (soil temp vs. Air temp)
  - Larval development: $8.9^0$ C (air temp)

- **Alfalfa weevil:**
  - **Two different thresholds:** $8^0$ C and $10^0$ C
  - $10^0$ C works the best

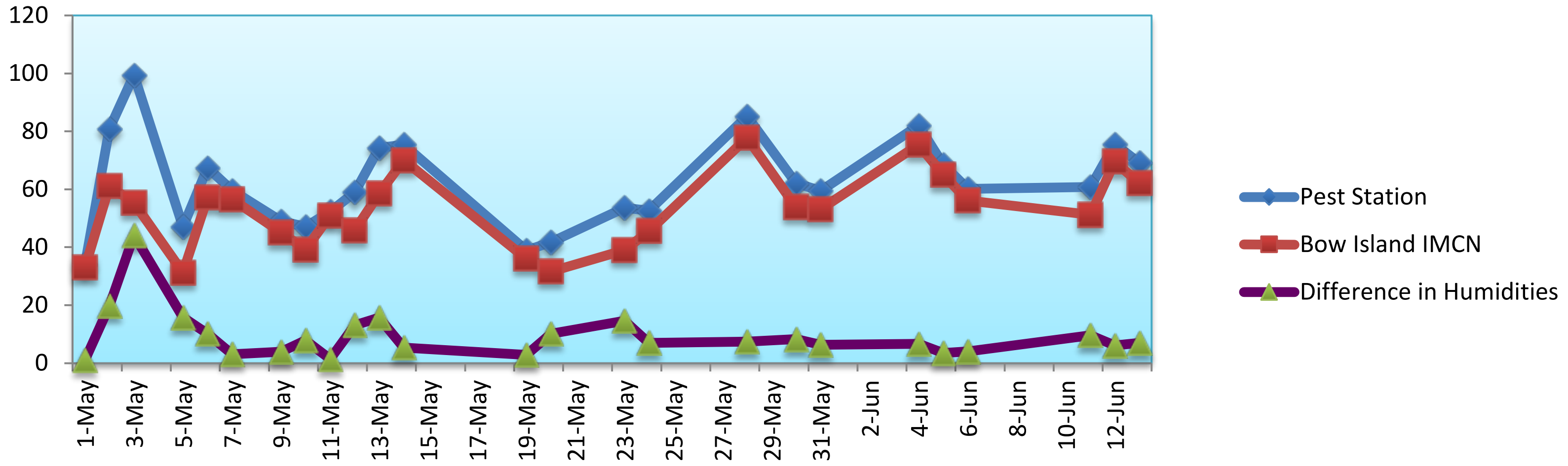
- **Bertha armyworm:**
  - **7**$^0$ C

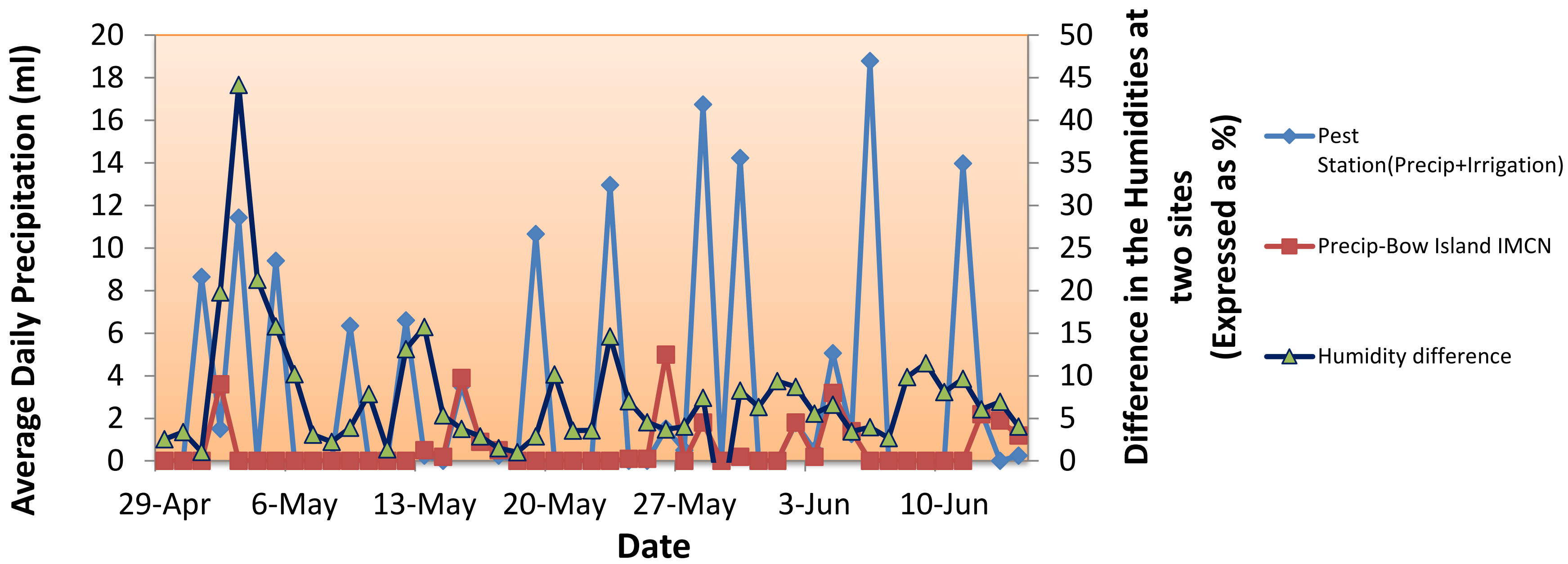
# How does onsite weather compare with surrounding network stations?



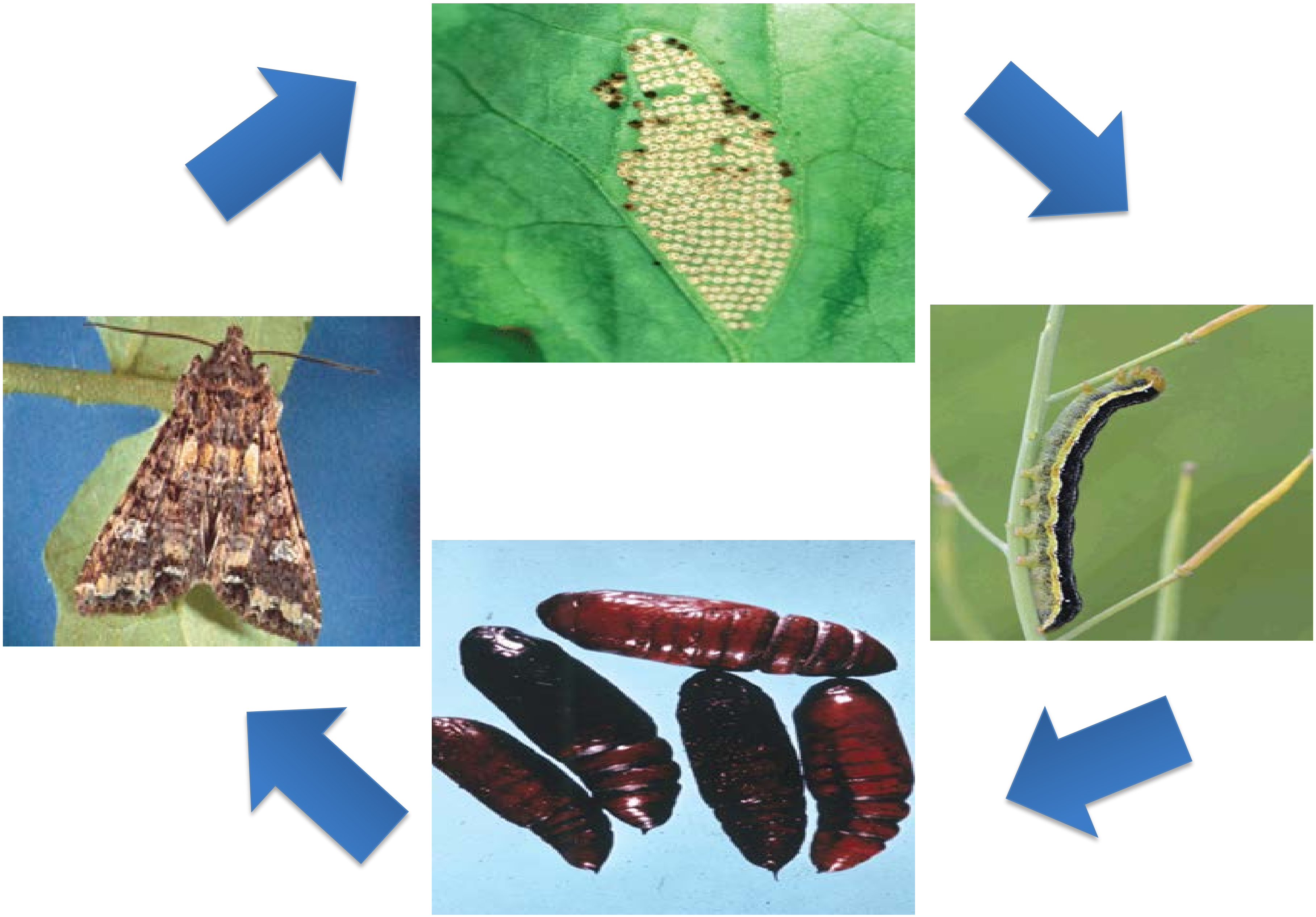



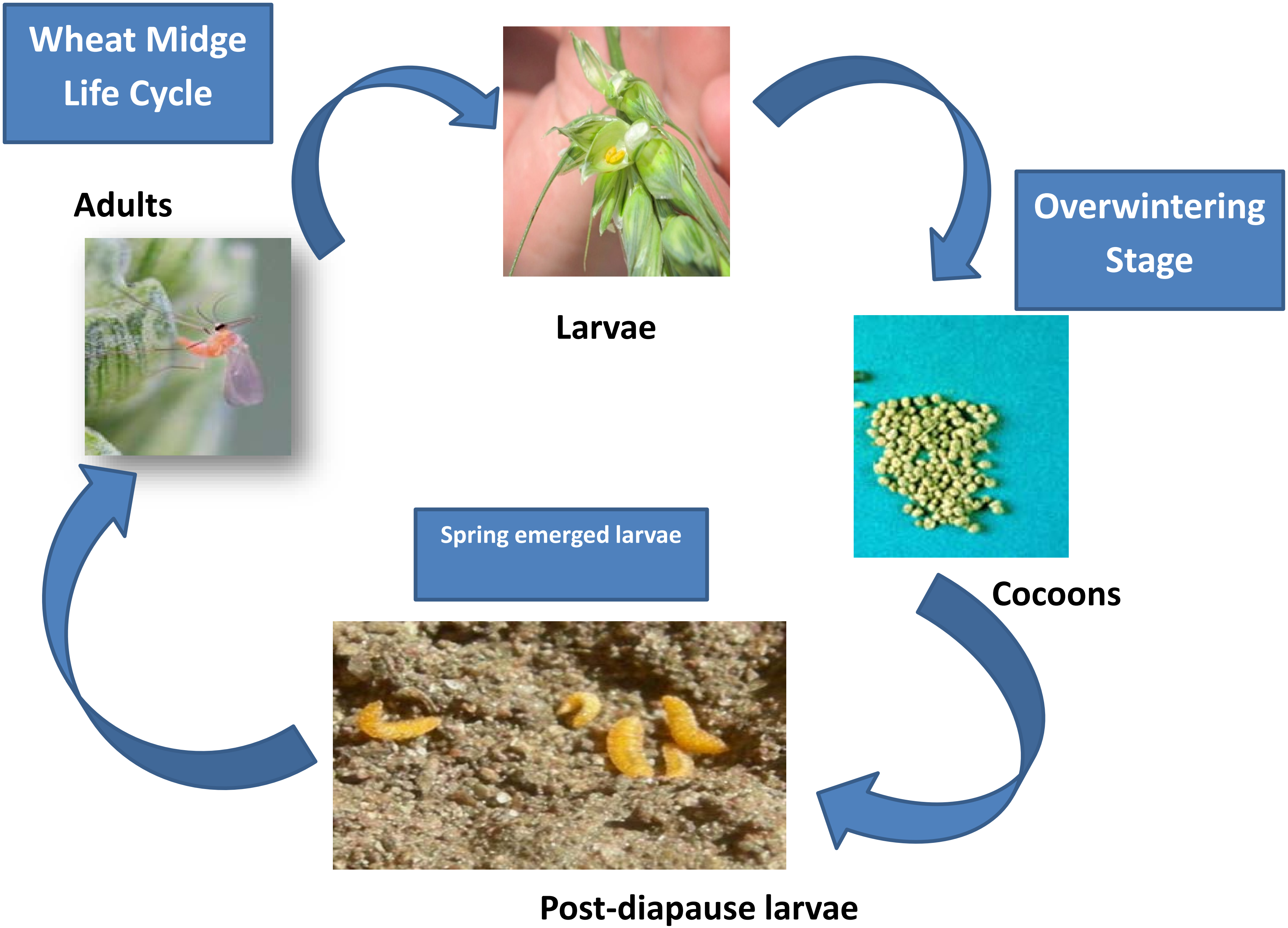
# Comparison of R.H. and Precipitation



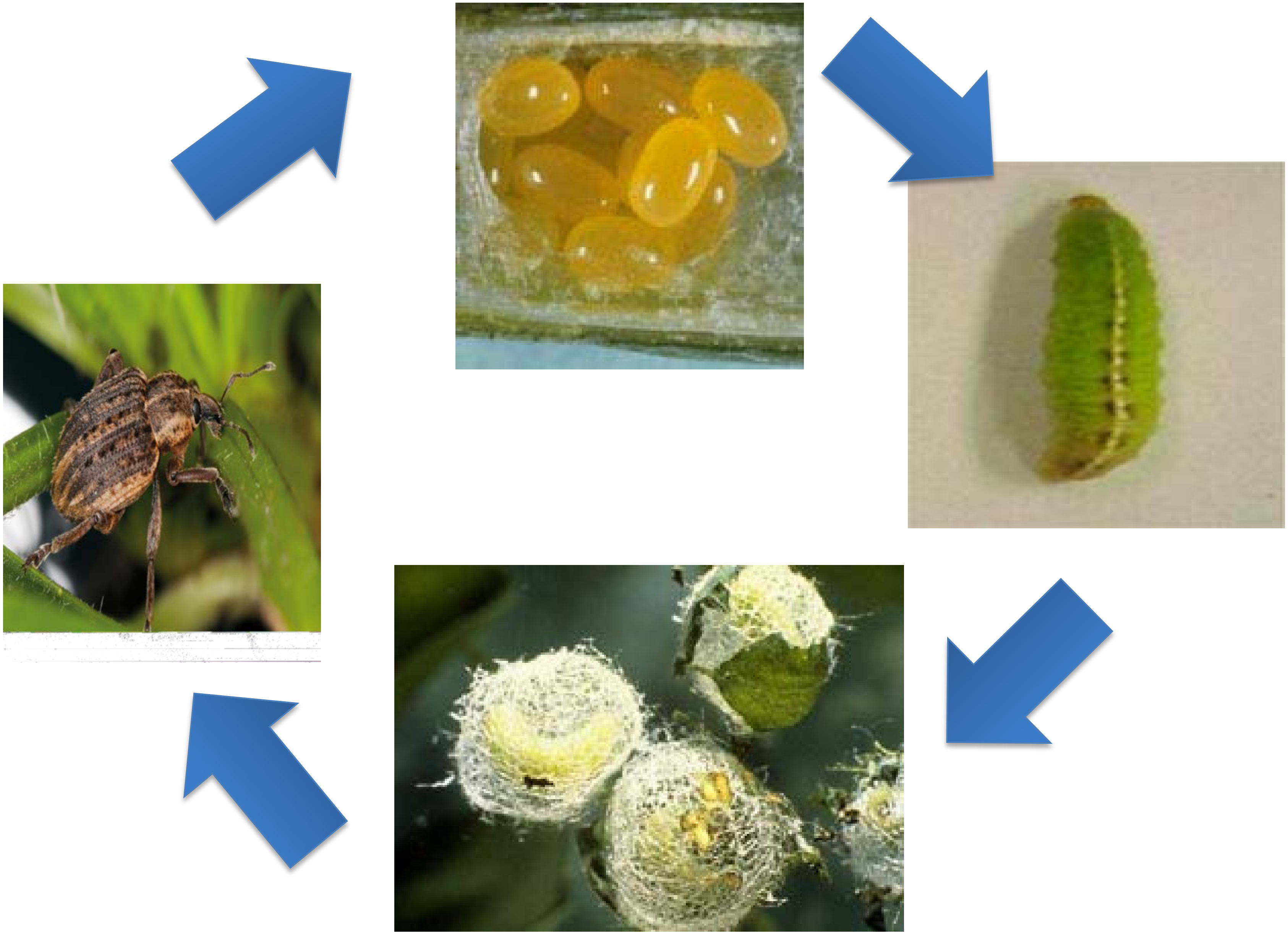



# Bertha Armyworm




Wheat Midge Life Cycle
Adults
Larvae
Overwintering Stage
Cocoons
Spring emerged larvae
Post-diapause larvae

# Alfalfa Weevil



# Pest Project: Crop Phenology Component

Picture here

**wheat growth stage record**
**Location: Flagstaff County, Erions Field**
**Week of: 27 June-1 July 2016**

**Field ID: Pest_Erions _Wheat2016**

**Crop Type:** Wheat (dry)

**Sampled by:** Justina Nibourg

**LLD:** NW-11-40-13w4

**Date picture taken: 29 June 2016**

## Crop Growth Stage: Heading

# Existing Monitoring Systems: Wheat Midge

**Wheat Midge:**

- **Pheromone trap counts**
  - Setup at June 20- observations reported weekly for two weeks during peak adult activity

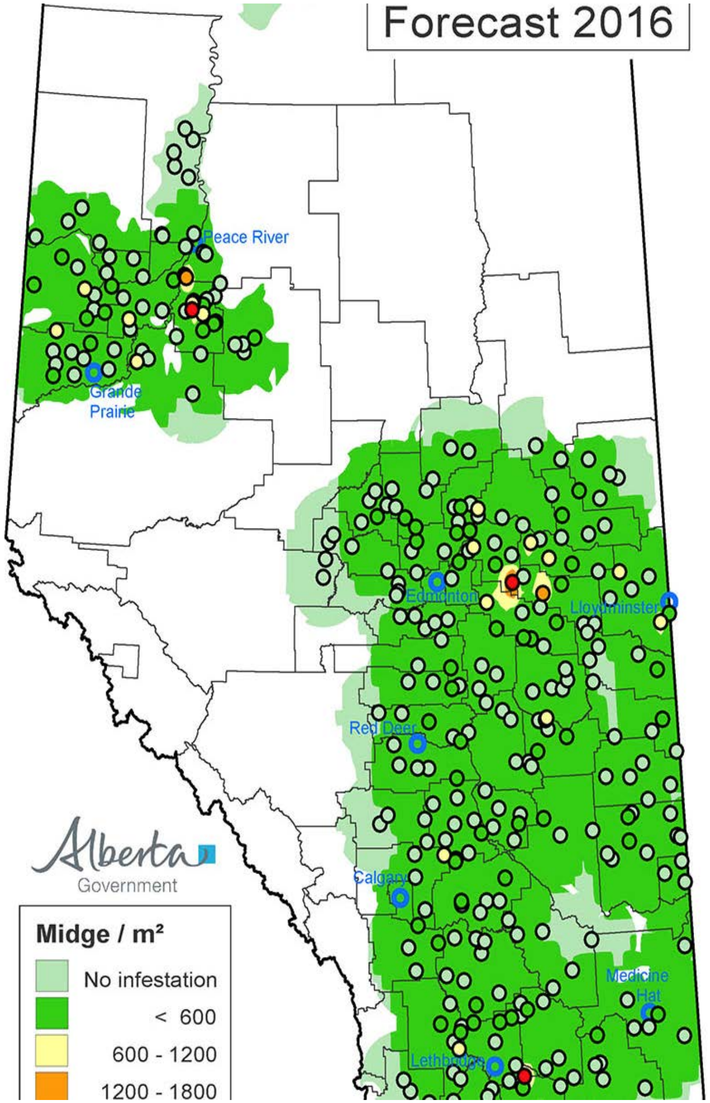
- **Fall soil sampling:**
  - **Soil cores to estimate numbers/$m^2$ of midge cocoons to predict fields with midge activity next year**

# Fall Sampling: Tool for next year

Prediction for next season based on soil sampling results

Use of nominal threshold values to risk and identify hot-spot

A great tool to find areas with midge infestation but not a predictive tool



# Pheromone Trap Counts: Current Season

- Weekly trap counts reported from province
- Provide emergence pattern for ONLY MALES and no information on females
- Peak male activity is considered to coincide with female activity but exact female activity is not known

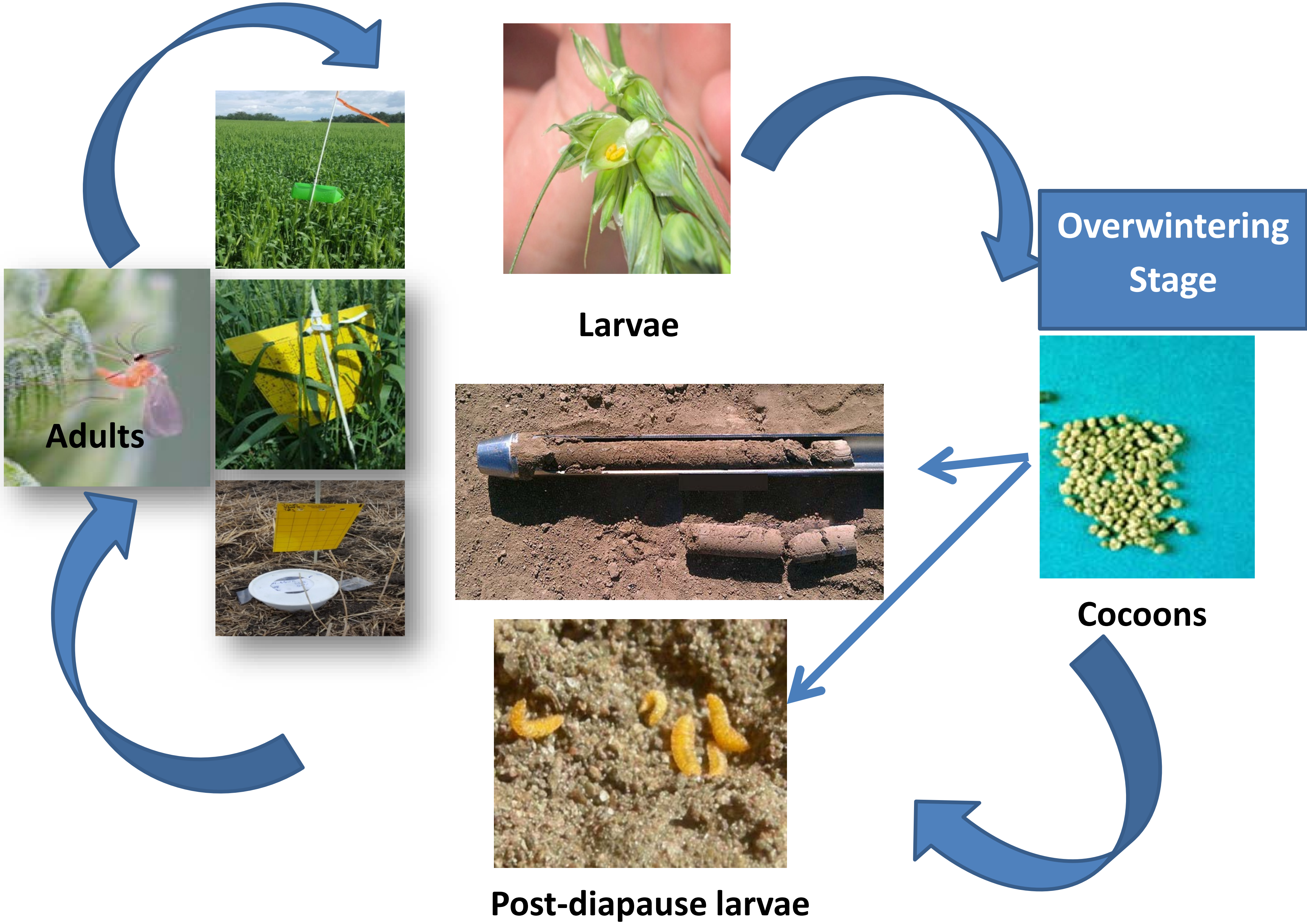
Pic: Pheromone traps in the field

# Current Knowledge Gaps: Wheat Midge Model

- What parameters are not known?
  - Female oviposition activity of wheat midge
  - Activity of overwintered larvae
  - Beginning and end of male and female flight patterns
  - Active oviposition period window
  - Initiation of egg hatch and peak larval activity in the field
  - Emergence and activity of natural enemy: *M. penetrans*

# How did we address this gap?

- We refined existing protocols to include sampling on:
  - Postdiapause larvae
  - Emergence and activity of <u>both</u> MALES AND FEMALES
  - Sampling of eggs
  - Sampling of larvae, identification of instars
  - Identification of crop stages for wheat
  - Sampling of natural enemy activity


Larvae
Overwintering Stage
Adults
Cocoons
Post-diapause larvae

# Wheat Midge Phenology

**Site Pairing**

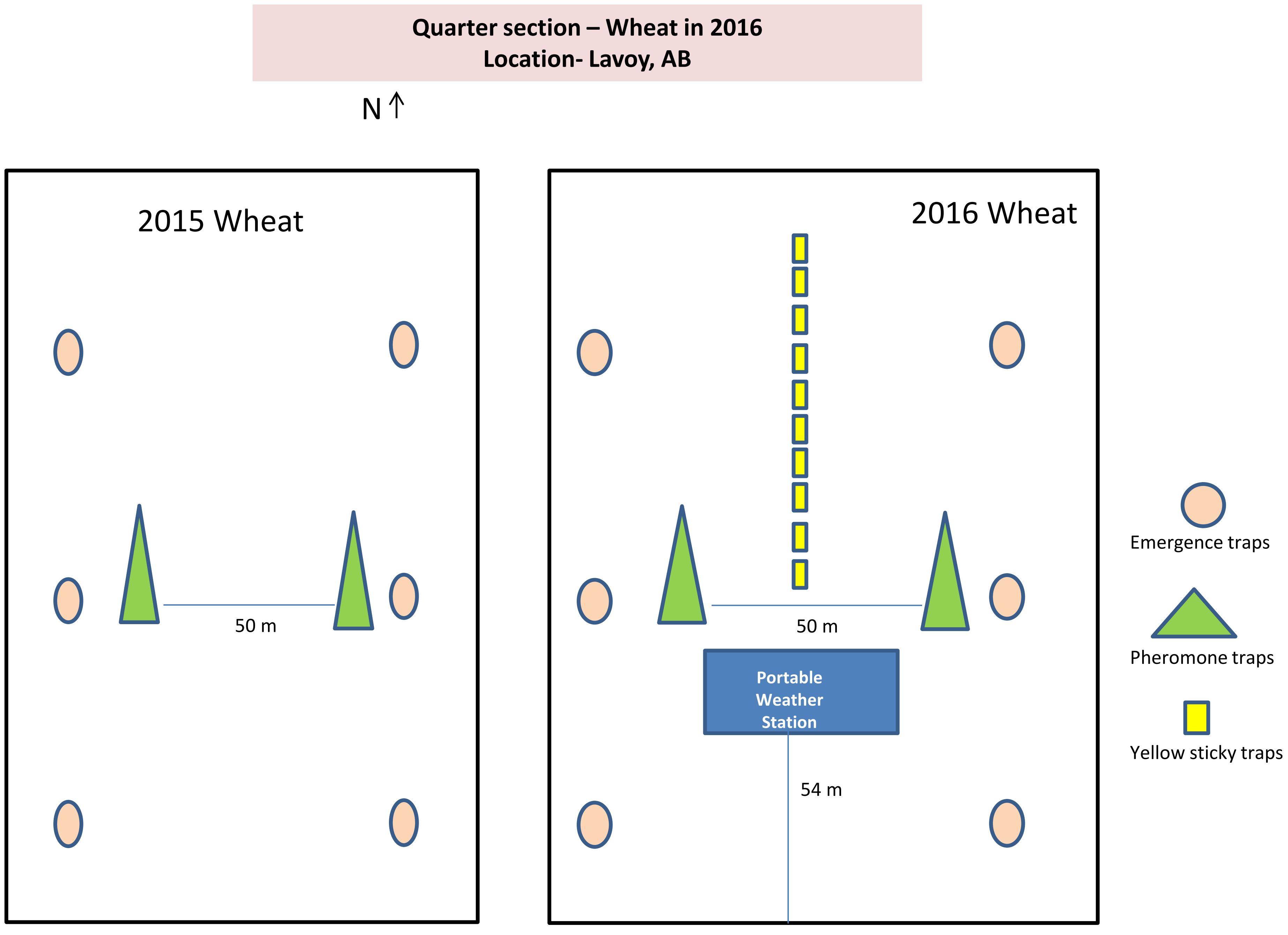
Wheat of current year

Wheat past year-canola current year

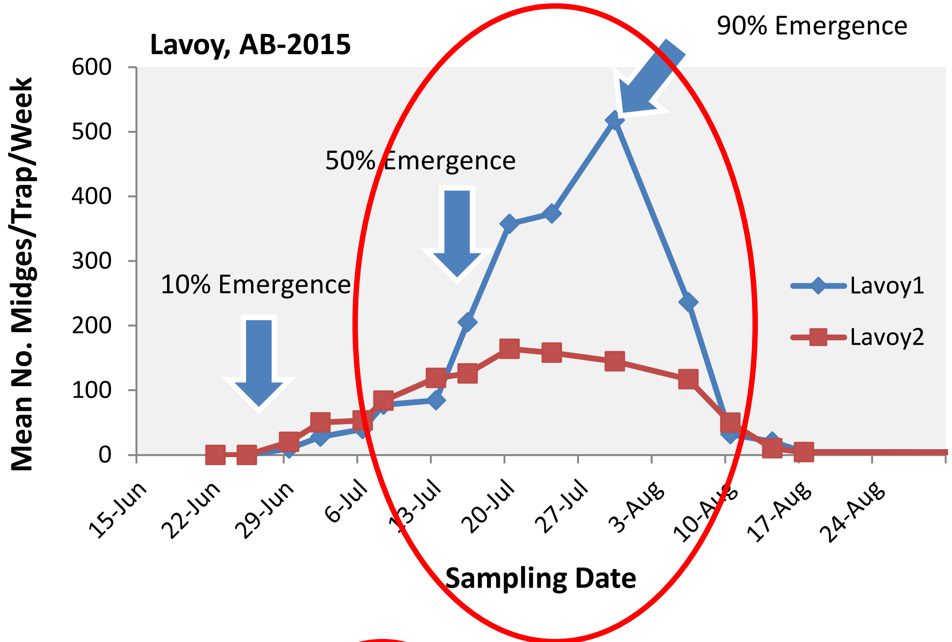
Emergence Traps

Pheromone Traps

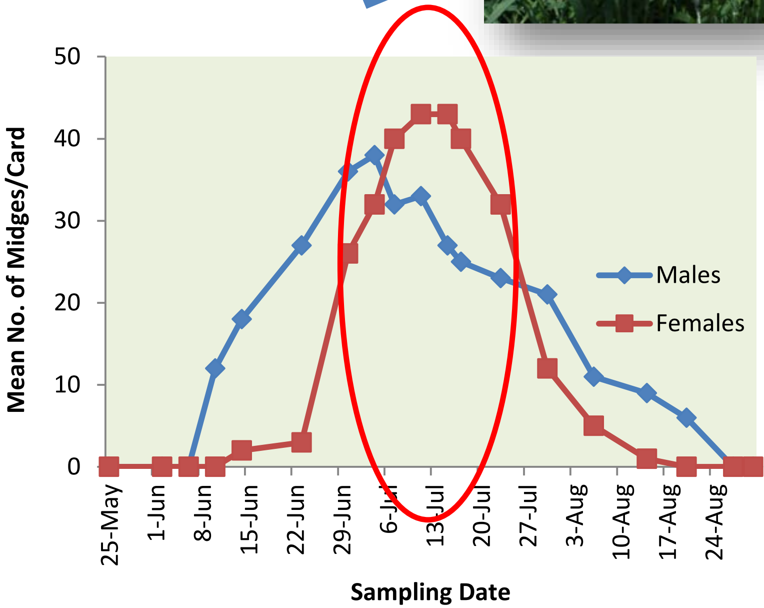
Yellow sticky Traps

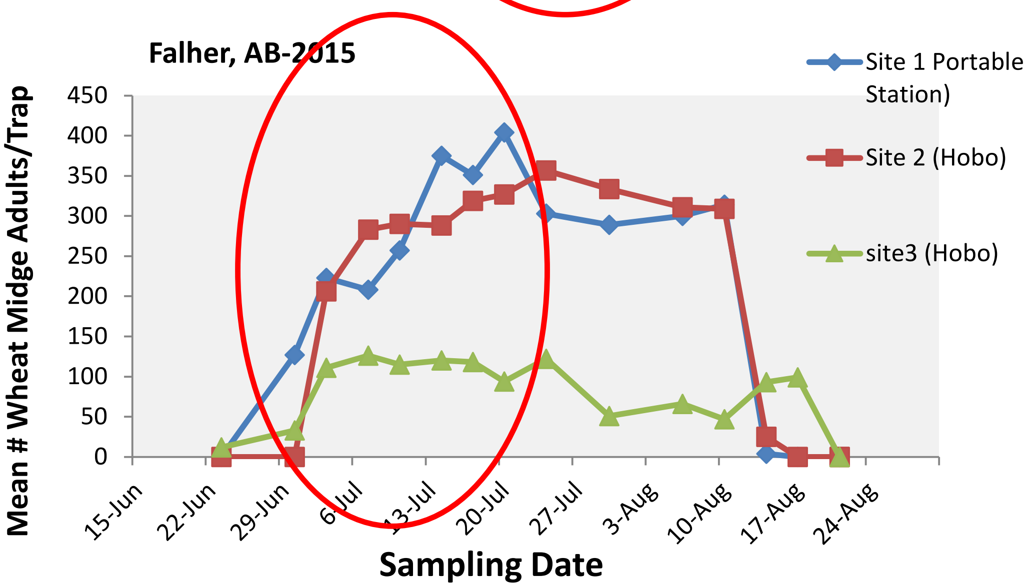

Quarter section – Wheat in 2016
Location- Lavoy, AB
N
2015 Wheat
50 m
2016 Wheat
50 m
Portable Weather Station
54 m
Emergence traps
Pheromone traps
Yellow sticky traps

# How the improved sampling filled the knowledge gap?

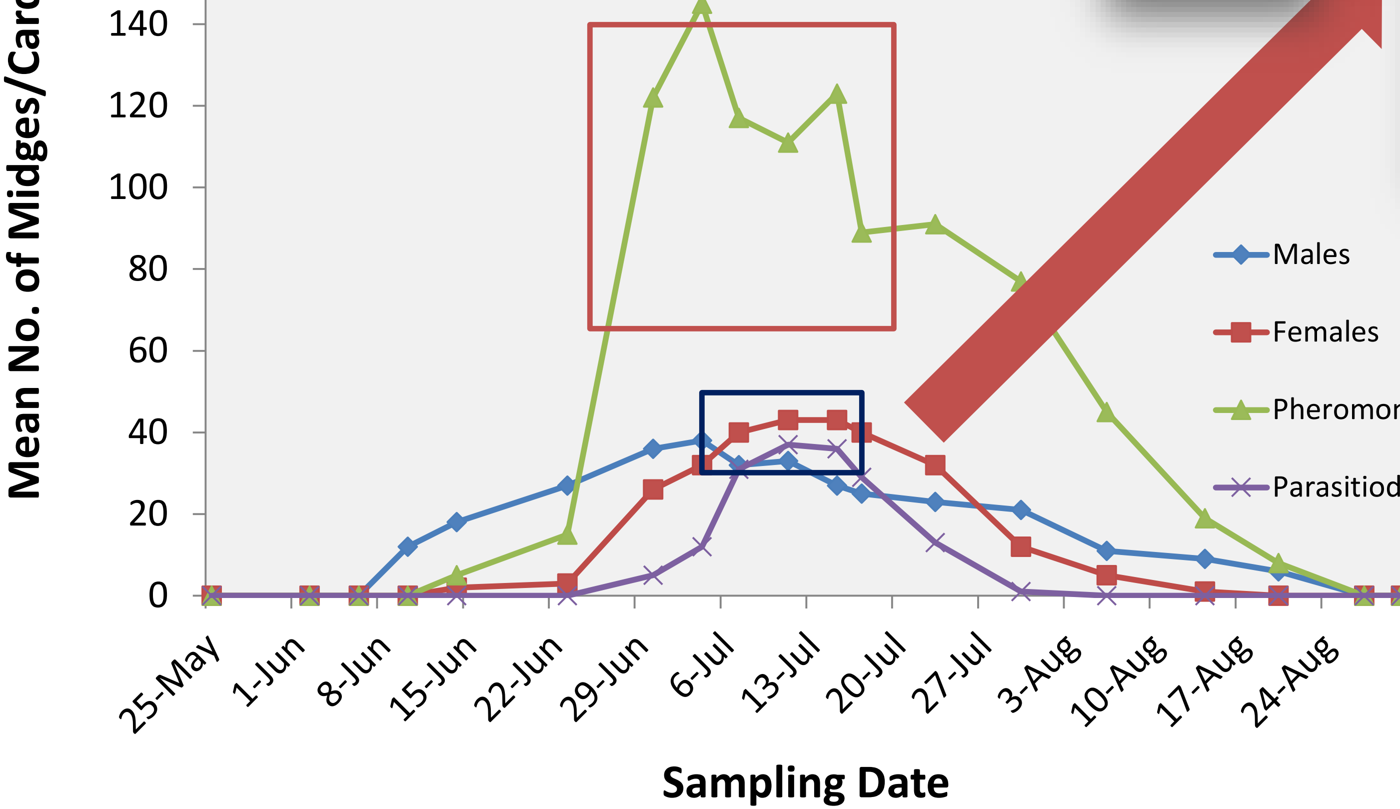



Critical Window for Oviposition



# Understanding Critical Events

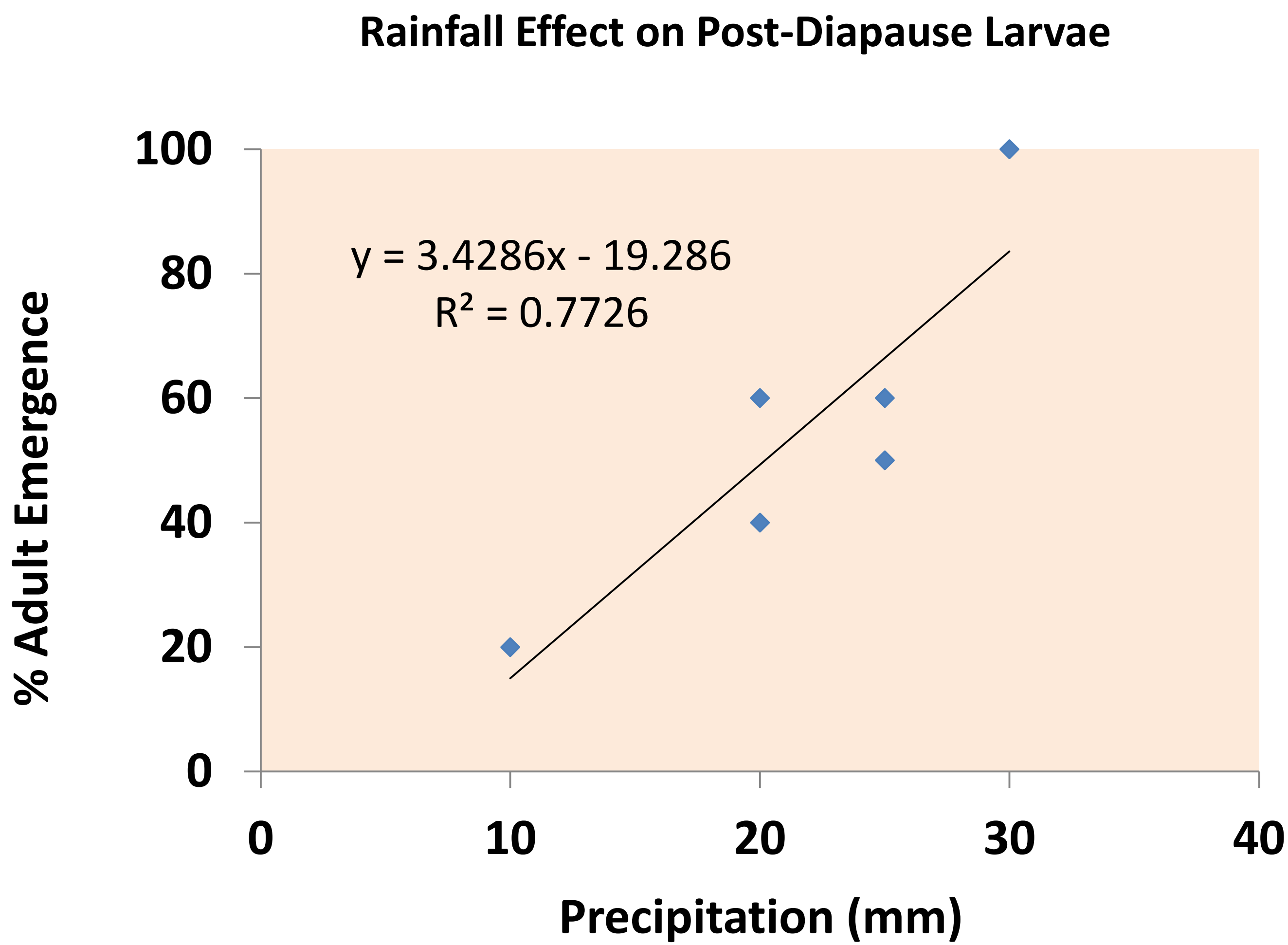



Wheat Midge

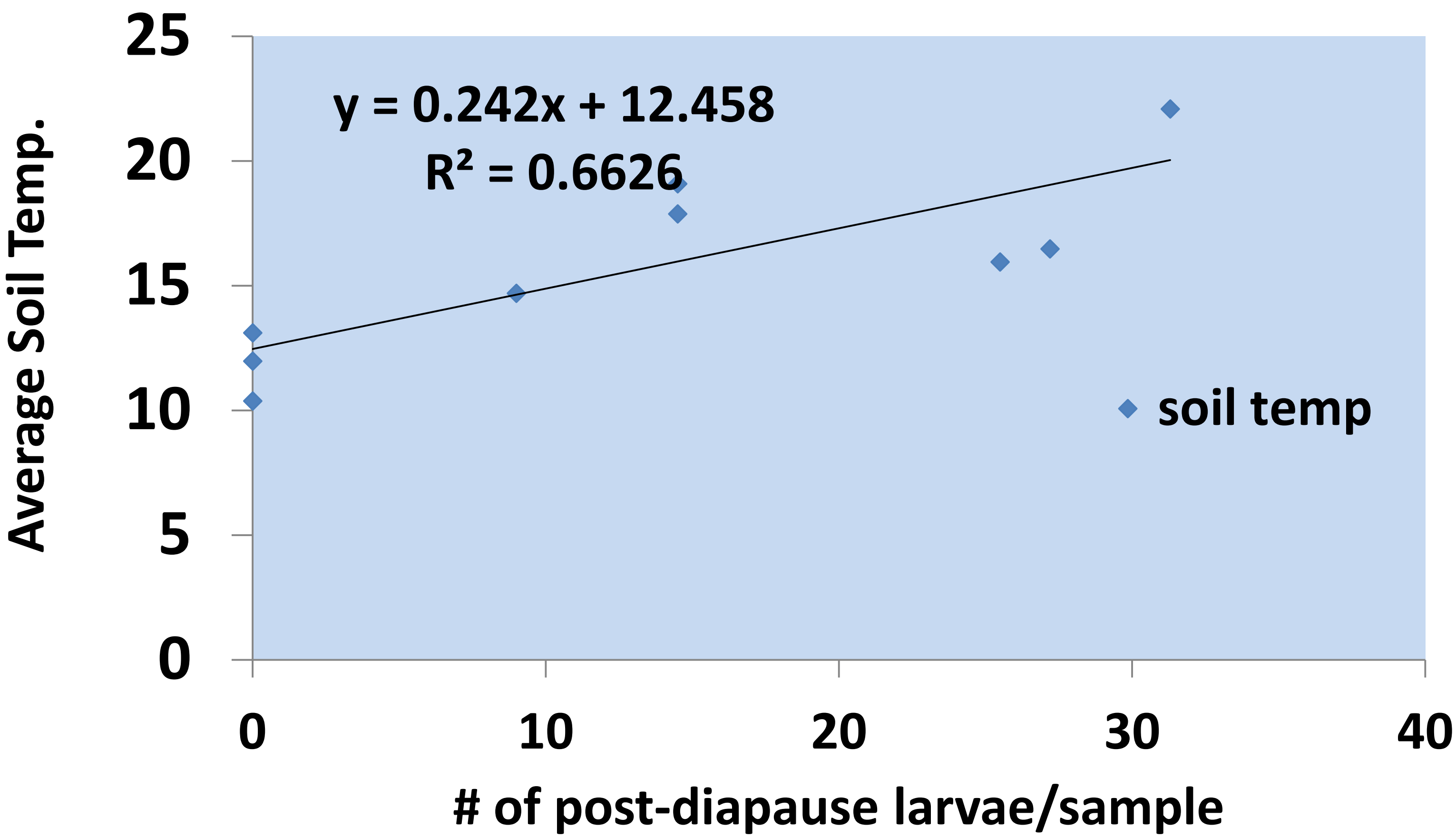
Natural Enemy

Midge Eggs

# Wheat Midge Phenology: Precipitation has a role in predicting adult emergence patterns



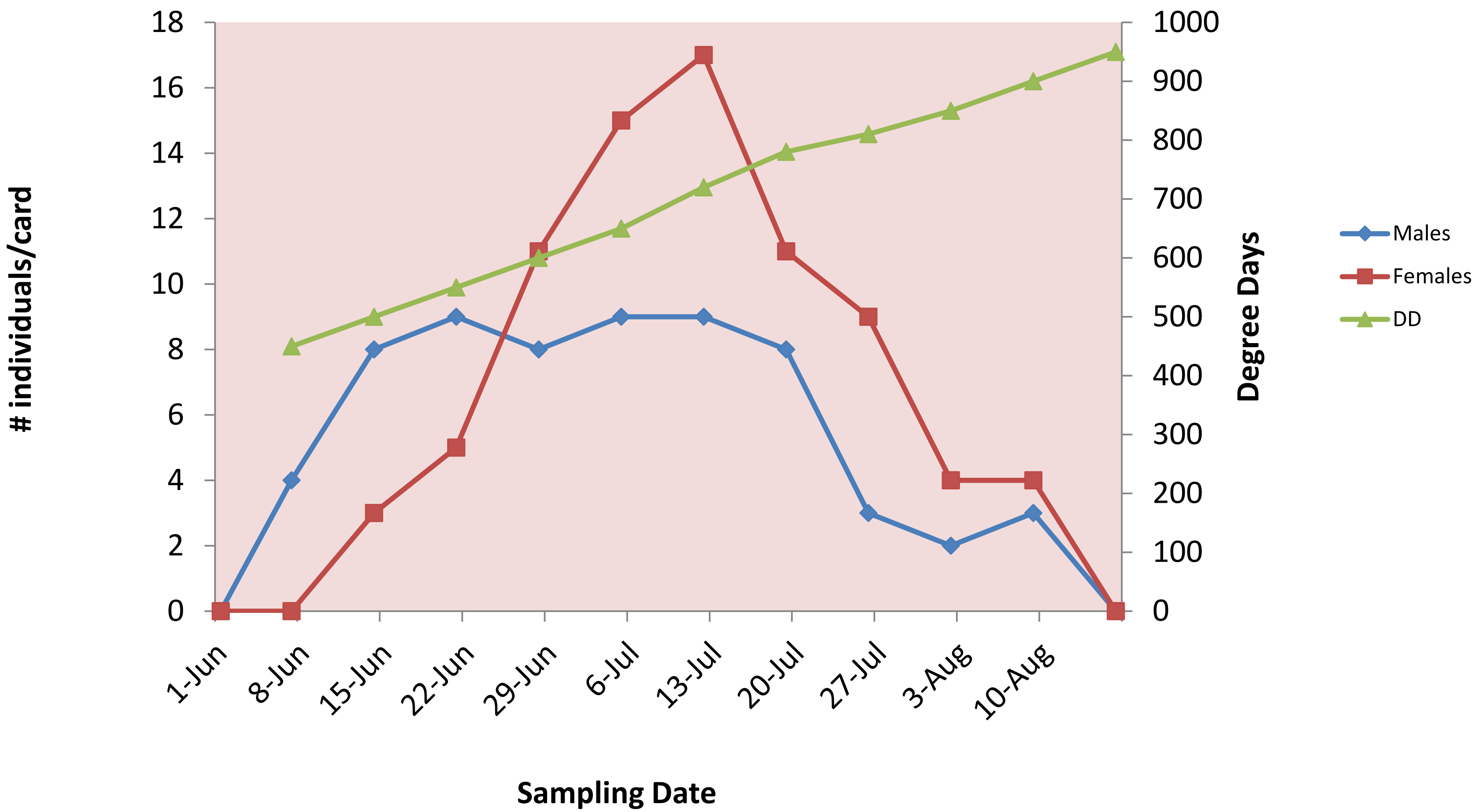
# Soil Temperatures influence post-diapause development



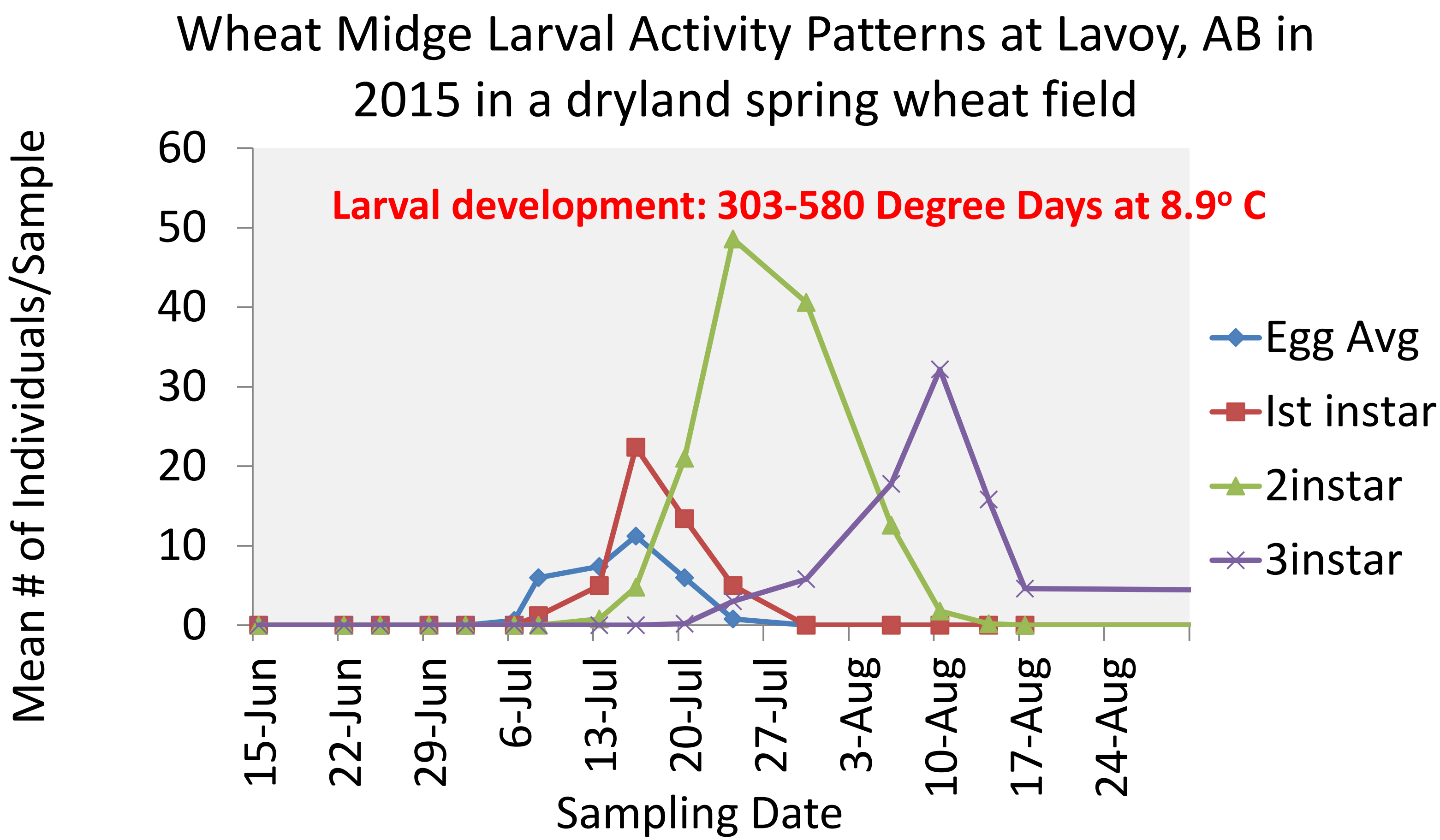

Efect of soil temperatures between 1 May-30 June on post diapause development

# Wheat Midge Emergence: Yellow Sticky Card based monitoring

**Better approach over using pheromone traps: data on both males and females**



# Wheat Midge Larval Activity



# Alfalfa Weevil: Current Approach

- Monitoring typically initiated in mid to late May, with increasing frequency of scouting in June as the crop develops

- Following threshold's used:

| Stage or event | Degree days (Base 9°C)* | Weevil activity |
|---|---|---|
| Egg hatch | 155-167 | |
| Instar 1 | 176-206 | Light leaf feeding |
| Instar 2 | 218-243 | |
| Instar 3 | 260-280 | Major leaf feeding |
| Instar 4 | 306-331 | |

* Peak alfalfa weevil developmental times from Harcourt (1981) and Beauzay et al. (2013)

Source: Alfalfa Weevil Factsheet, PPMN 2015

## Alfalfa Weevil: Current Knowledge Gaps

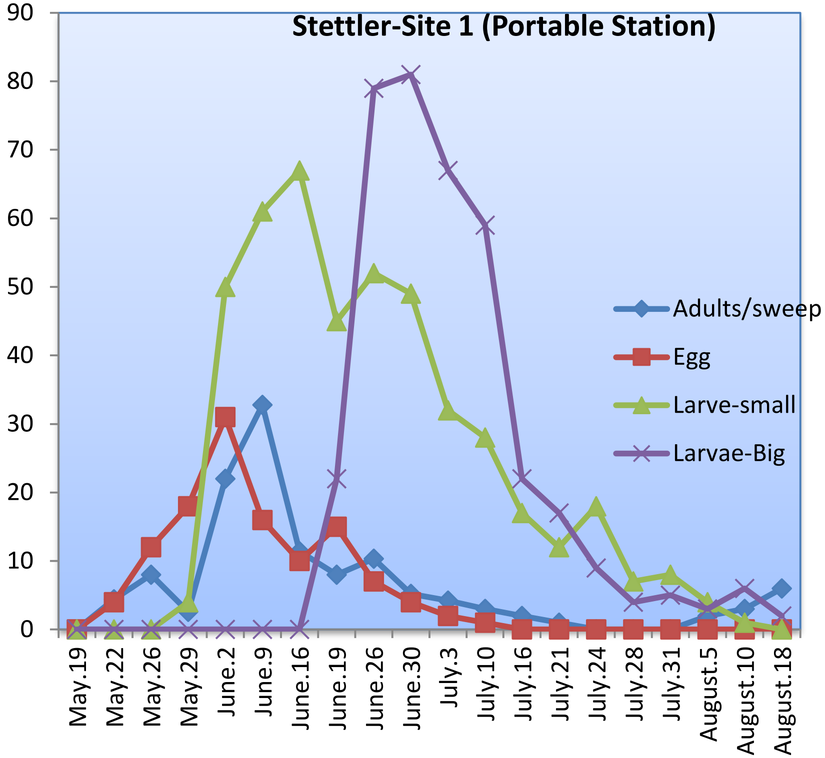
- How early does the adult emergence occur?
- When does oviposition start, for how long and when does first larva appear?
- Does phenology differ between seed and forage purpose crops or do management practices influence AW occurrence?
- How well is parasitoid activity synchronized with larval activity?

## Alfalfa Weevil: How did we bridge knowledge gap?

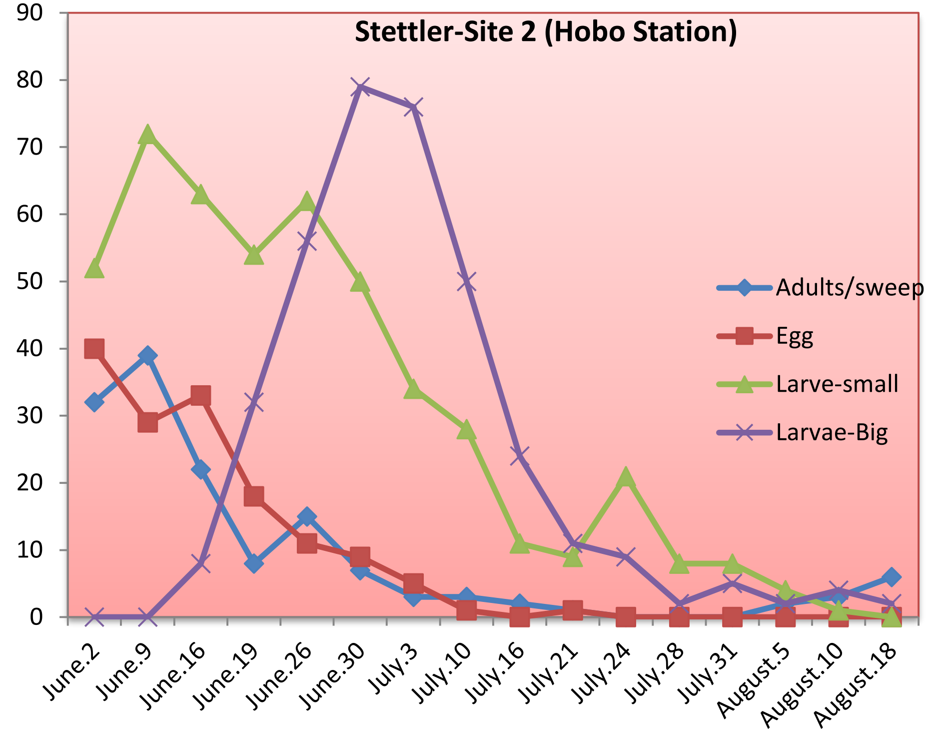
- Early scouting for adults (starting from April 1)
- Improved protocol for egg sampling (this stage is missing)
- Improved monitoring of larval activity: beginning, peak, end
- Continued scouting in second cut crop and recording of larvae until end of August
- Monitoring of teneral adults

# Alfalfa Weevil Phenology: Stettler, AB

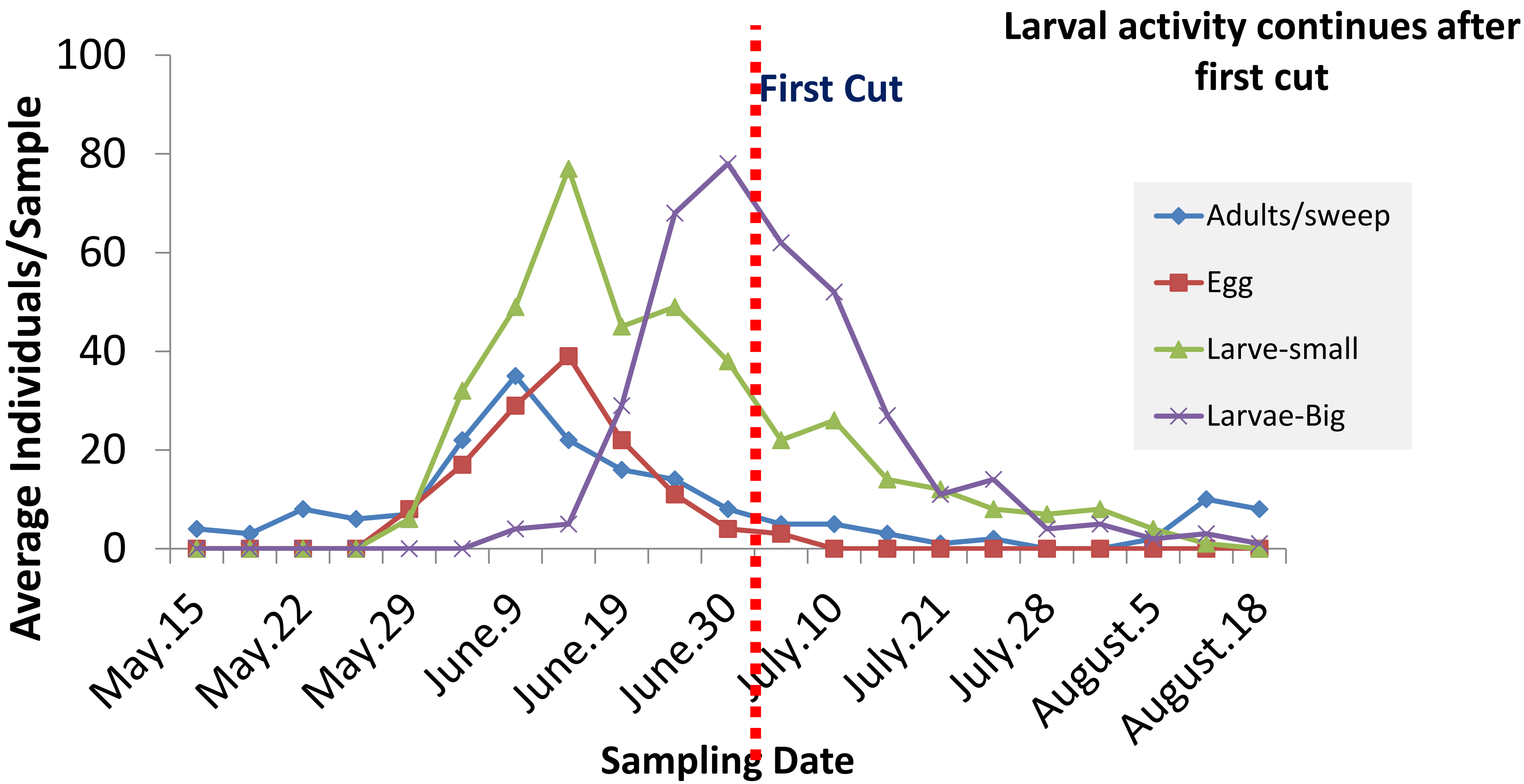
## Sampled early



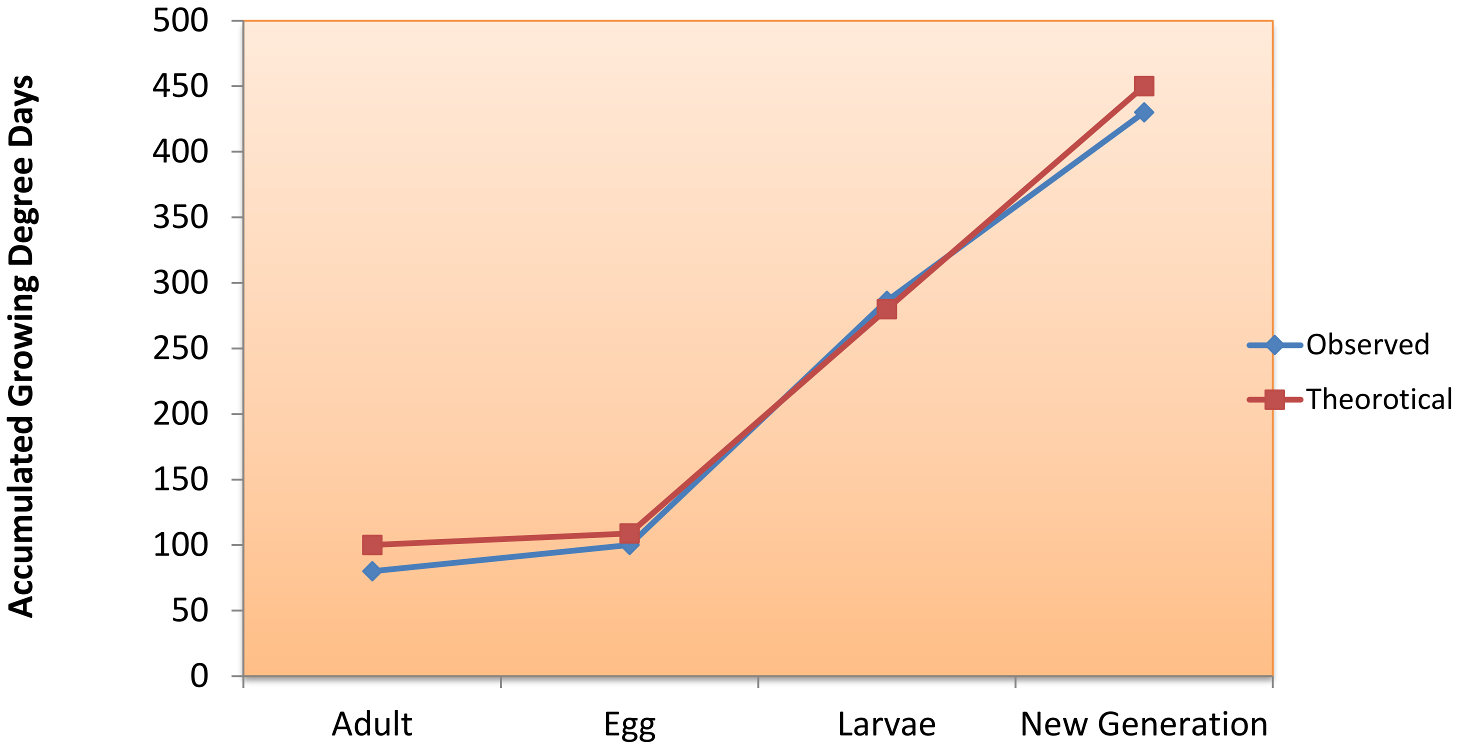

## Sampled Late



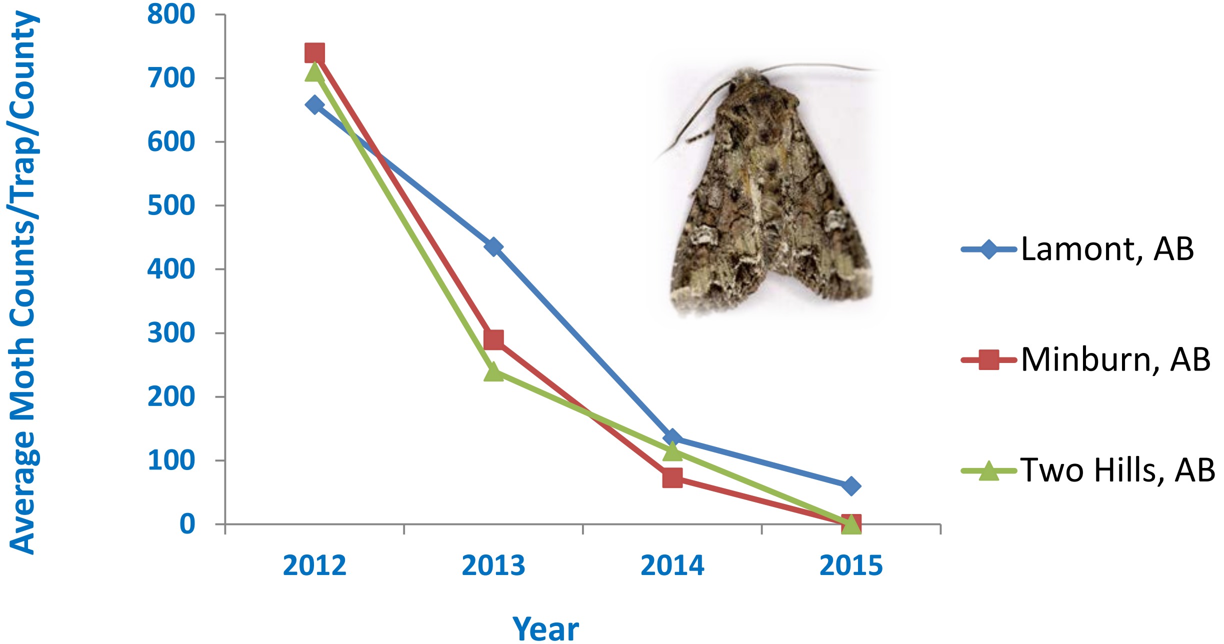
# Alfalfa Weevil Devlopment



# Alfalfa Weevil: Observed vs. Theorotical



# Bertha Armyworm: Adult Trap Captures between 2012-2014




The graph shows average adult captures of bertha armyworm in pheromone traps in three counties in Alberta with data from 35 townships in each county over a four year period from 2012-2014

**Collapse of bertha armyworm adult populations indicate declining phase of an outbreak cycle**

**(Picture Courtesy: Shelley Barkley, CDC South, Brooks)**

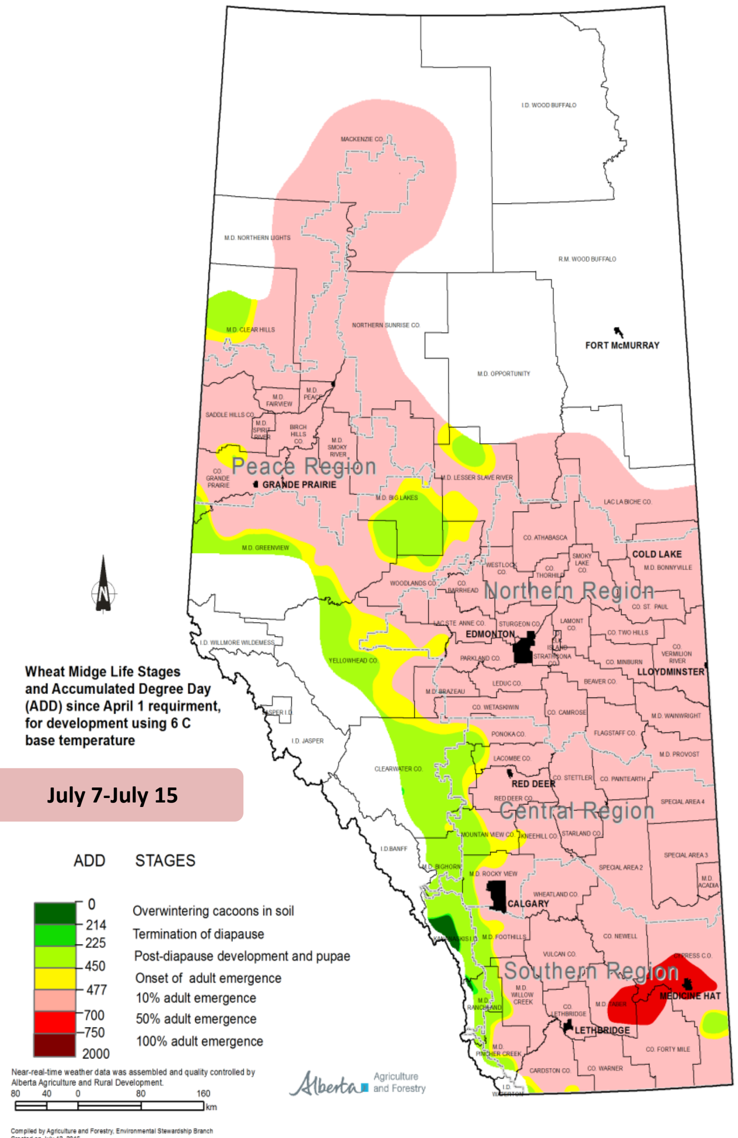
# Modeling Component

- Will involve insect phenology modeling in response to weather parameters (R.H, precipitation, temperature, wind speed, solar radiation etc.)
  - GDD and crop phenology ongoing
  - Stage structured insect developmental modeling

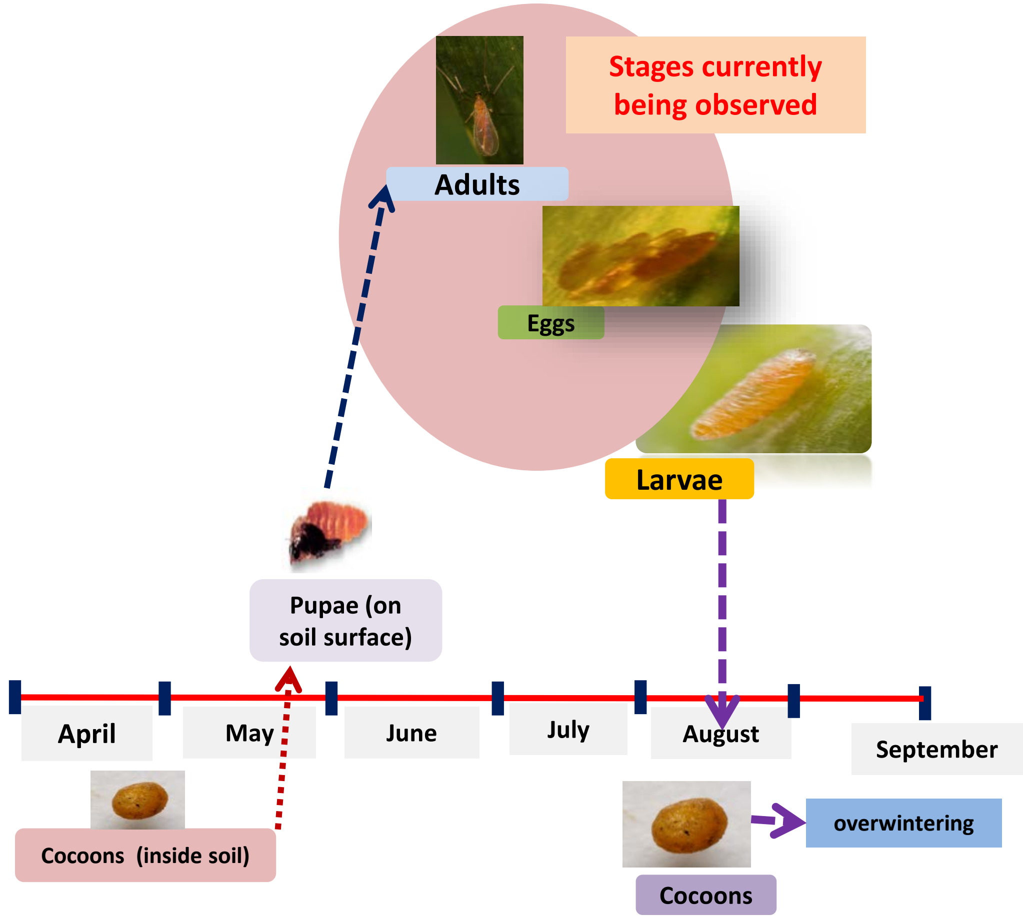
# Model validation

- Model validation: comparing field developmental requirements with lab based theoretical requirements

**Wheat Midge Status**
**Week of: July 7-15**



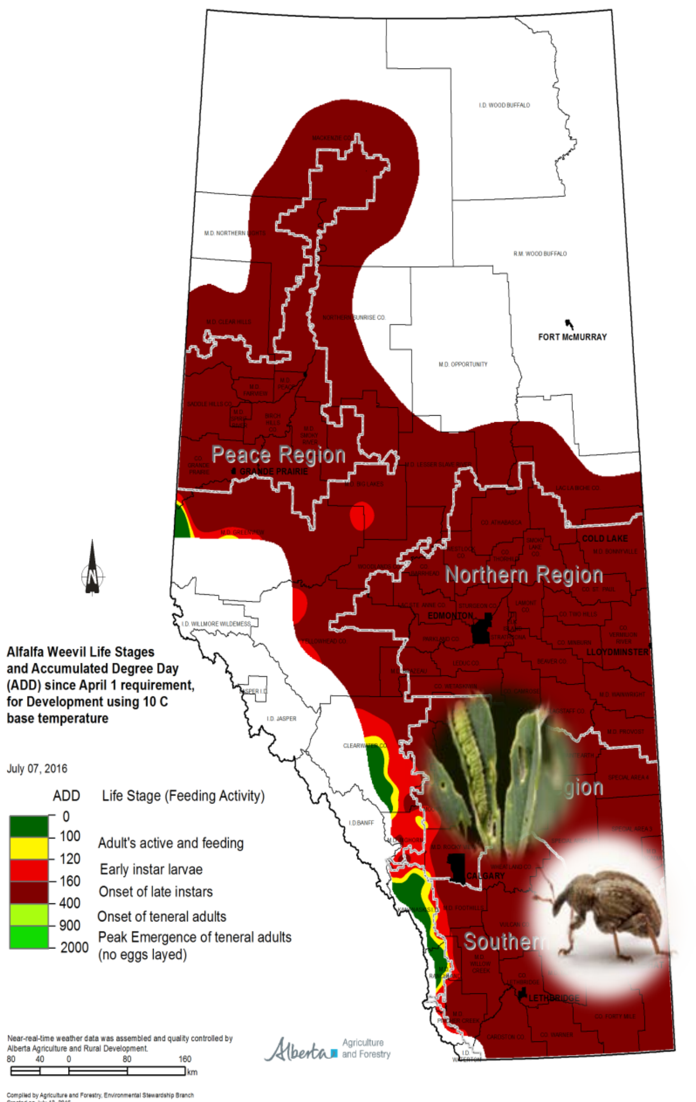

# Observed Life Cycle of Wheat Midge

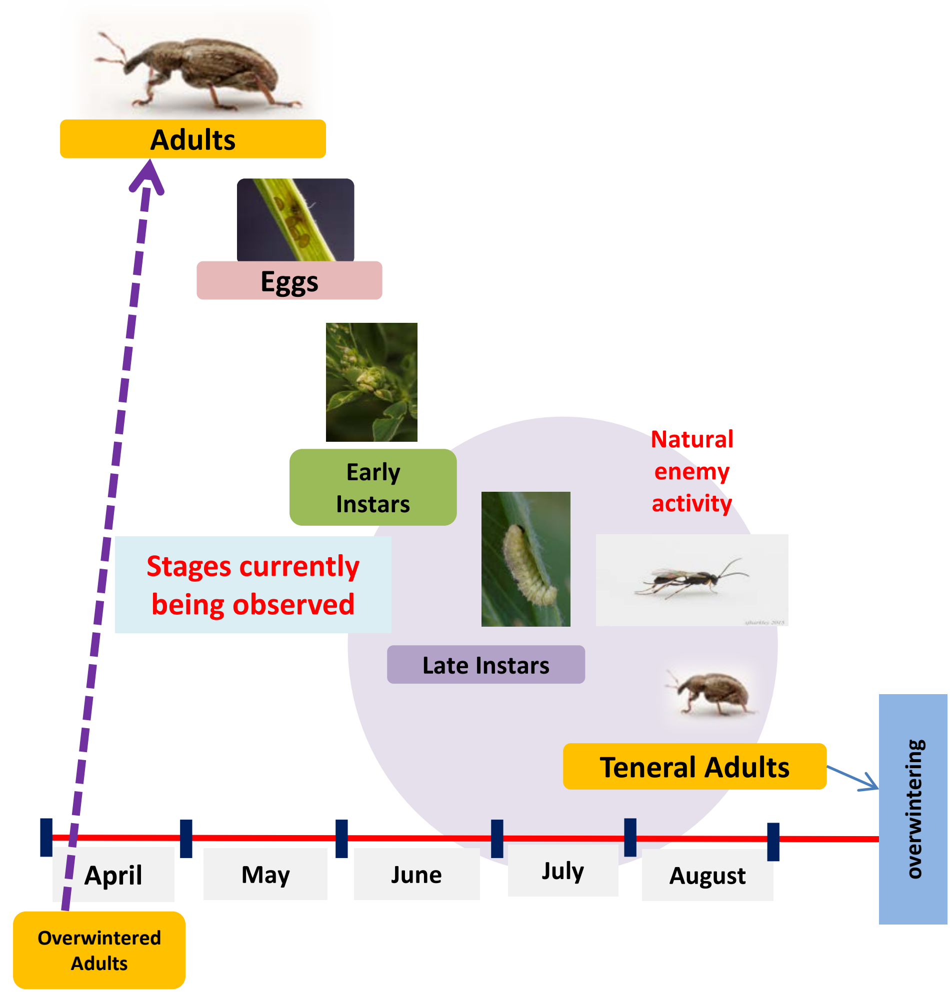



**Picture Courtesy: Shelley Barkley, Government of Alberta**

**Alfalfa Weevil Status**
**Week of: July 7, -July 15, 2016**

# Life Cycle of Alfalfa Weevil




**Picture Courtesy: Shelley Barkley, Government of Alberta**

# Pest Project: Progress

- Two field seasons of data collection
- 65+ sites sampled for the insect models
- On-site monitoring for weather parameters at 16 sites: 6 full weather stations+10 hobo stations
- Improvement in insect phenology protocols

# Our work

- 2100 yellow sticky cards
- 1200 White sticky cards
- 1200 emergence trap cards
- 3000+ wheat heads
- 500 soil samples across Alberta

# Pest Project: End Goal

- Development of provincially applicable pest models based on NRT weather data

- Model validation and development of web-based decision support system for producers, industry and pest managers

- Potential for collaborations for expertise development in designing decision support systems

# Acknowledgements

- Alberta Canola Producers Commission (ACPC)

- Pest Surveillance Branch
  - Scott Meers
  - Shelley Berkley
  - Team of summer students and technicians

- Agroclimatic and Engineering Services Branch

Alberta Government

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