# Host Plant Resistance to Wheat Stem Sawfly in Barley

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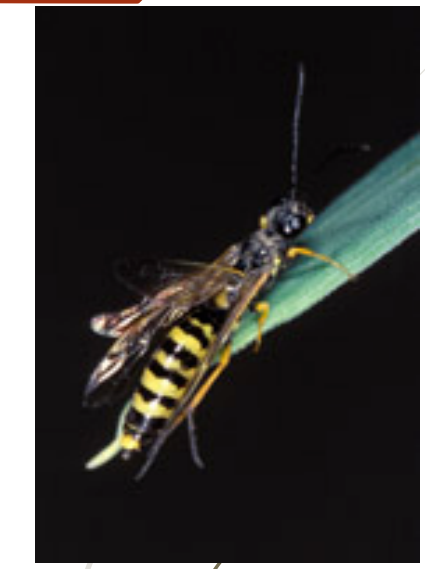
# Overview of the presentation

- Life cycle of *Cephus cinctus*
- Economic loss and distribution of *Cephus cinctus*
- Management tactics for *Cephus cinctus*
  - **Host plant resistance**
- Materials and methods
- Results
  - Infestation in barley cultivars
  - Larval mortality in barley cultivars
- Ongoing activities

# Life cycle of *Cephus cinctus*



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Eggs

Spring

Summer

Feeding larvae and frass

Fall and Winter

Larva in diapause

Stems cut by larvae

# Economic losses and distribution of *Cephus cinctus*

**Lost plant vigor, accelerated senescence, and yield loss**

- **Economic loss:** direct loss is caused by reducing photosynthetic rate (Macedo et al. 2005)
- Up to 30% potential loss at harvest (Delaney et al. 2010)

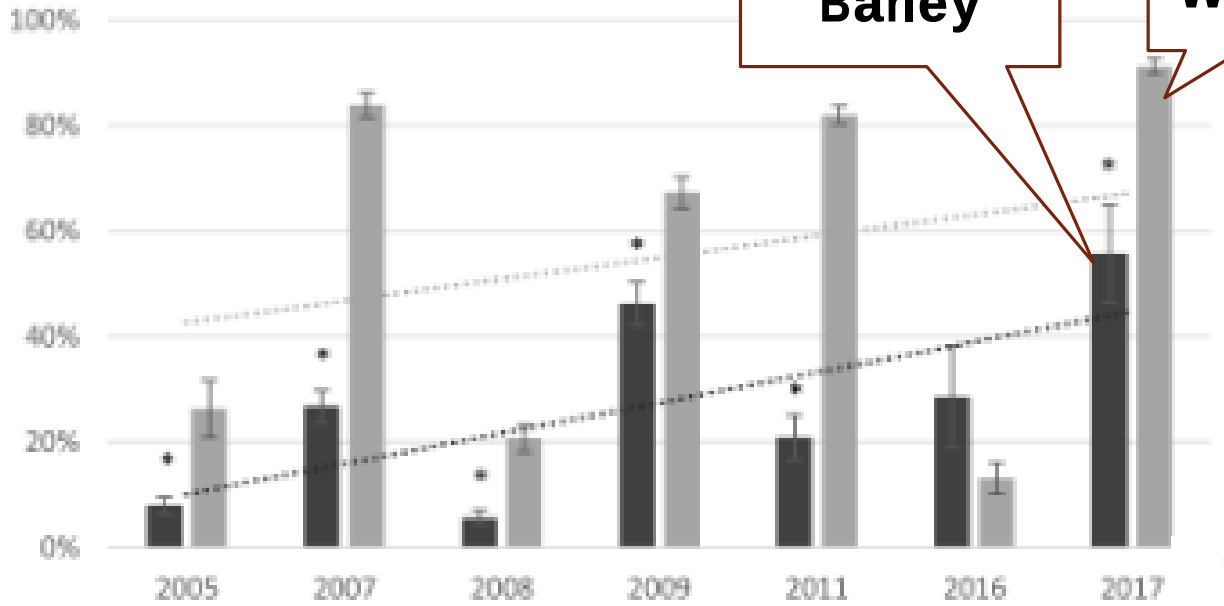
- Stem cutting by larvae at harvest makes it difficult to recover grains.
- Overall losses of 44-80 million USD per year in Montana.

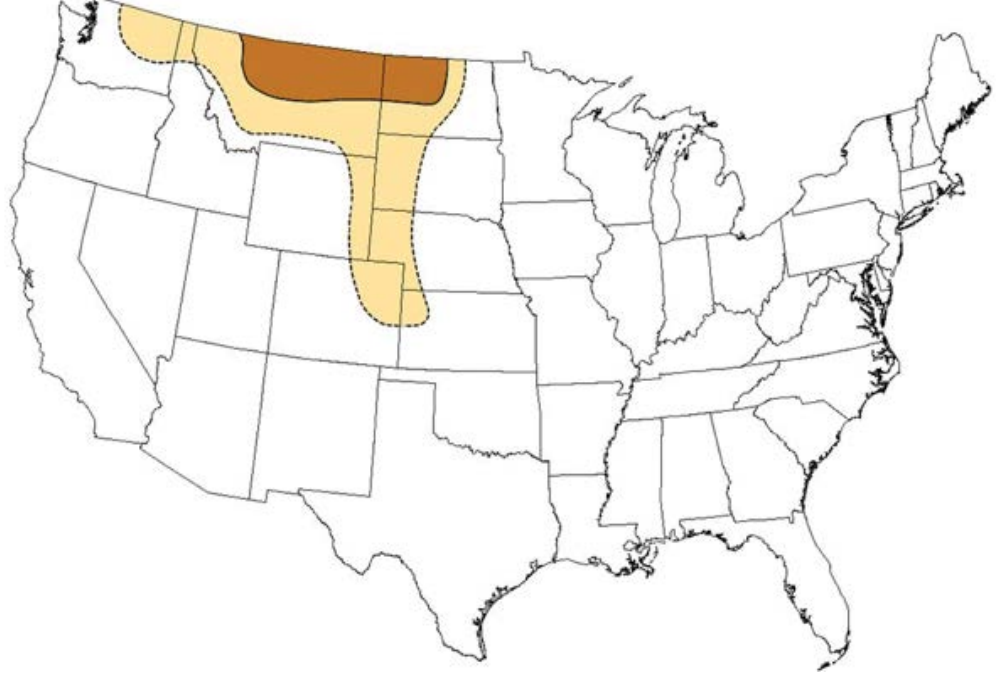
(Bekkerman, 2014; Bekkerman and Weaver, 2018)

Feeding damage

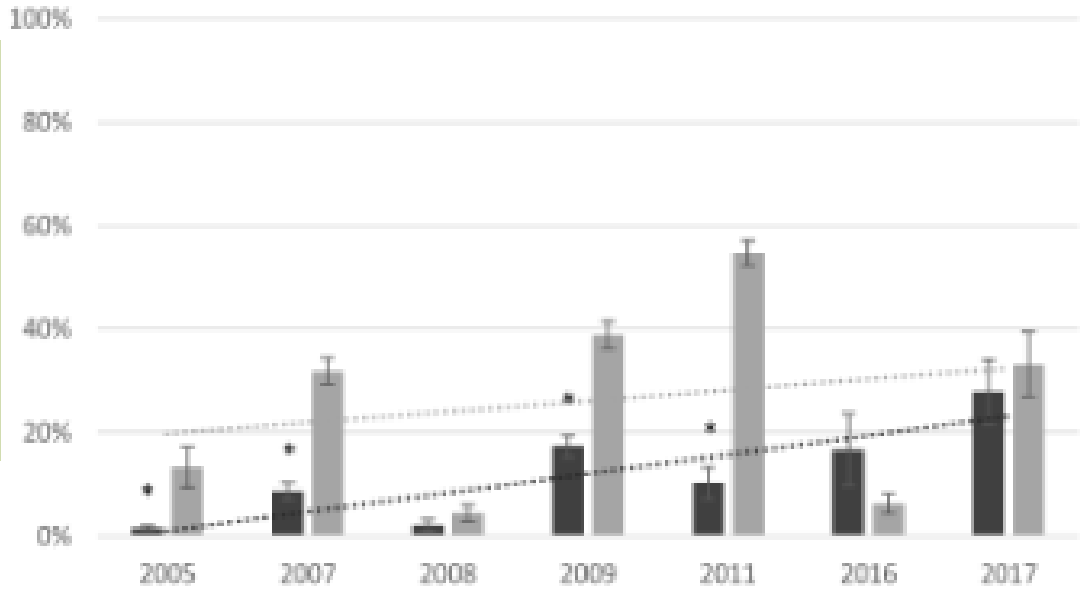
Lodged stems due to stem cutting

Infestation %



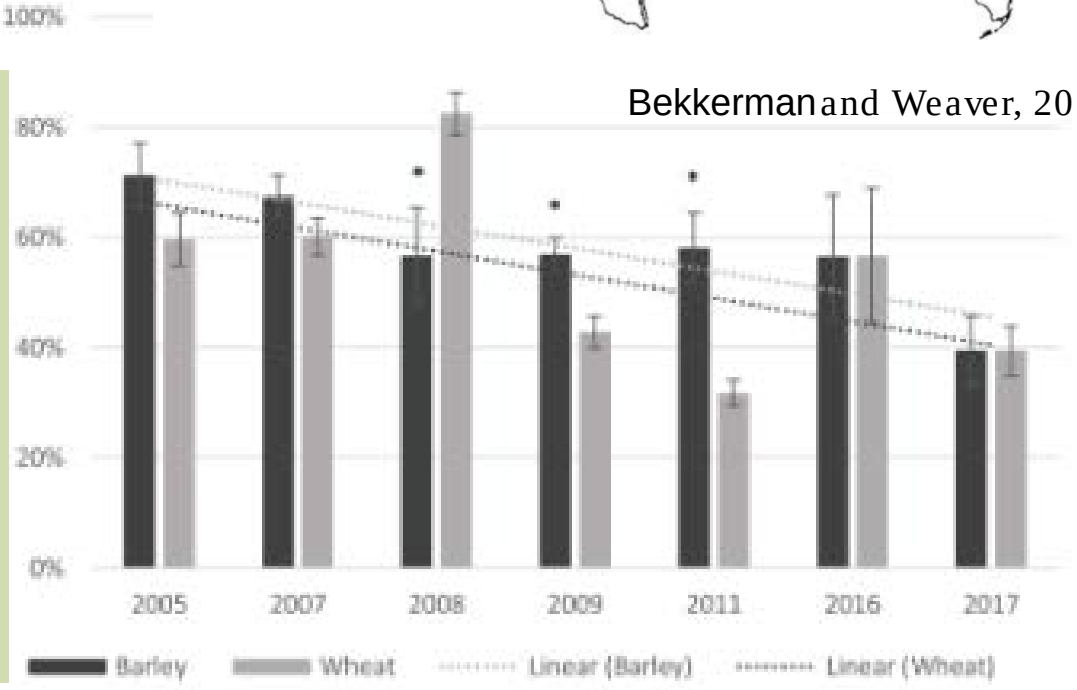



Cut stem %




Bekkerman and Weaver, 2018

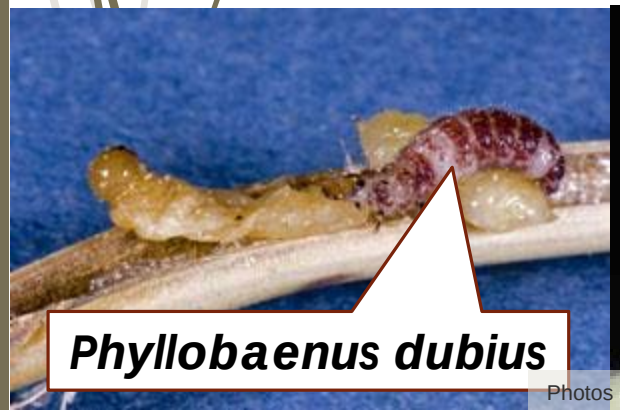
Larval mortality %

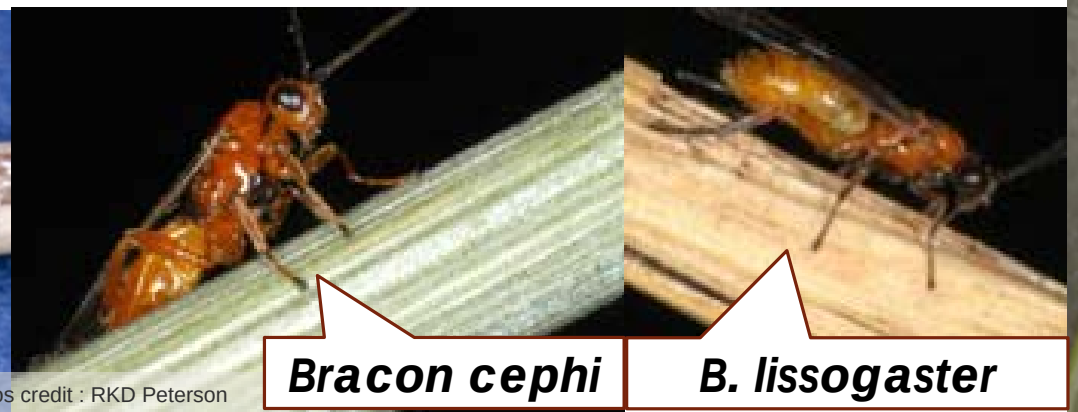



Varella et al. 2018

# *Cephus cinctus* management tactics

- **Cultural control**: Tilling field to expose diapausing larvae to predators and freezing temperature, crop rotations
- **Chemical control**: Thimet®
- **Biological control**:
  - **Parasitoids**: *Bracon cephi* and *B. lissogaster*
  - **Predator:** *Phyllobaenus dubius*
- **Host plant resistance**: solid stem wheat




Photos credit : RKD Peterson

Photo credit : Ag NDSU

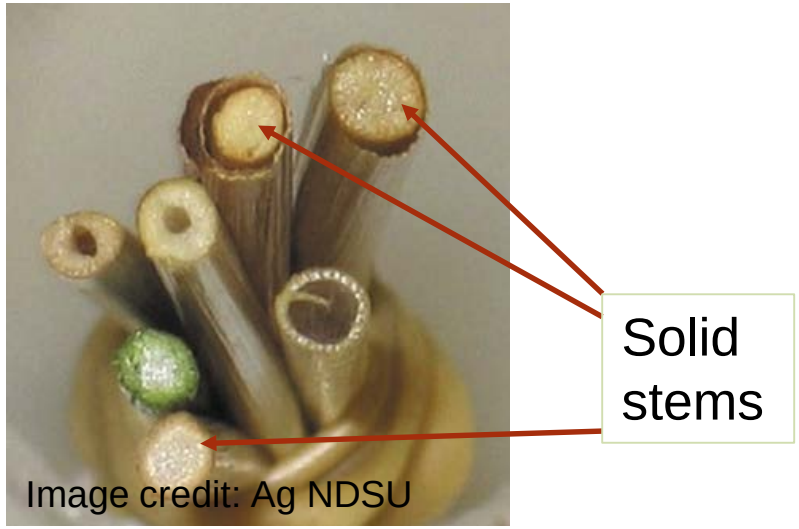
# Host plant resistance

**i) Antixenosis (non-preference):** host plant characters that interfere with the ability to infest.

**ii) Antibiosis:** host plant characteristics that reduce growth or survival of the feeding stage(s) of the insect.

**iii) Tolerance:** the ability of plant that can grow and reproduce even after insect damage.

(Painter, 1951)




## Overall goal

To develop barley as a useful tool for *Cephus cinctus* management in wheat and barley cropping systems

## Objectives

i) To assess WSS infestation and stem cutting across a set of barley cultivars

ii) To assess WSS larval survival rates

iii) To estimate the age-specific mortality

## Hypothesis

Cultivars with greater host plant resistance receive fewer eggs, have greater larval mortality, and fewer cut stems.

# Materials and Methods

| Cultivar | Class | Use |
|---|---|---|
| Hockett | Two-row | Malt |
| Craft | Two-row | Malt |
| Lavina | Two-row | Forage |
| Haybet | Two-row | Forage |
| Haxby | Two-row | Feed |
| Champion | Two-row | Feed |
| Celebration | Six-row | Malt |
| Tradition | Six-row | Malt |


Experimental sites in Montana

**Design:** Randomized complete block
**Replication:** 3
**Plot size:** 1.8 m × 3.6 m
**Seed rate:** 9 gm/$m^2$

**Planting date:** April 11, 14, and May 3rd

# Sampling

- First sampling: 59 days after seeding (Approximately 50% of plants have elongated stems).
- Three 0.3 m samples from each plot at weekly interval (Total nine subsequent weeks of sampling)

Dissected 35 primary stems from each bag of samples

# Assessment of infestation and stem cutting


Eggs


Live larva


Stubs


Cut stems


Dead larva

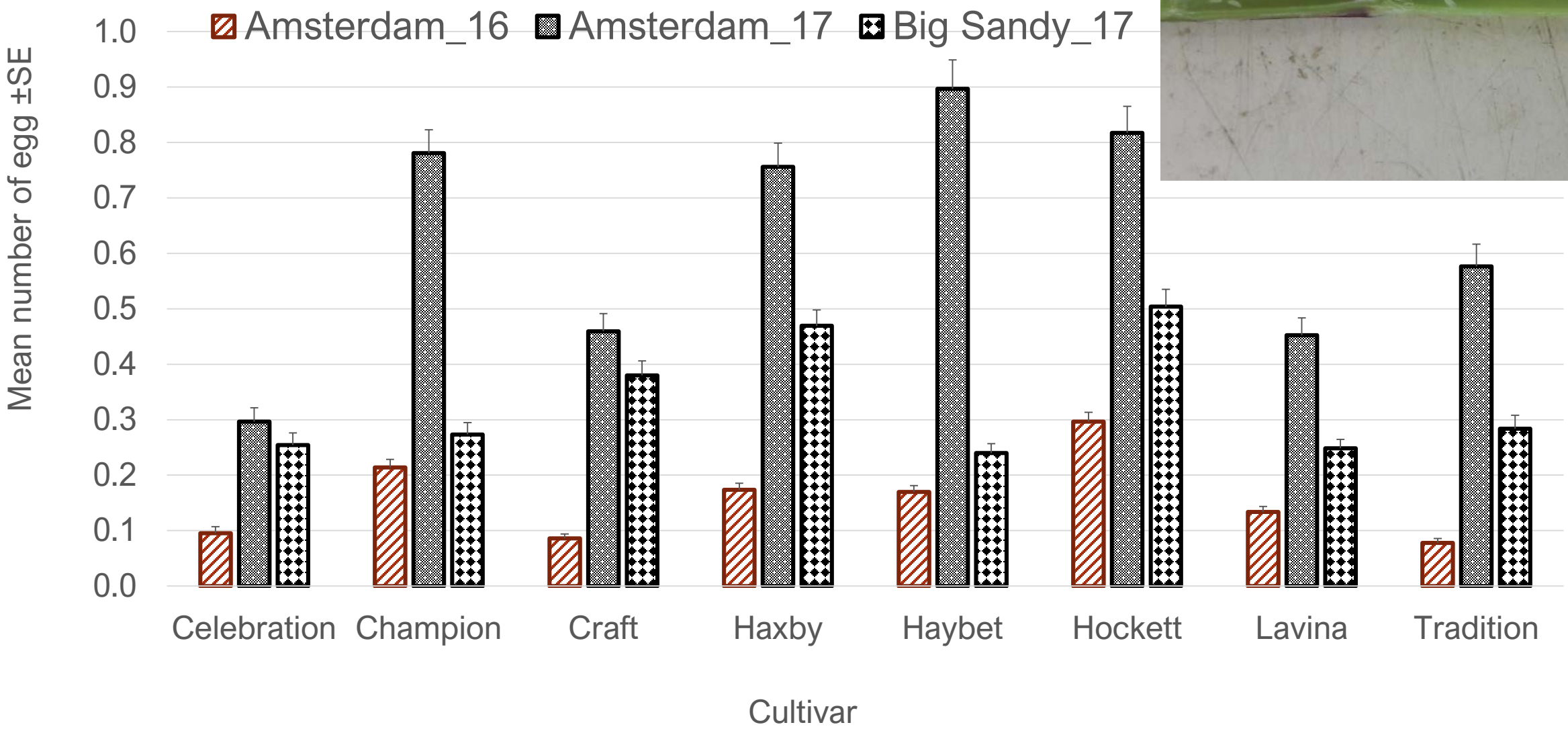

Live larva with hibernaculum in a stub

# Results

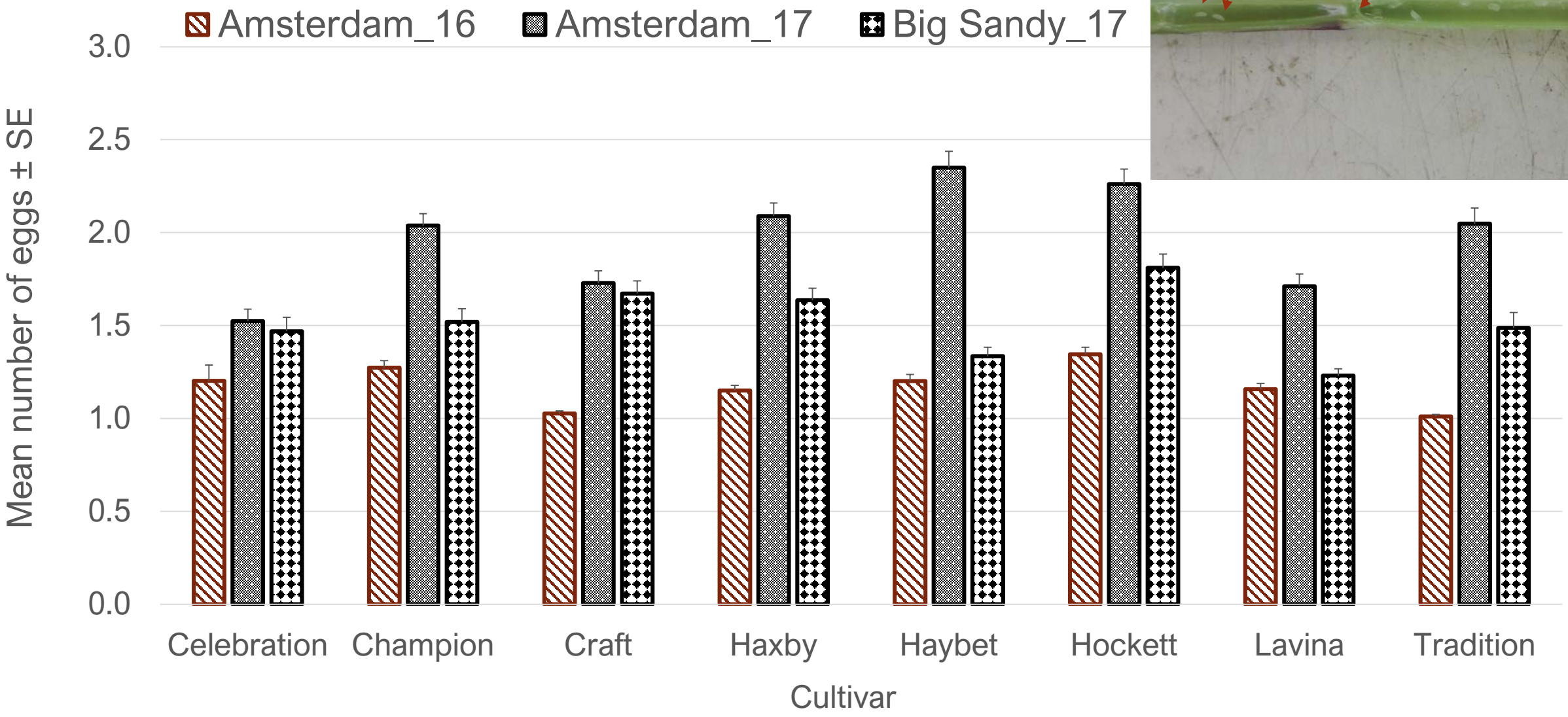
# 1. Assessment of infestation in barley

presence of eggs, larvae or frass

# 1.2 Mean number of eggs per stem



# 1.3 Mean number of eggs per infested stem



# 1.4 Assessment of cut stems in infested plants

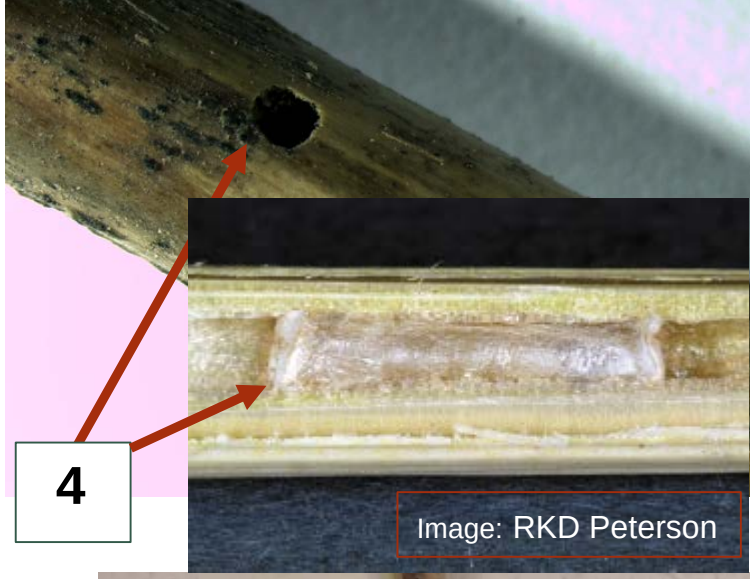
# Summary: Assessment of infestation and cut stems in barley

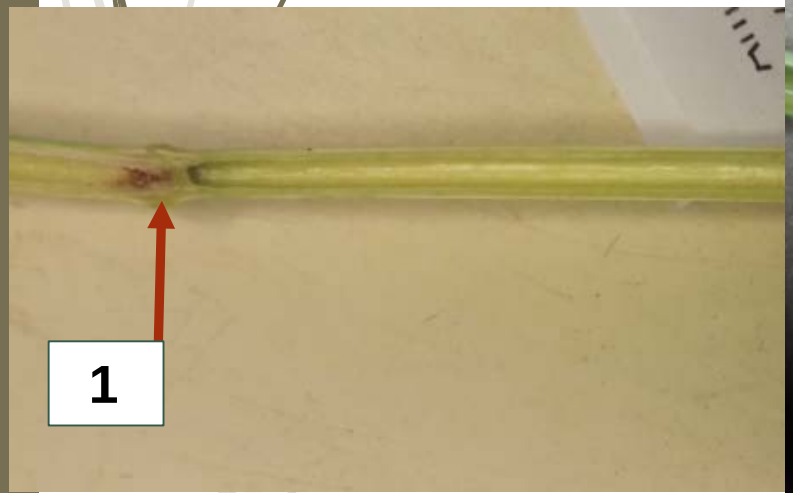
- Mean infestation in **Celebration, Craft, Lavina, and Tradition** had the **lowest (~40-45%); Champion, Haxby,** and **Haybet** had moderate (~55%), **Hockett** had **the highest (~ 65%)**.
- Average number of **eggs per stem** was **0.2 to 0.8**, with **1 to 2.4 eggs per infested stem.**
- Mean cut stem in **Craft** was **~ 8%, Celebration, Champion, Haxby, Lavina, and Tradition** was ~ 15%, in **Haybet** was 25%, and **the highest was 30% in Hockett.**

# 2. Mortality of WSS larvae

## Methodology

- Dissected 105 stems per plot for each cultivar at each location.
- Categorized larval mortality into four groups:
  1) Host plant resistance (plant factor)
  2) Unknown factor
  3) Cannibalism
  4) Parasitism






# 2. Estimation of age-specific mortality

- Allow to estimate the age-specific mortality rate and associated morality factor in absence or presence of other mortality factors.
- M-DEC (Davis et al. 2011) was used to calculate probability of mortality of one mortality factor in absence of other factor **(=also called irreplaceable mortality).**
- Summer, pre-flight period, and post flight periods were chosen to assess mortality.

| Celebration | Life stage (x) | Number of individual live at x (lx) | Total number of death in x (dx) | Cannibalism (1x) | Cannibalism (2x) | Plant Factors (3x) | Parasitoid (4x) | Unknown (5x) |
|---|---|---|---|---|---|---|---|---|
| | Egg | 264 | 146 | 146 | 0 | 0 | 0 | 0 |
| | Larva I | 556 | 293 | 0 | 90 | 180 | 0 | 23 |
| | Larva IV | 542 | 404 | 0 | 14 | 315 | 14 | 61 |

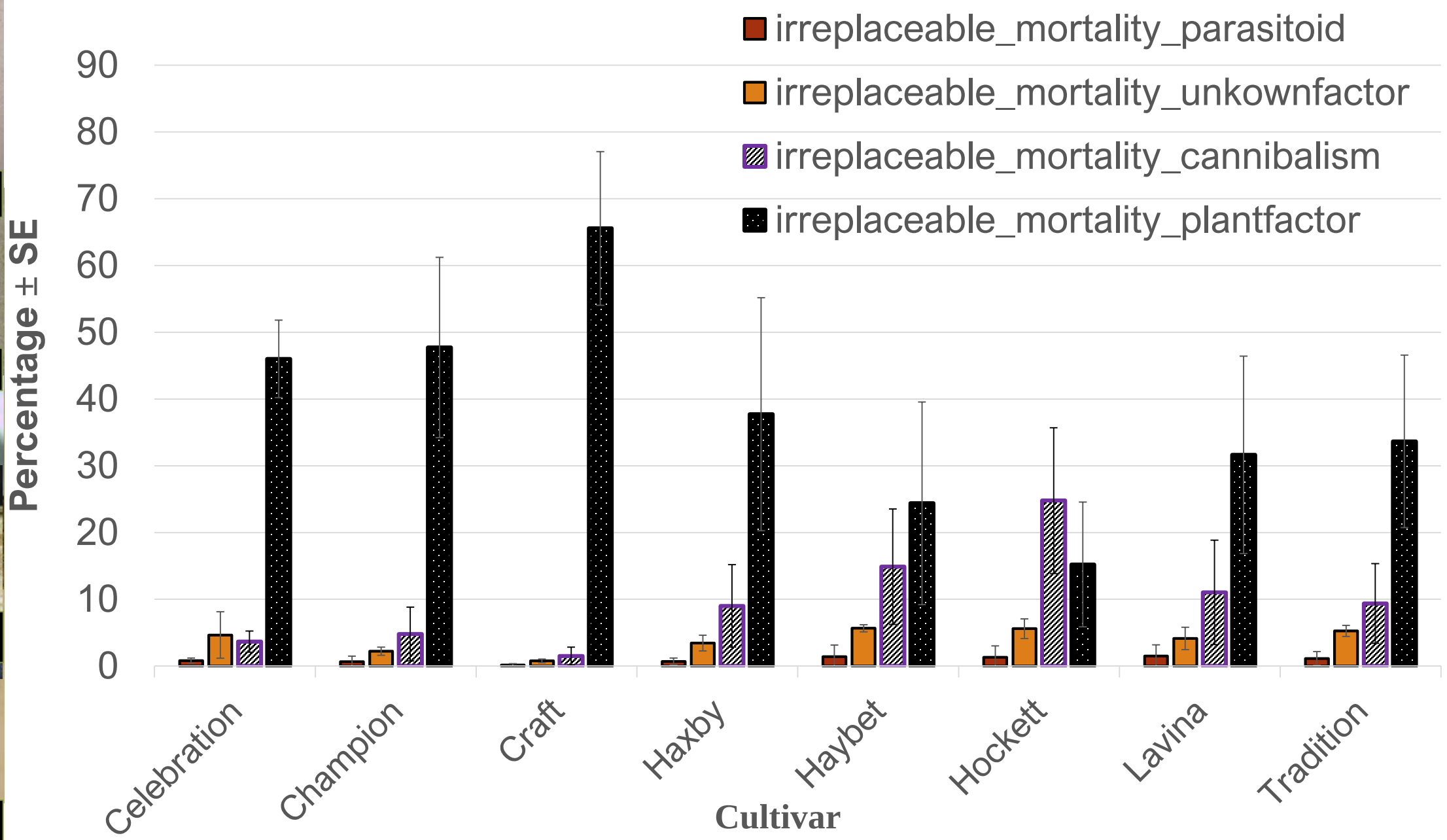
# 2.1 Irreplaceable mortality of summer larvae

Cannibalism

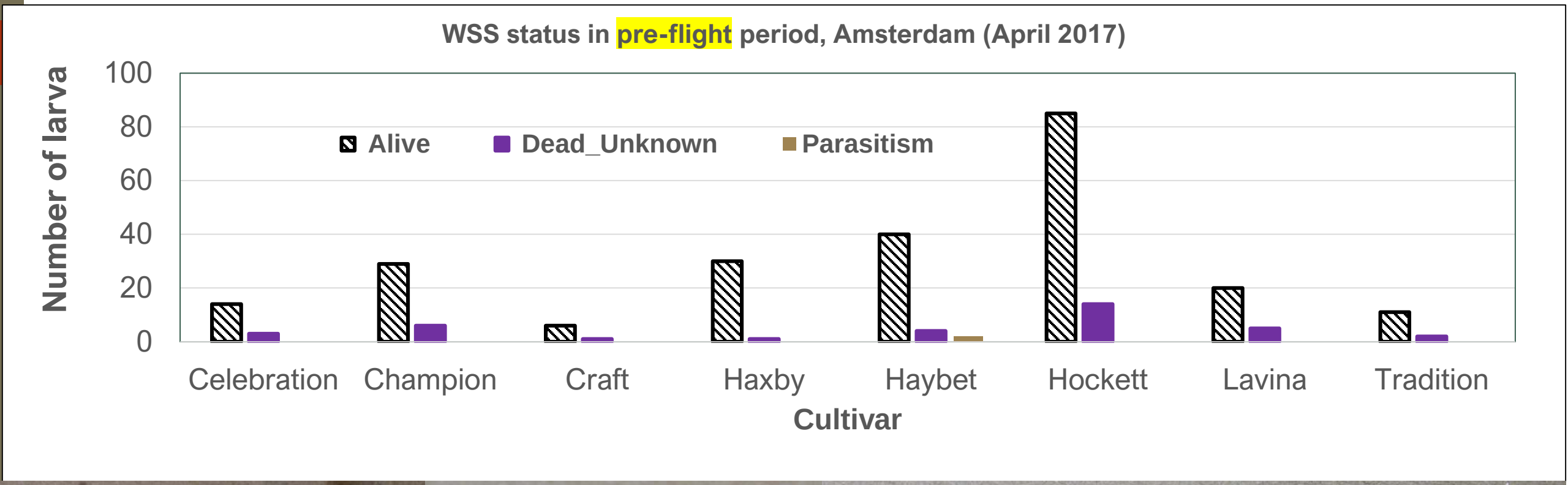
Unknown factor

Parasitoid

Plant factor

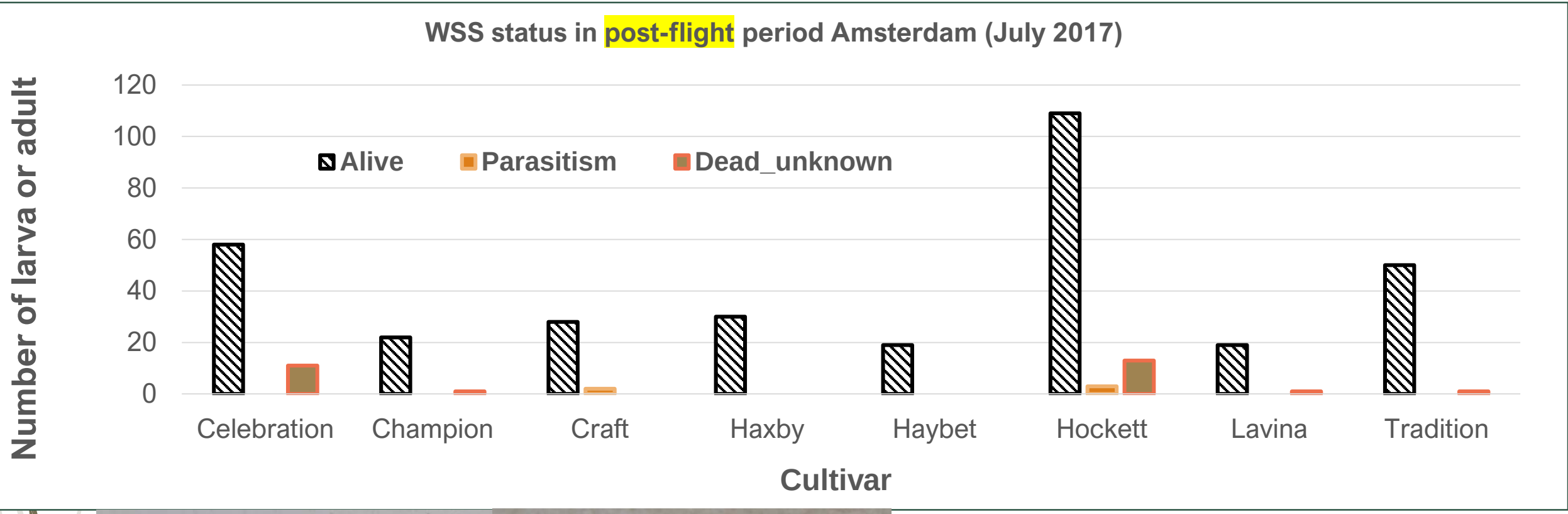


# 2.2 Post diapause larval status (from 2016 plots)






# Post flight period (July 2017)




# Summary: Estimation of age-specific mortality

- **Irreplaceable mortality** due to **plant factor(s)** was the greatest percent followed by unknown factor, cannibalism, and the parasitism in summer larvae

- Survival rate of overwintered WSS larvae and emergence of adults was the highest in **Hockett** and the lowest in **Craft.**

**Hypothesis**

Cultivars with greater host plant resistance receive fewer eggs, have greater larval mortality, and fewer cut stems.

# Works in progress

## Behavioral (antixenosis) study

i) Oviposition
ii) Y-tube olfactometer
iii) Volatile collection

## Molecular analysis of antibiosis

i) Tissue collected from infested and uninfested barley plants will be used for comparison.

Plant volatile collection

Infestation cages

# Acknowledgements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## Wheat stem sawfly lab members

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# Questions ?