

BC Cone and Seed Pest Research Program

Research and Knowledge
Management Branch Seminar Series

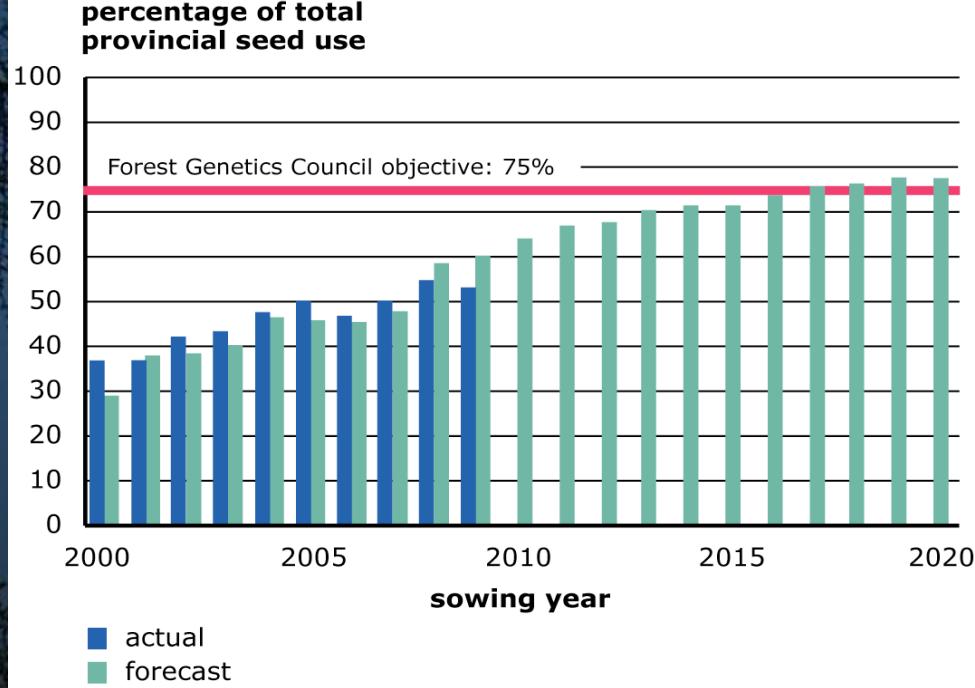
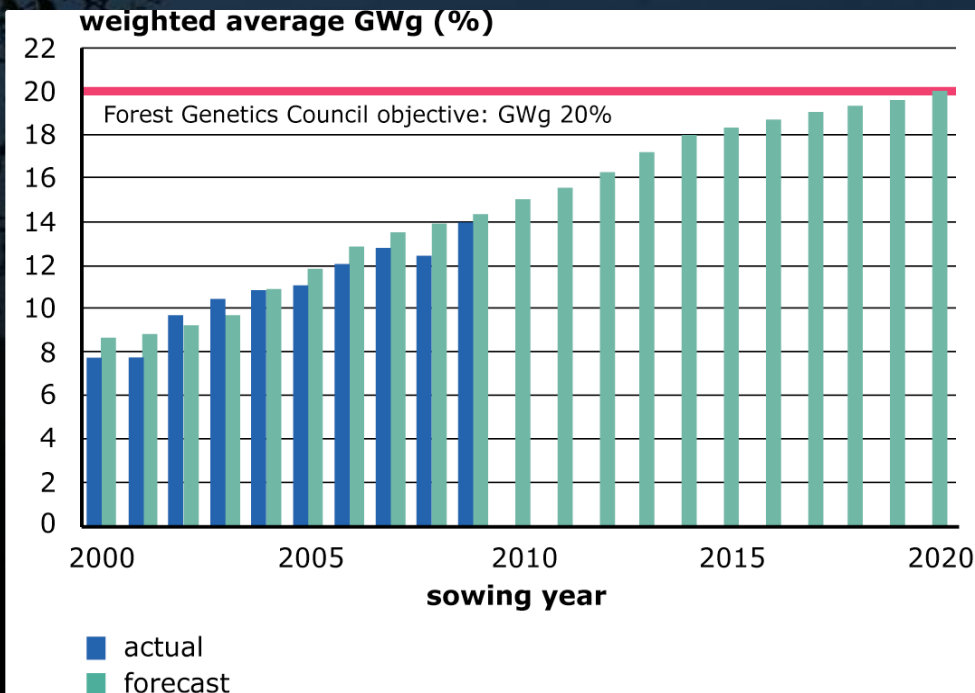
June 2, 2010

Ward Strong, Ph.D.
BC Ministry of Forests and Range

Conifer Seed Orchards in British Columbia



B.C. Seed Orchard Program Goals



Pests are a major limiting factor



Pests are a major limiting factor



Pests are a major limiting factor



Pests are a major limiting factor

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Pests are a major limiting factor



Pests are a major limiting factor



Pests are a major limiting factor





Cone and Seed Pest Management Group



- Two staff by 2002
- Increasingly complex pest issues
- Little knowledge of pest taxonomy, biology or ecology
- Few Integrated Pest Management programs in place

- No research mandate
- No way to develop new management protocols

2004: lost up to \$1M in spruce seed due to *Dioryctria abietivorella*



Research Program created in 2006

- Based at Kalamalka Forestry Centre, Research Branch
- Funding through FIA and Forest Genetics Council: PM-TAC
- Designed to address background questions of pest biology and ecology
- Management solutions are the long-term goal, not short-term result

Major Research Areas

- **Pesticide trials:** testing novel insecticides
- **Adelgids:** species composition and life history
- ***Dioryctria*:** life history and reproductive biology
- ***Leptoglossus*:** mark-release-recapture; communication and host-finding
- ***Contarinia*:** Pheromone mass production system; density/damage relationship
- **Other pests:** *Synthedon*, *Eucosma*, *Megastigmus*, Western Gall Rust

Dioryctria studies

Partners: University of Alberta,
University of California, Canadian Forest Service

Goals:

- Species complex identification
- Monitoring methods
- Life history
- Flight Phenology
- Reproductive behaviour



Species Identification

- 86 Pyralid adults reared from conifer cones
 - 100% *Dioryctria abietivorella*
- Identified to species by Amanda Roe, U. of Alberta



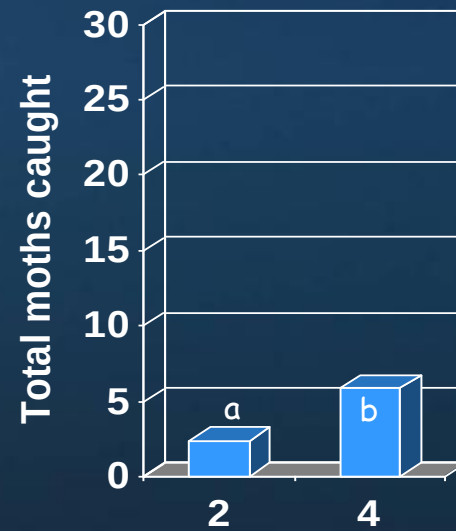
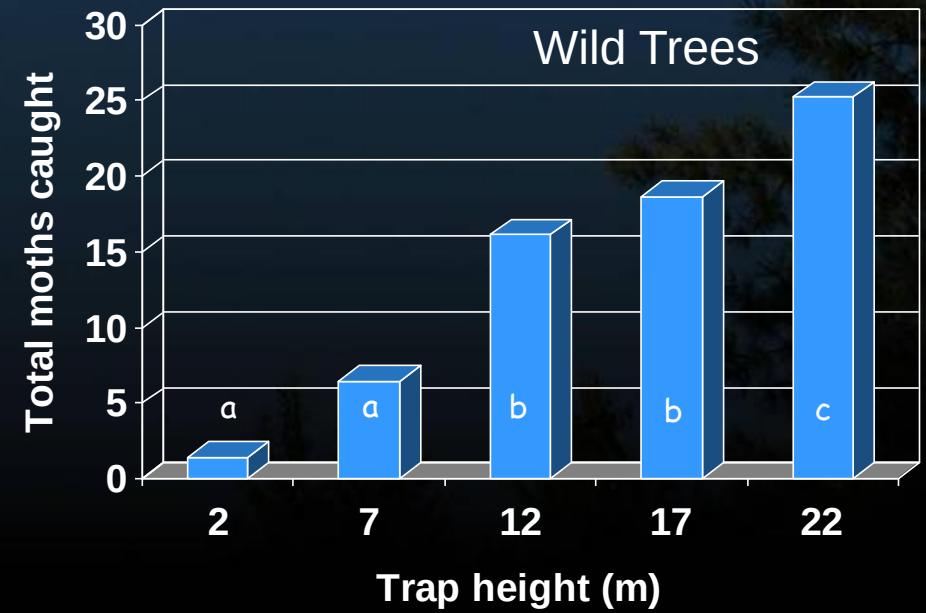
Monitoring Methods

- Pheromone development

Cooperator: Jocelyn Millar lab, University of California Riverside



Trap height

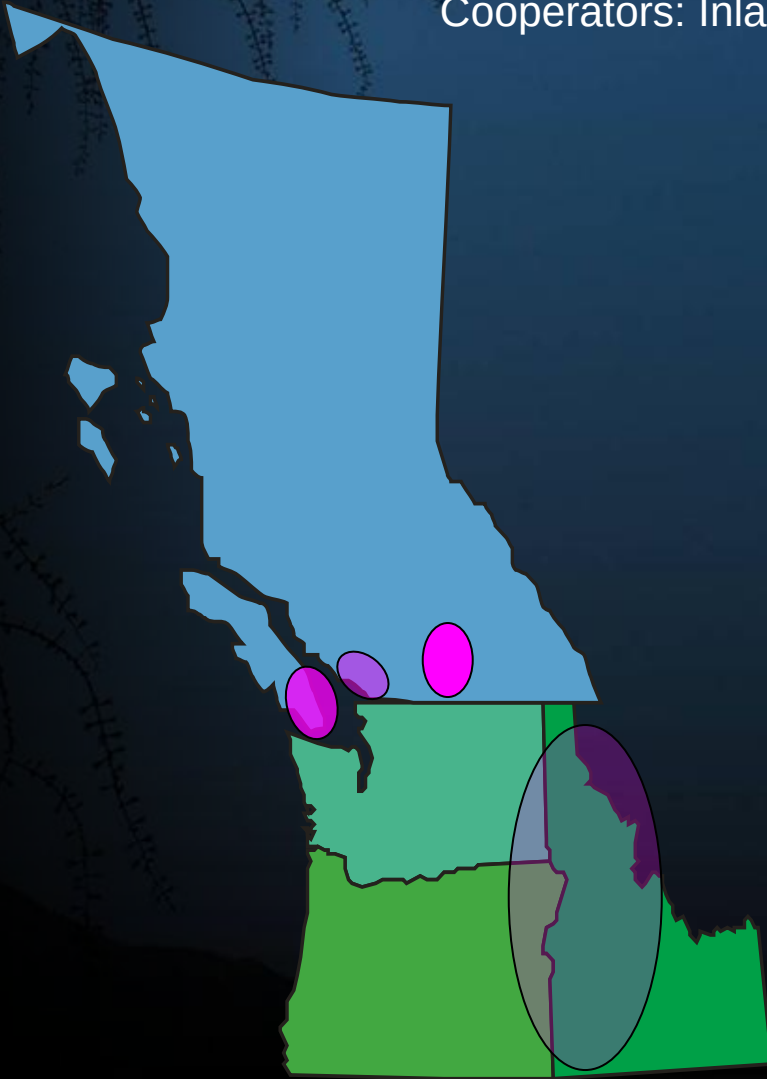


Broad-scale flight phenology

Cooperators: Inland Empire Tree Improvement Cooperative

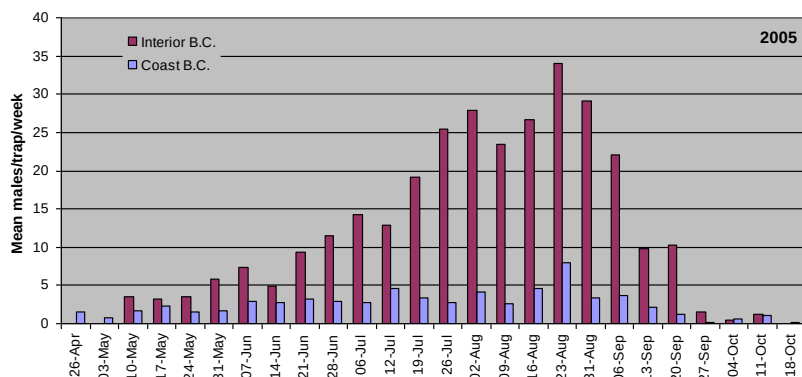
Objectives:

- Determine flight period of *Dioryctria*
- Identify number and duration of generations
- Find out if local or regional differences exist

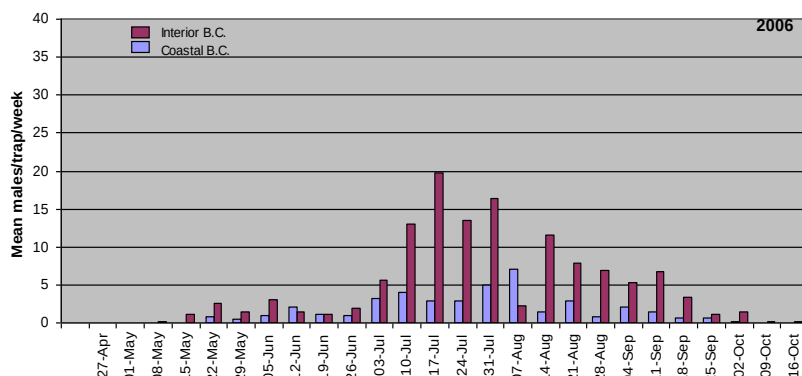


BC Interior and Coast

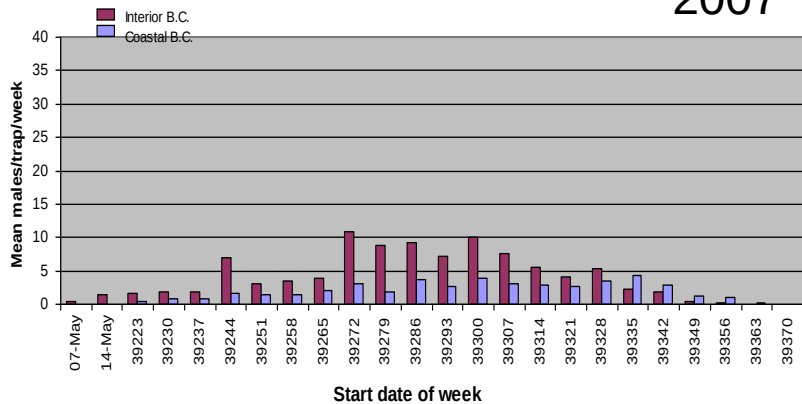
2005



2006

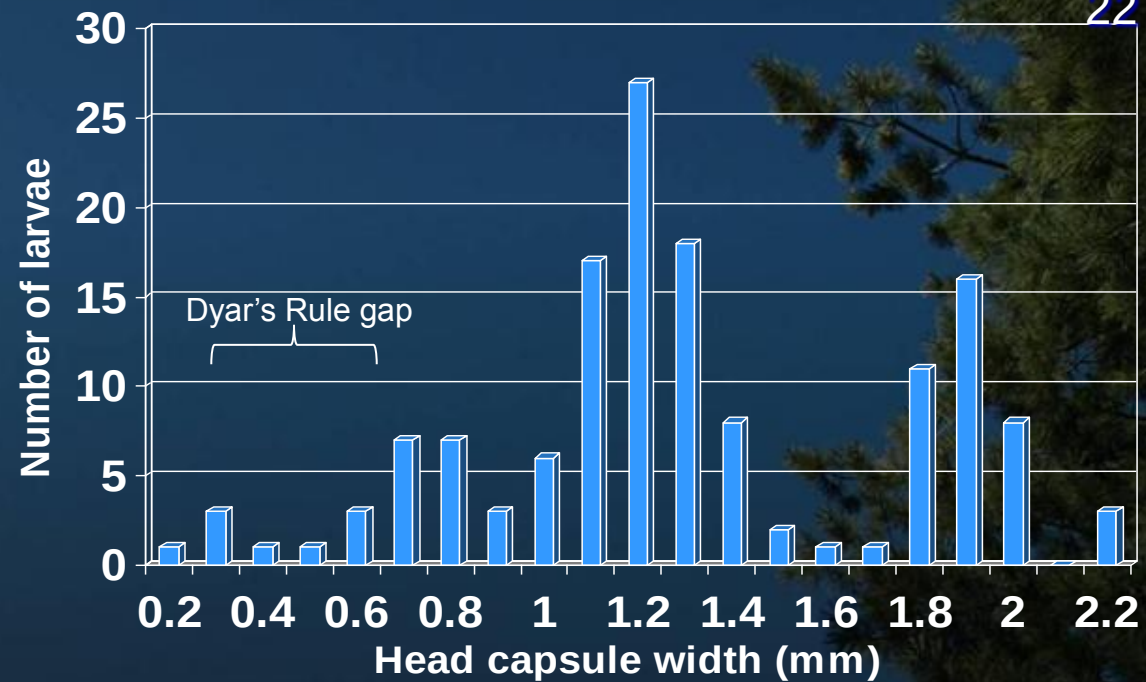
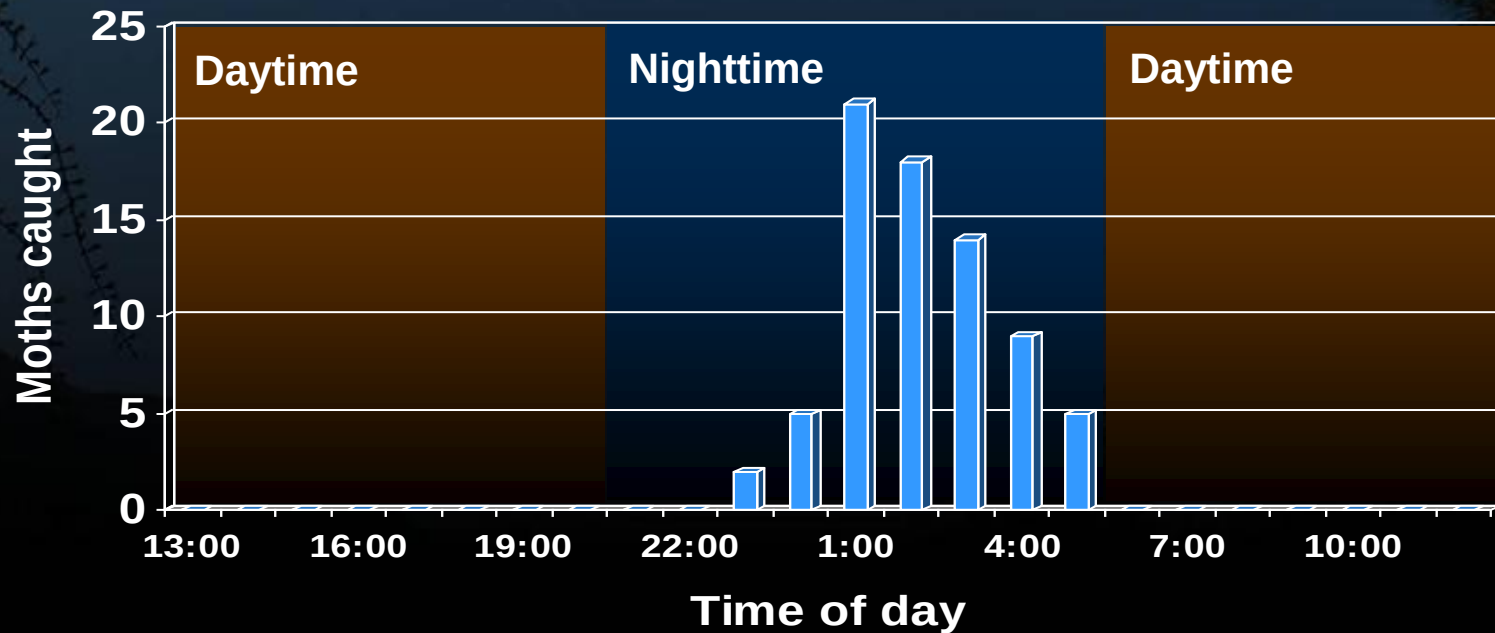


2007



Life History

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Current *Dioryctria* program

- Maya Evenden & Caroline Whitehouse at University of Alberta
- Focus on biology and reproductive behaviour:
 - Where in nature are eggs laid?
 - At what stage and where do they overwinter?
 - Are females active all summer?
 - What is their reproductive behaviour?
(can pheromones be used for control?)

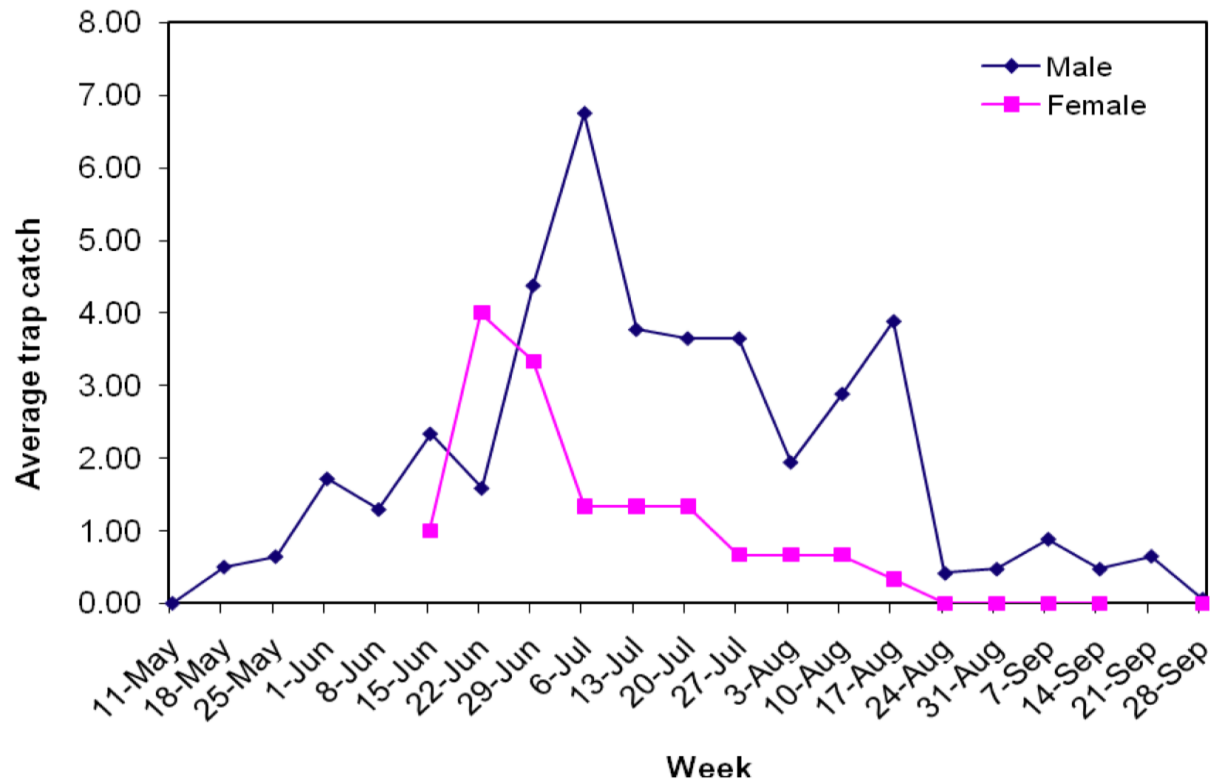


Current *Dioryctria* program

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 - ~~Where in nature are eggs laid?~~
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Dioryctria light trapping



Mating frequency



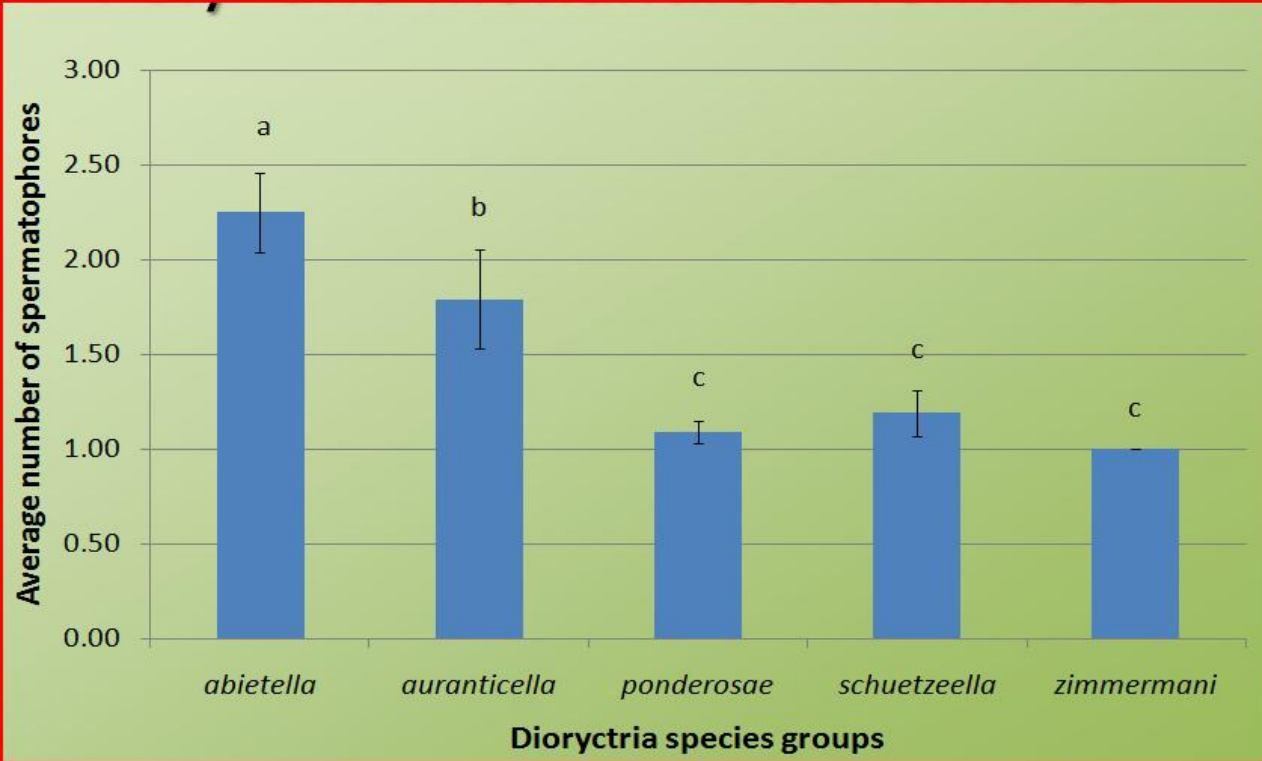
Bursa copulatrix



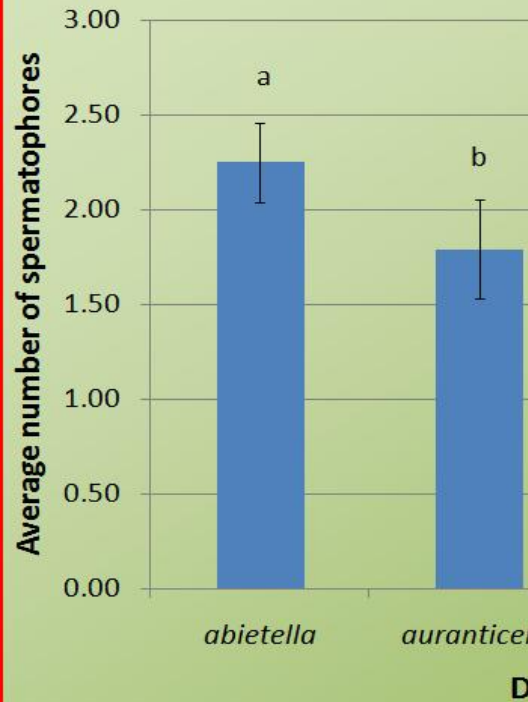
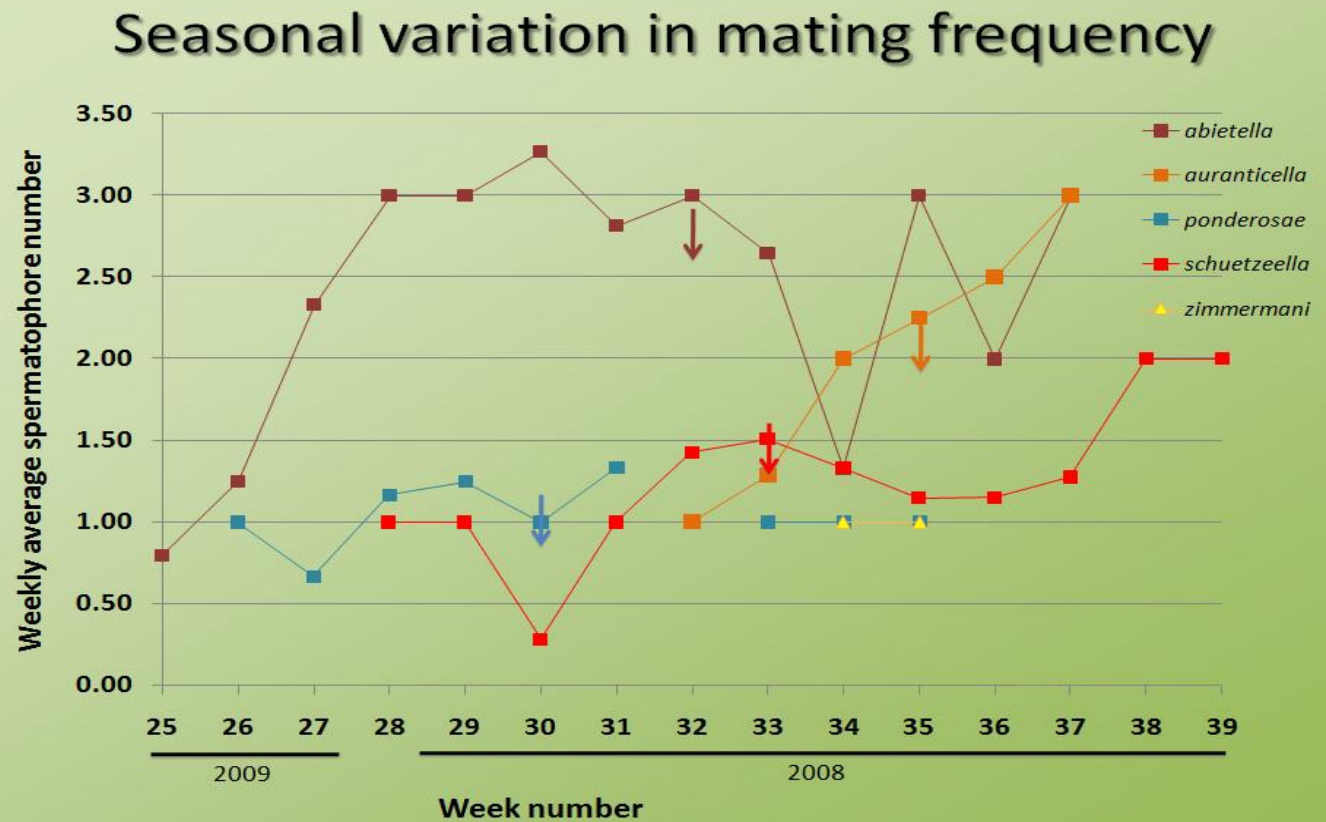
Photos: Caroline Whitehouse

Ductus bursae

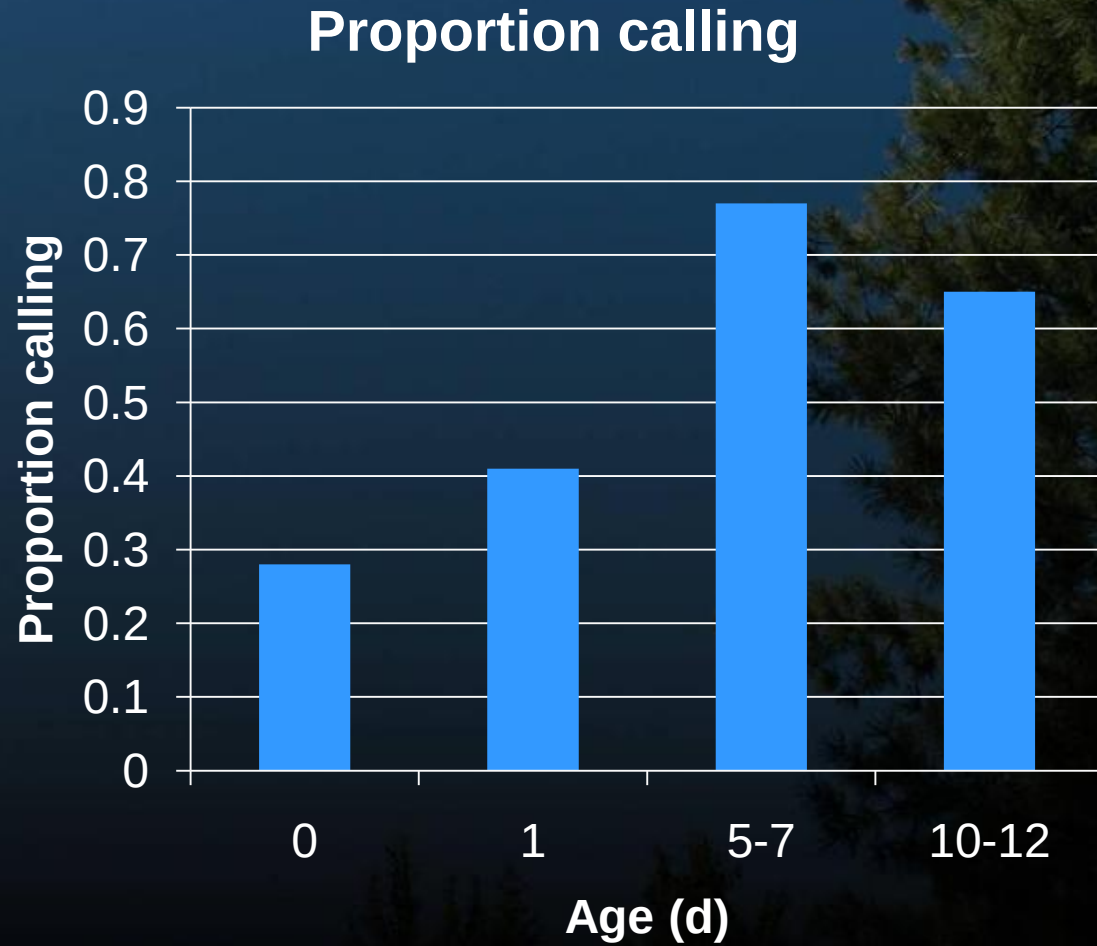
Mating frequency



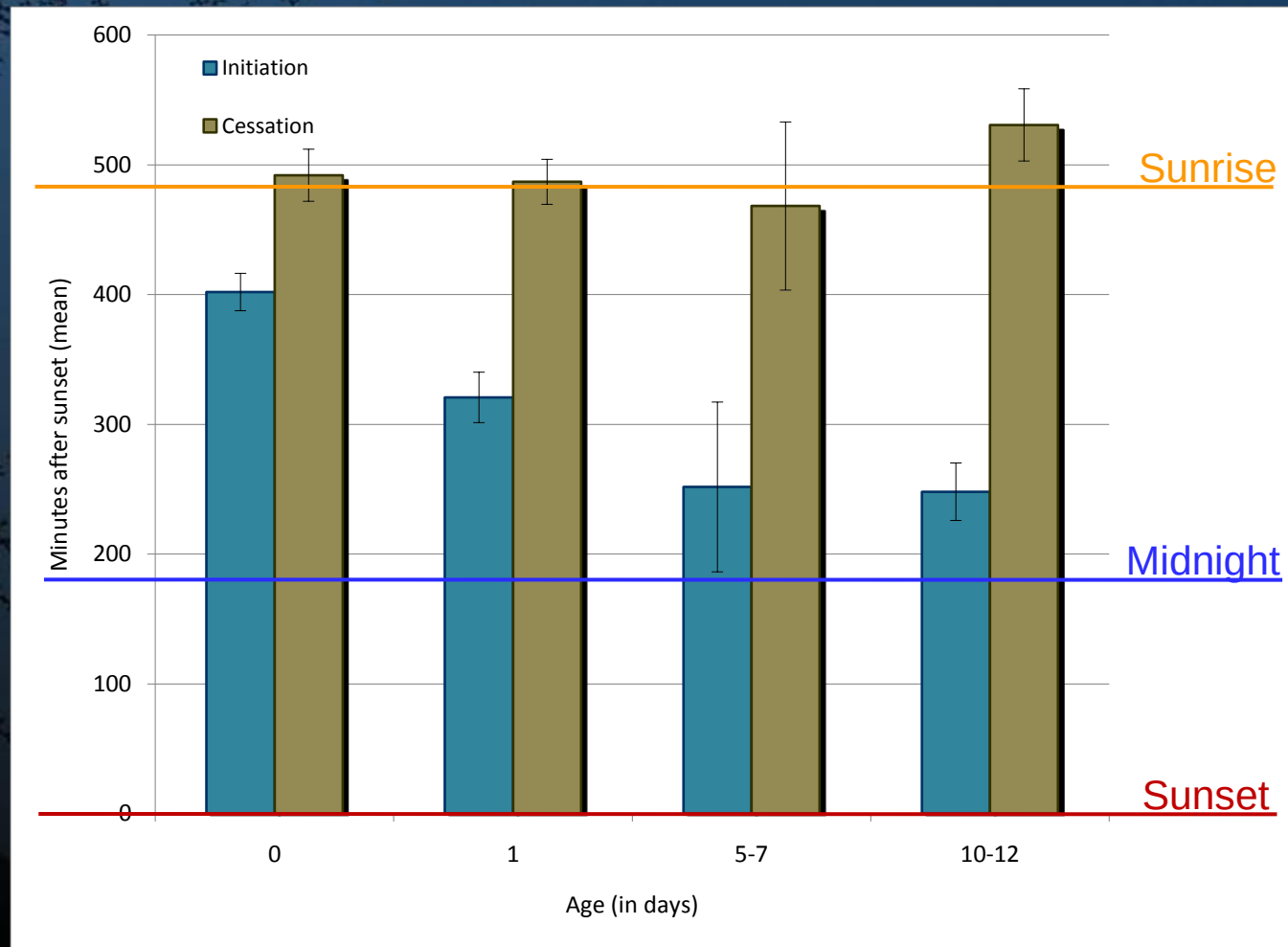
Mating frequency



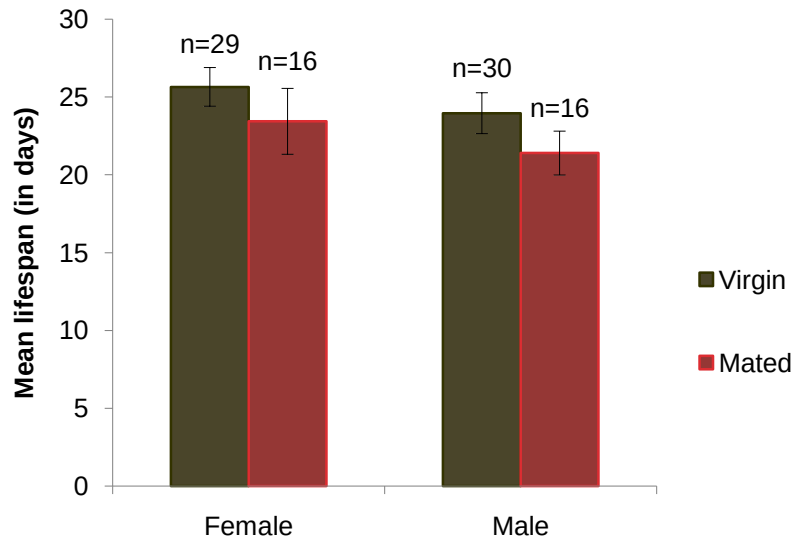
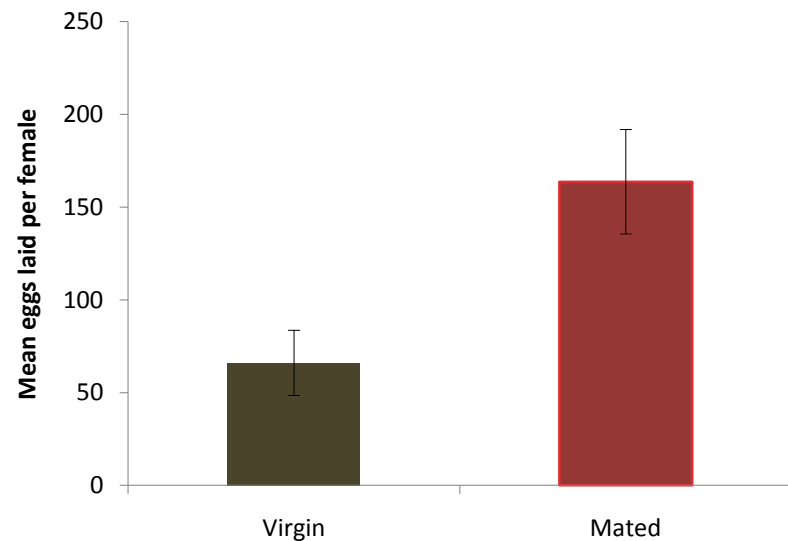
Calling behaviour



Calling behaviour



Longevity & oviposition



Future directions in Dioryctria research

- Pheromone-based control
 - Attract & Kill
 - Mating Disruption
- Host volatile influences on reproductive behaviour
- mDNA-based taxonomic studies



Leptoglossus occidentalis: Mark-release-recapture

Used to track movement, determine aggregation,
and calculate absolute population density



Photo: Steve Takacs

Determine marking method



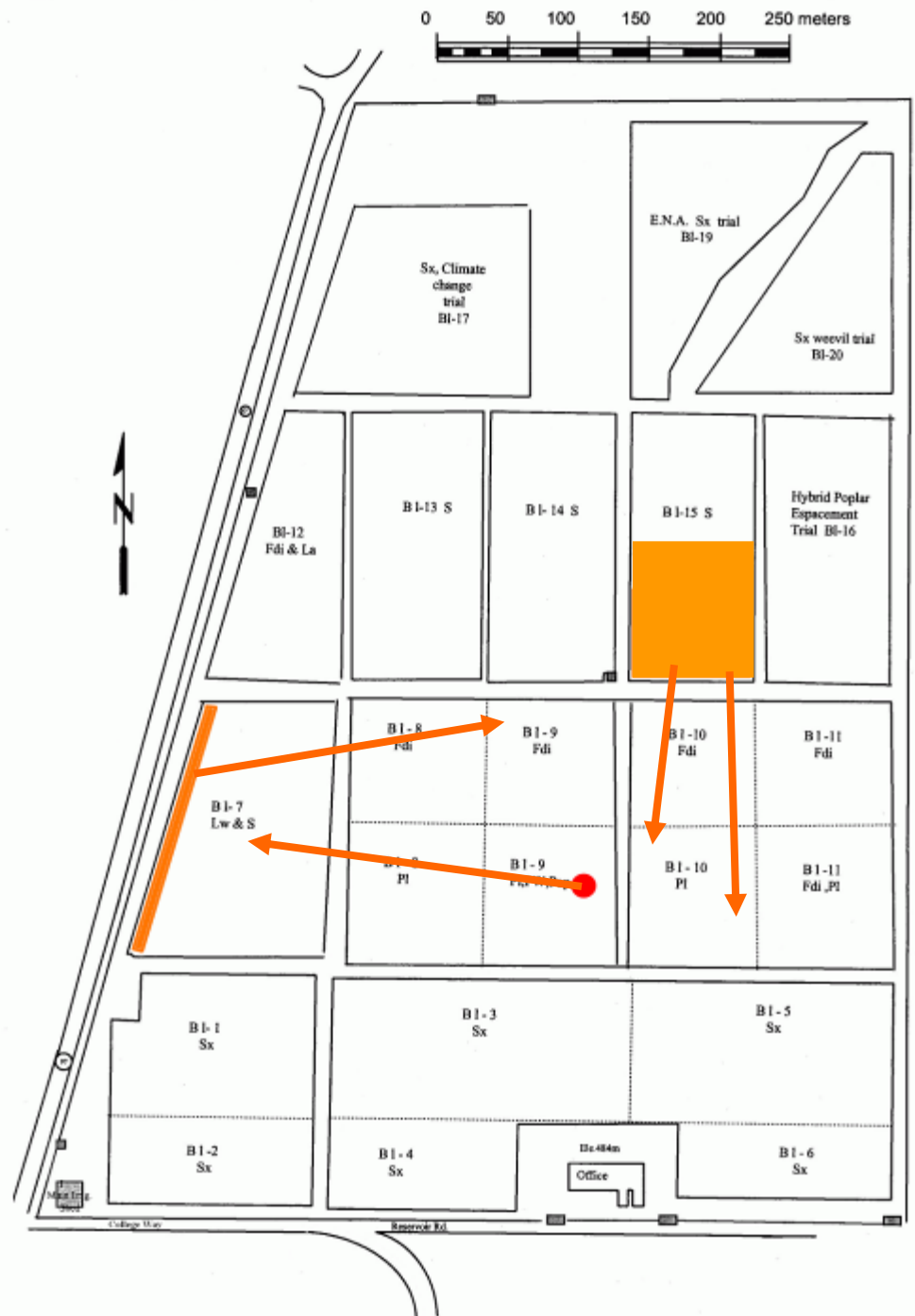
Determine marking method



Create release/recapture protocols

Preliminary Data Collection: 2006

- ~2600 marked bugs released
- 187 recaptured
- 20 recaptured twice or more
- maximum dispersal >200 m



Collaborative project started

Partners: Sylvie DesJardins lab, UBC-Okanagan
Staffan Lindgren lab, UNBC
Graduate student Tamara Richardson

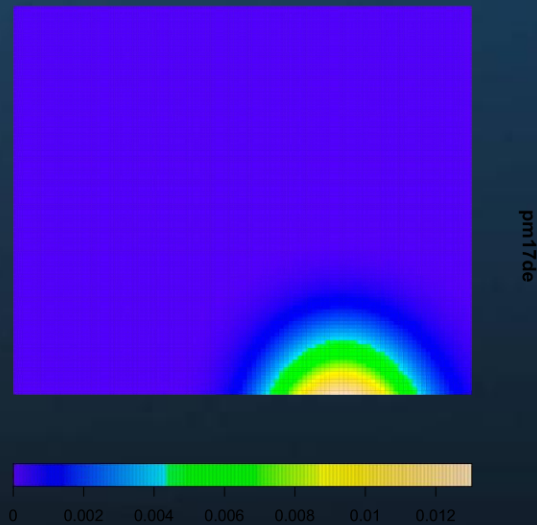


Orchard invasion & edge effects



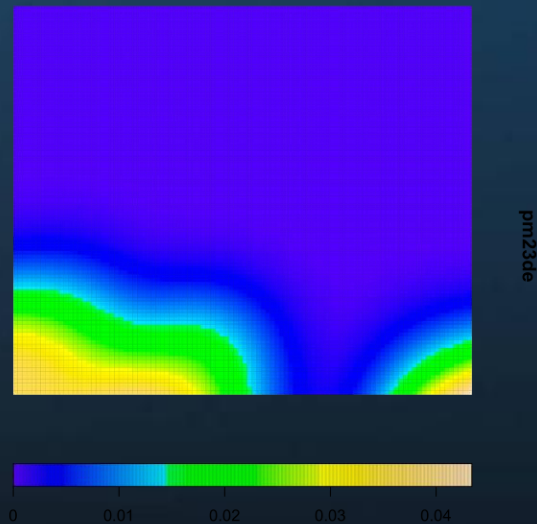
Orchard invasion & edge effects

Orchard 307



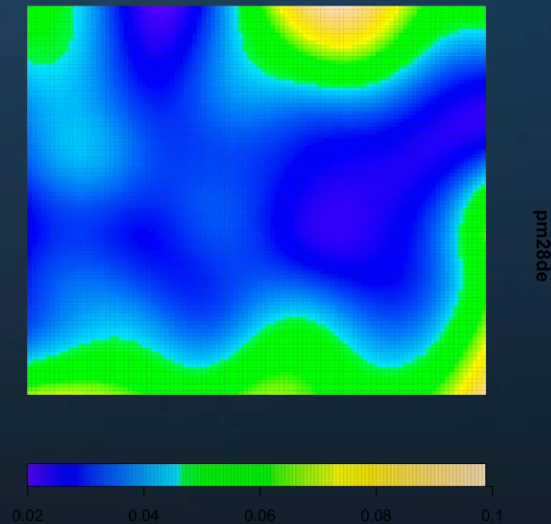
Orchard invasion & edge effects

Orchard 307



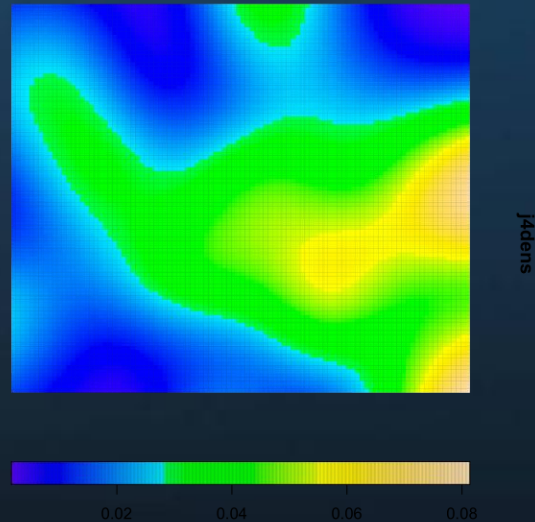
Orchard invasion & edge effects

Orchard 307



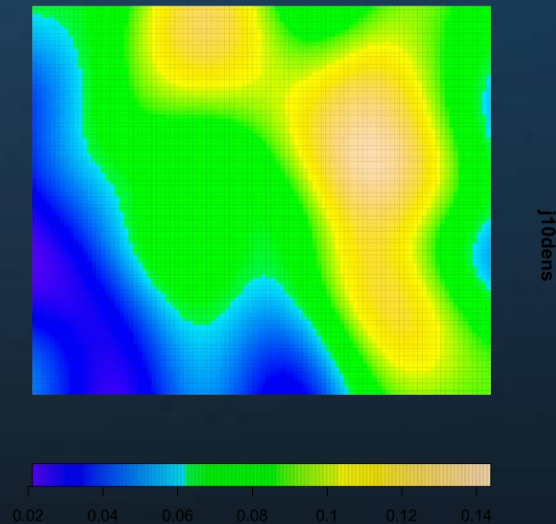
Orchard invasion & edge effects

Orchard 307



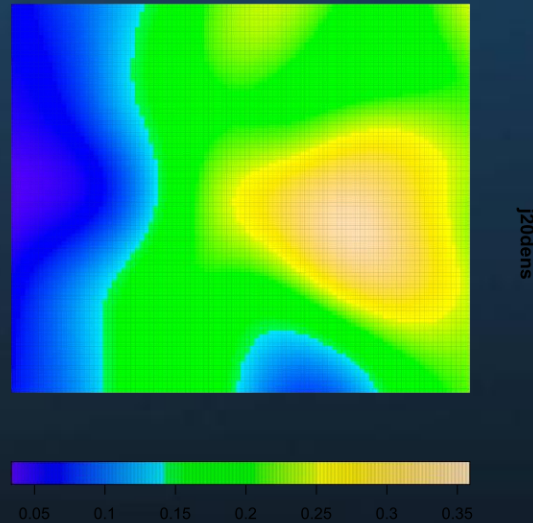
Orchard invasion & edge effects

Orchard 307



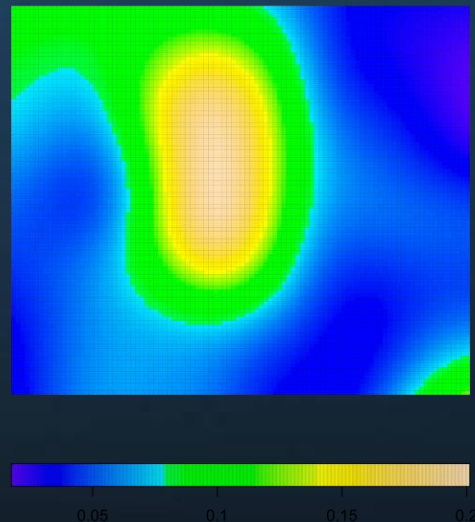
Orchard invasion & edge effects

Orchard 307



Orchard invasion & edge effects

Orchard 307



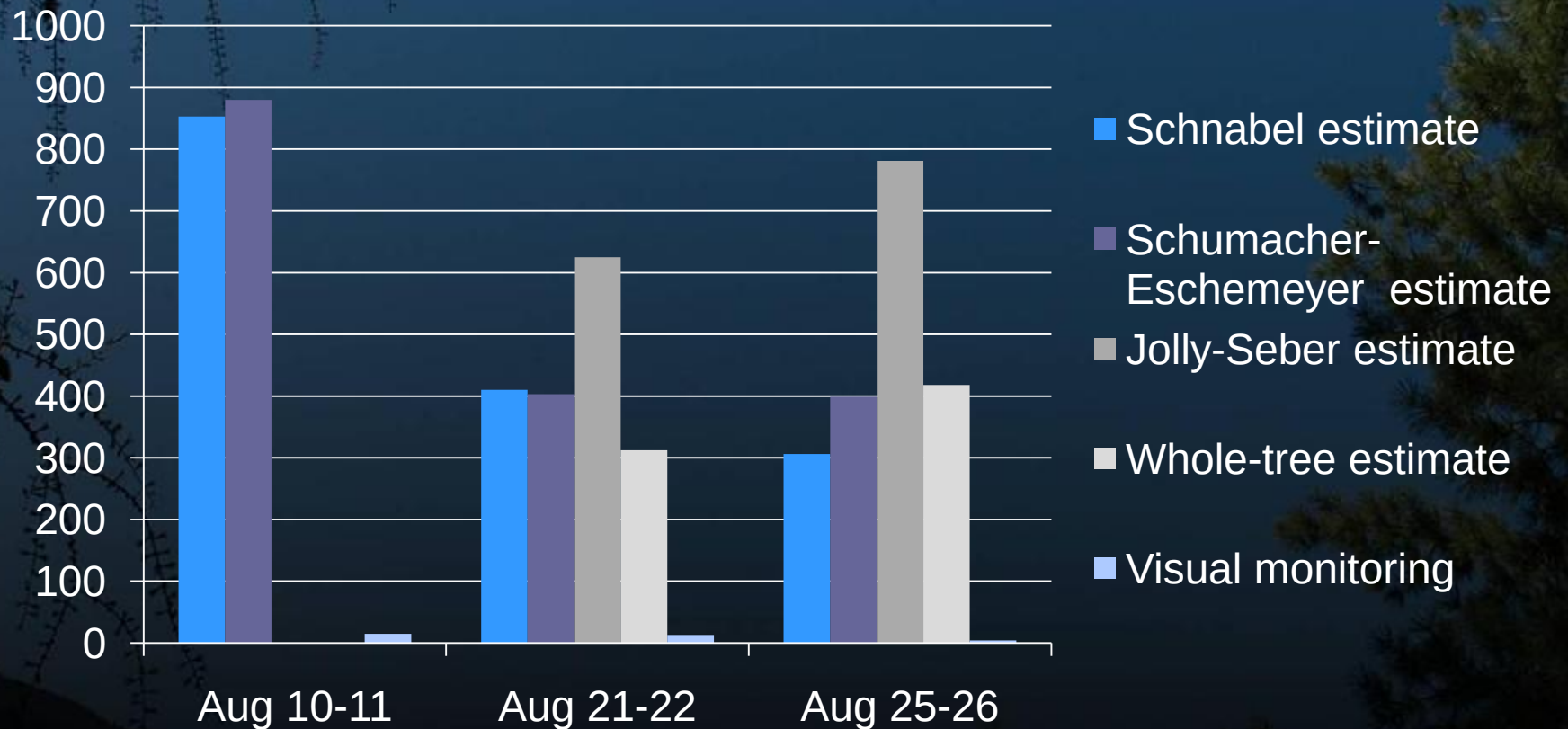
- Early-spring edge effect dissipates rapidly
- Densities shift unpredictably

Absolute Population Density

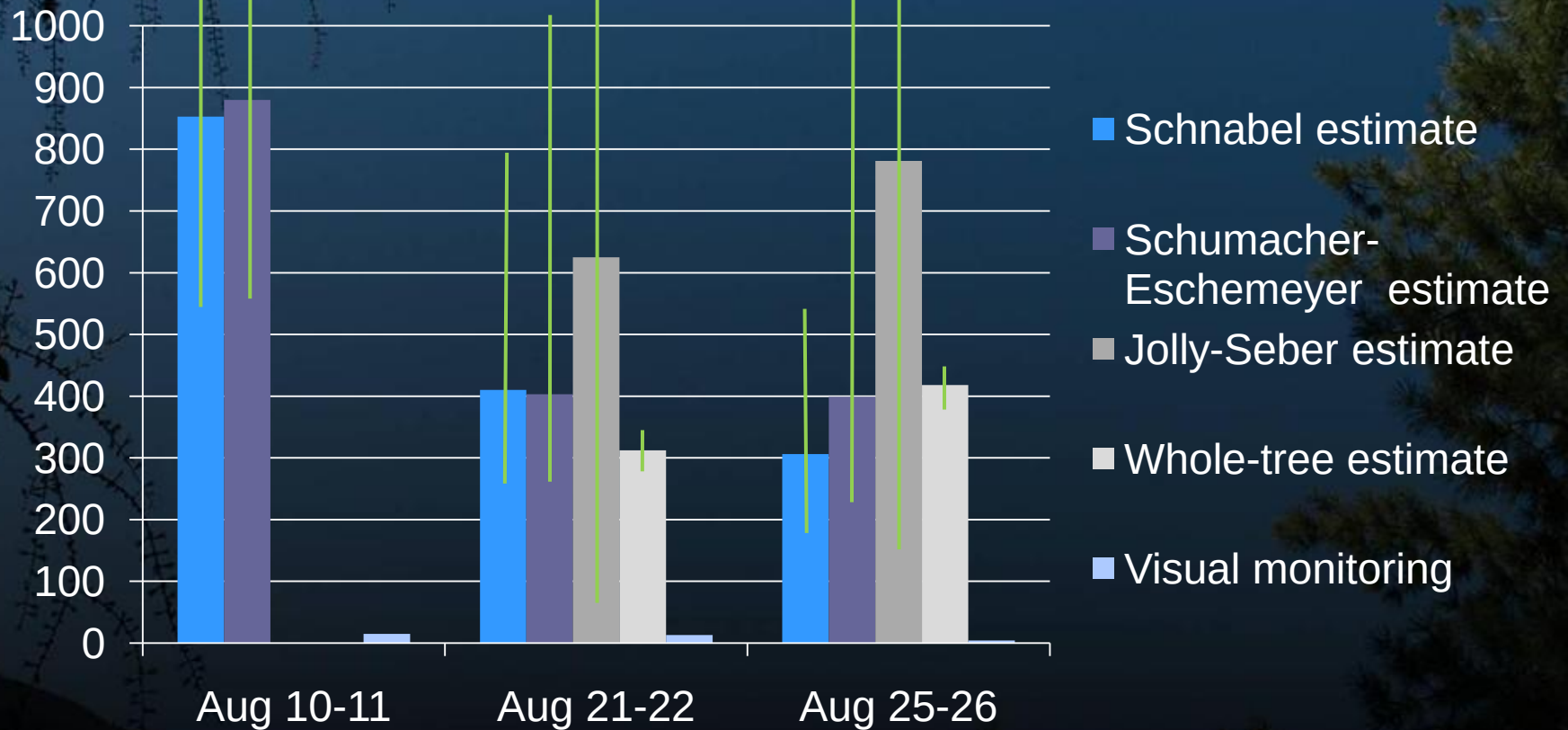
- Relate visual monitoring to actual population
- Calculate an economic threshold
- Use threshold for spray recommendations



Absolute Population Density

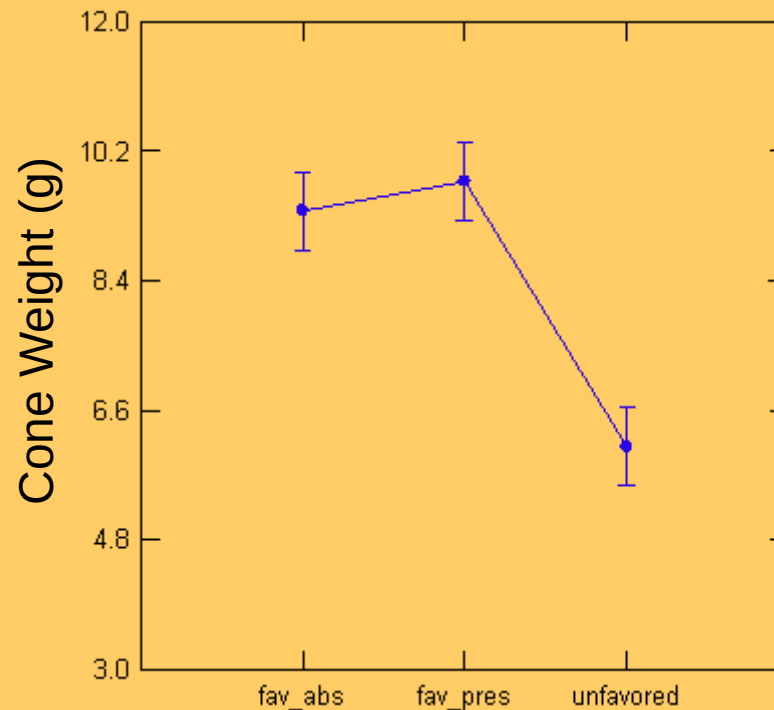


Absolute Population Density

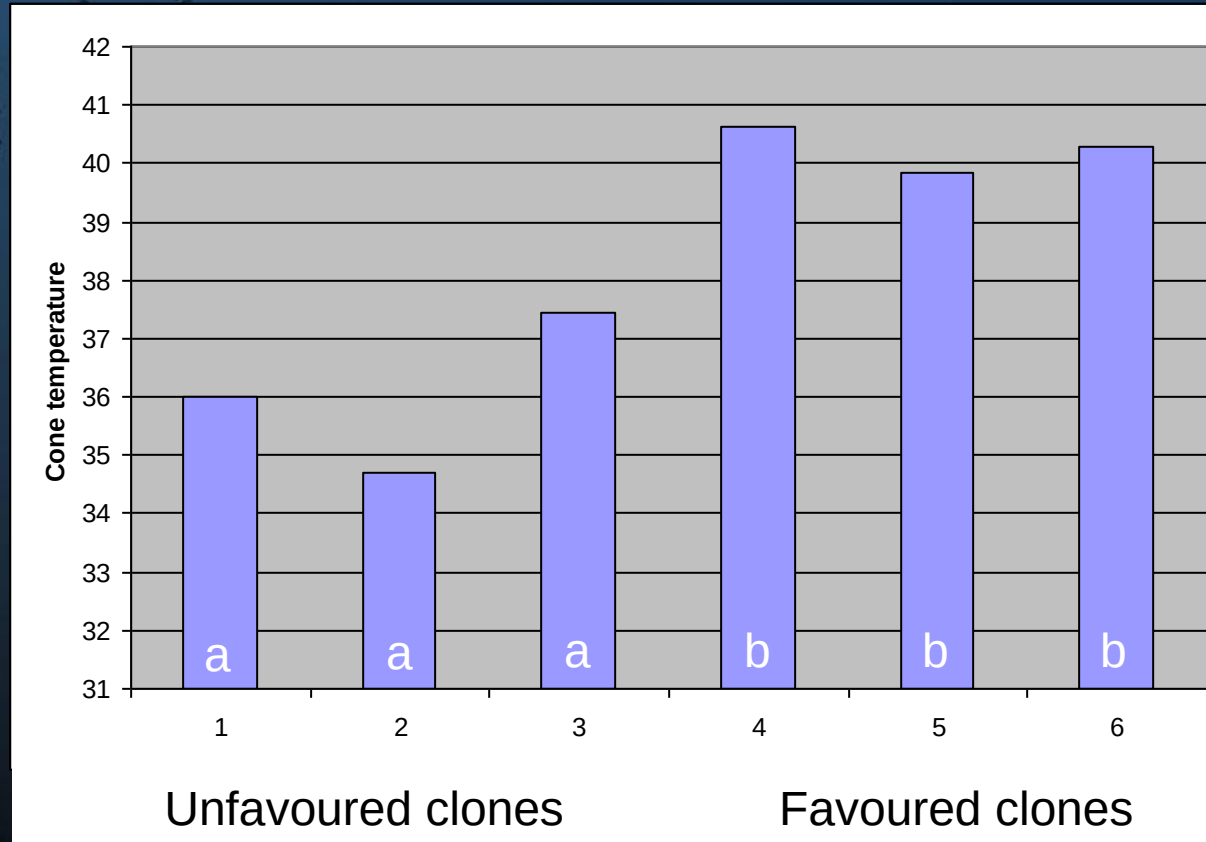


Leptoglossus Prefer Certain Clones

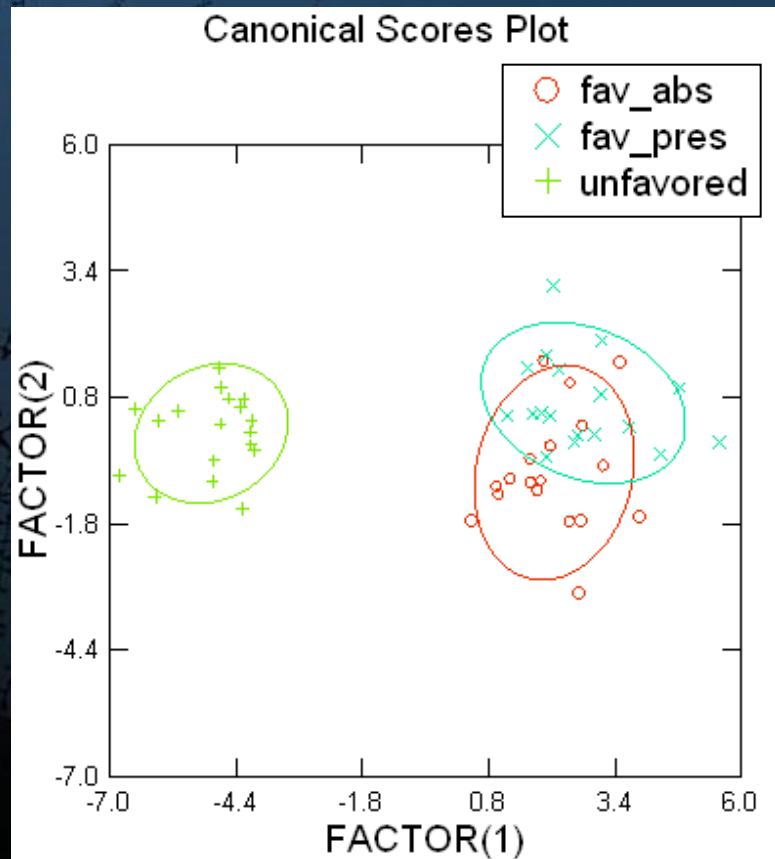
- 86% of captured insects were found on 10% of the clones
- Examined cones from least favoured and most favoured clones
- Looked at cone size & weight, terpene profiles, and temperature



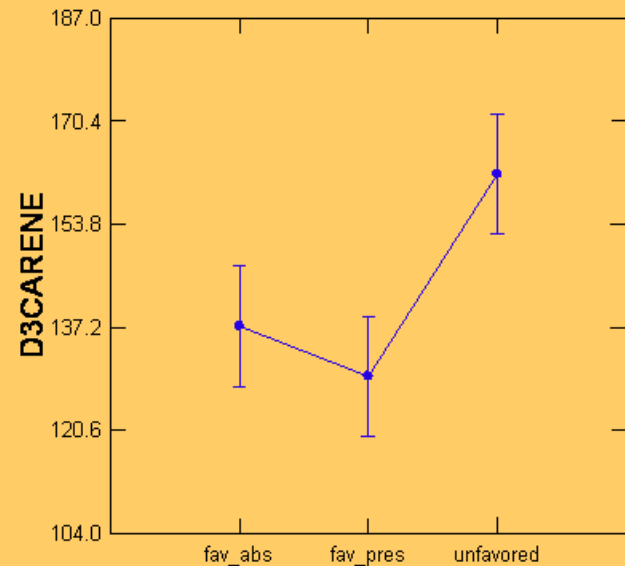
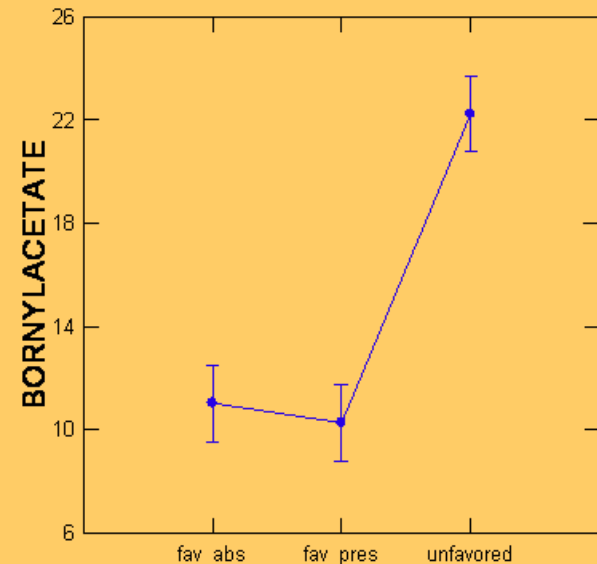
Cone temperature is higher for Favoured clones



Cone Terpene profiles: Favoured vs. Unfavoured Clones



Classical discriminant analysis



Leptoglossus Population Simulation Model

Partners: Sylvie DesJardins and
Natasha Mandryk, UBC-Okanagan

Objectives:

- To create a simulation model that will predict population densities and seed loss.
- To conduct a sensitivity analysis to determine which parameters have the most influence on model outcomes
- To test different management regimes to determine optimal management practices.

Leptoglossus Population Simulation Model

Model structure

- Approach based on insect stage
- Accounts for different feeding rates at different stages
- Matrices distribute probability of stage transition over time
- Tracks progression of a population

Model parameters

- Stage-specific survival rates
- Invasion rate: spring and after spray event
- Insect stage duration
- sex ratio
- Parameterized through the literature and field experience

Leptoglossus Population Simulation Model

$$E_i = \sum_{j=1}^n f_{ij} \cdot A_j \cdot \alpha_A^{i-j}$$

$$A_i = \frac{\lambda^i e^{-\lambda}}{i!} \cdot s$$

$$\tilde{E}_i = \sum_{k=0}^{i-1} \alpha_{E_1}^{i-k} \left(N_k^{(1)} - N_k^{(2)} \right)$$

$$N_i^{(1)} = \sum_{j=1}^n K_{ij} \cdot E_j \cdot \alpha_B^{i-j}$$

$$\tilde{B}_i = \sum_{k=1}^i \alpha_B^{i-k} B_k$$

$$B_i = \sum_{j=1}^n K_{ij} \cdot E_j \cdot \alpha_B^{i-j}$$

$$\tilde{N}_i^{(1)} = \alpha_{N_1}^{i-1} N_1^{(1)} + \sum_{k=2}^i \alpha_{N_1}^{i-k} \left(N_k^{(1)} - N_{i-k}^{(1)} \right)$$

$$A_i = s \left(\frac{\lambda^i e^{-\lambda}}{i!} + k \right)$$

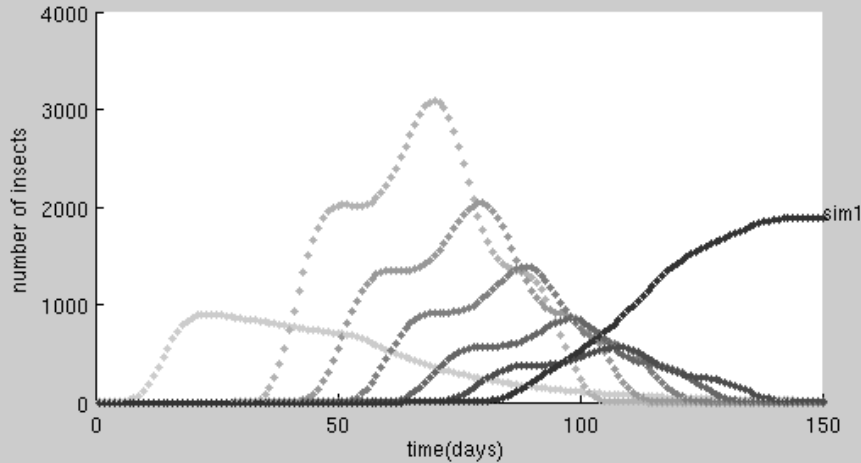
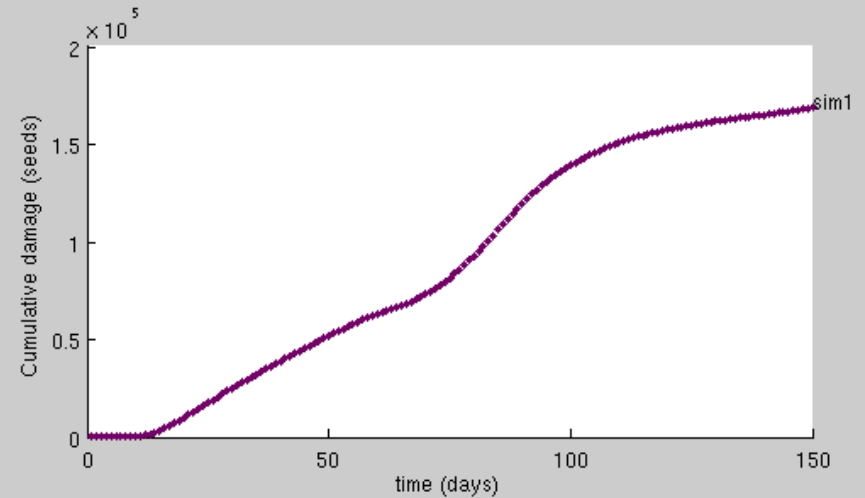
$$B_i = \sum_{j=1}^n K_{ij} \cdot N_j^{(5)} \cdot \alpha_{N^{(5)}}^{i-j}$$

$$\tilde{A}_i = \sum_{k=0}^i \alpha_A^k \cdot A_{i-k}$$

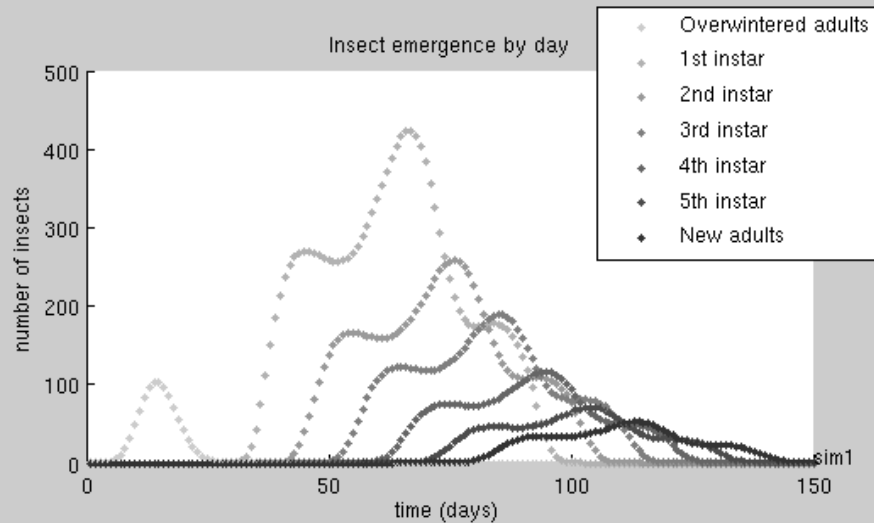
$$N_i^{(t)} = \sum_{j=1}^n K_N[i, j] \cdot N_j^{(t-1)} \alpha_{N^{(t-1)}}^{(i-j)}$$

Leptoglossus Population Simulation Model

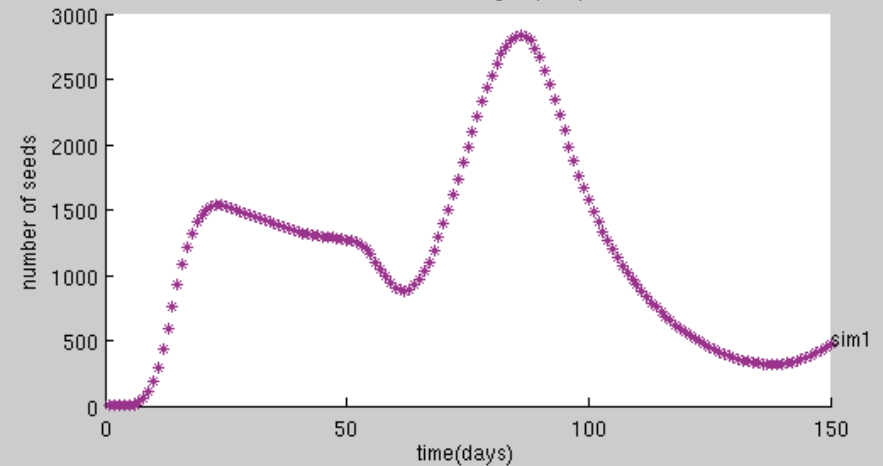
Insect survival by day



Insect emergence by day



New seed damage by day

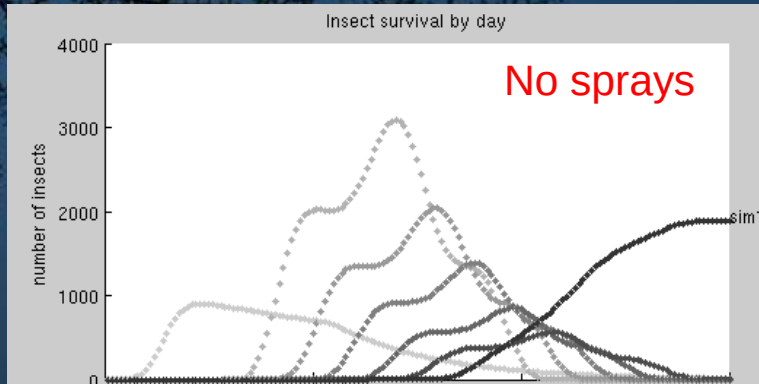


Simulation Model Sensitivity Analysis

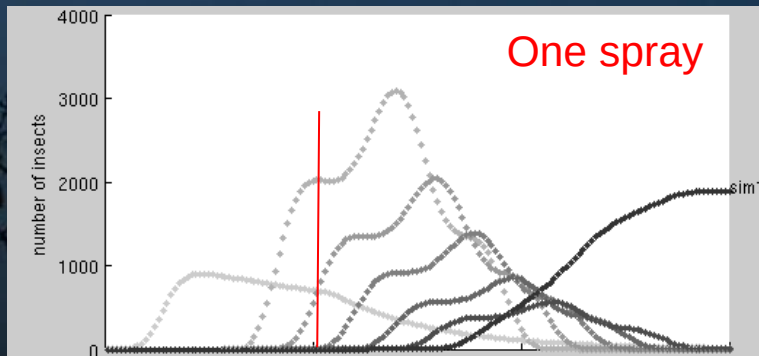
Most sensitive parameters

Parameter being varied	SI-1 (Hanson)	SI-2 (Strong)
1st instar survival	0.32	0.28
egg stage survival	0.27	0.21
Overwintered adult survival	0.26	0.22
2nd instar survival	0.11	0.10

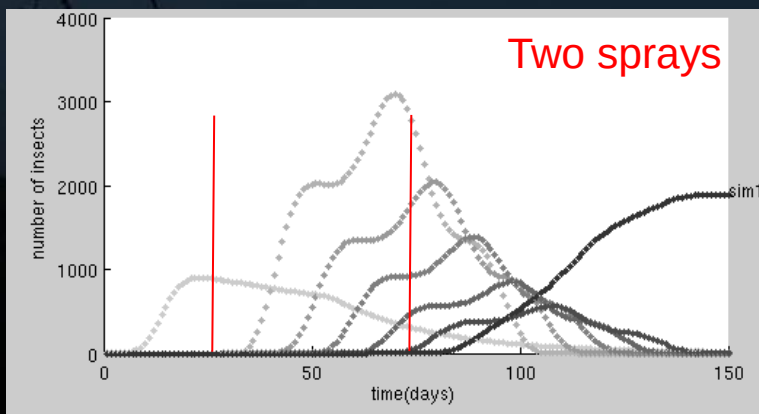
Simulation Model Spray Simulations



Cumulative Damage: 71,000 seeds



Cumulative Damage: 31,000 seeds



Cumulative Damage: 23,000 seeds

Current and future directions

- Determine motivation for movement within and between orchards, and whether it changes through the season
- Develop an economic threshold for spraying
- Continue investigating why certain clones are preferred
- Finalize the model and use it to simulate management activities.



Leptoglossus occidentalis: Communication and host finding

Partners: Gerhard Gries lab, SFU

Goals: to understand attraction to each other and to food source

- Sound production and detection
- Visual host finding



Sound production in *Leptoglossus*

60

Recording substrate-borne sound



Photo: Steve Takacs

Sound production in *Leptoglossus*

61

Recording substrate-borne sound

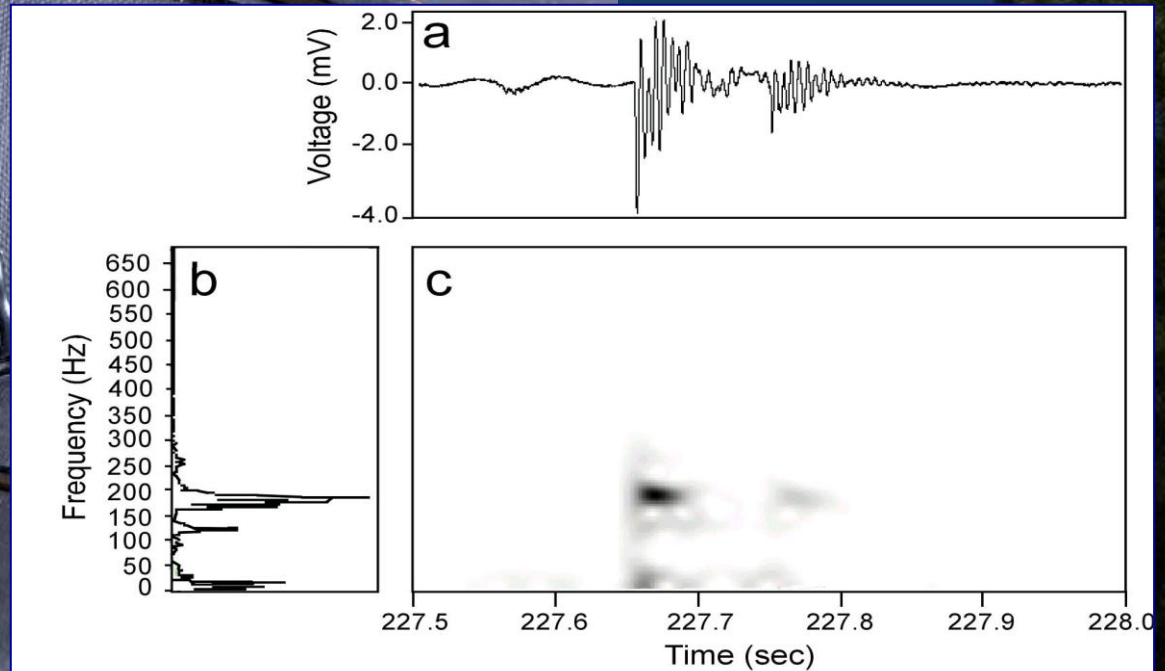


Photo: Steve Takacs

Sound production in *Leptoglossus*

62

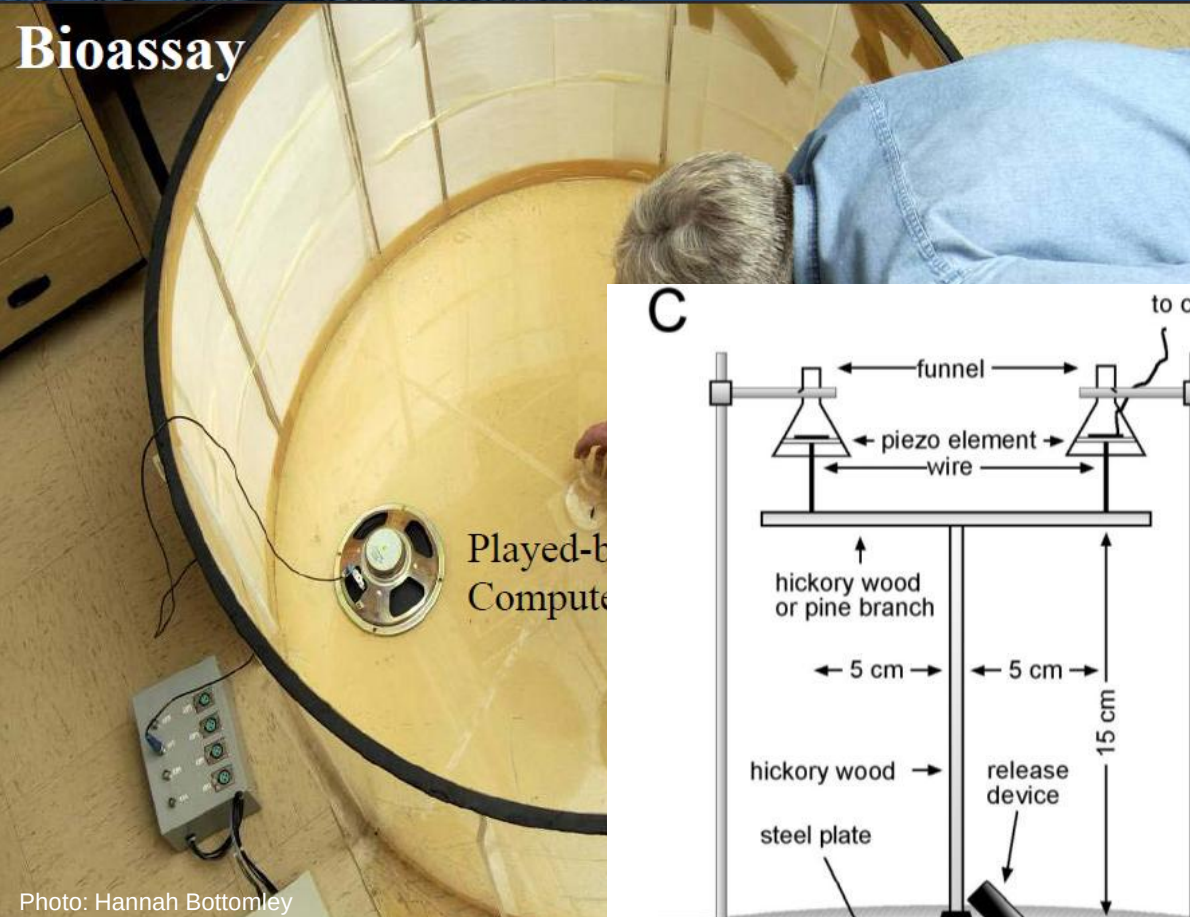
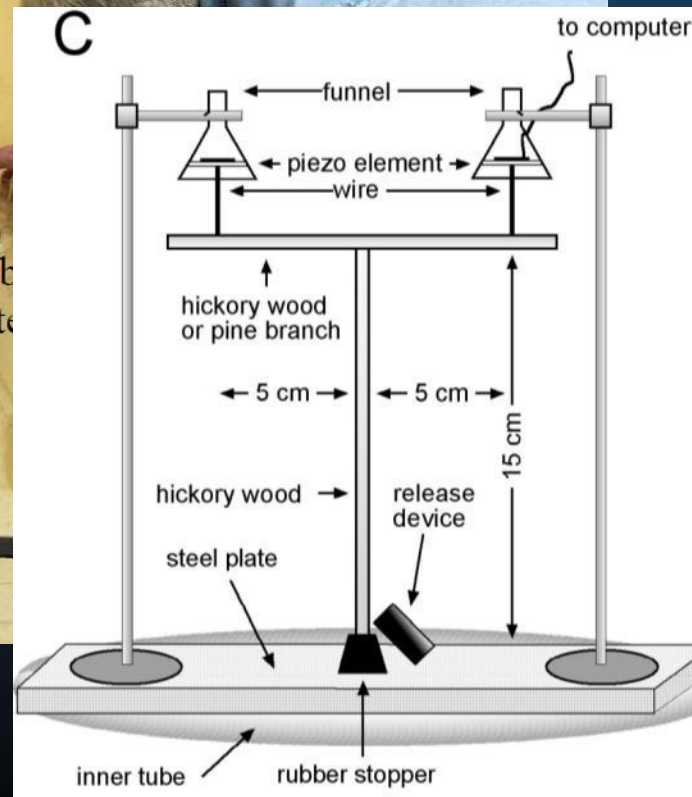
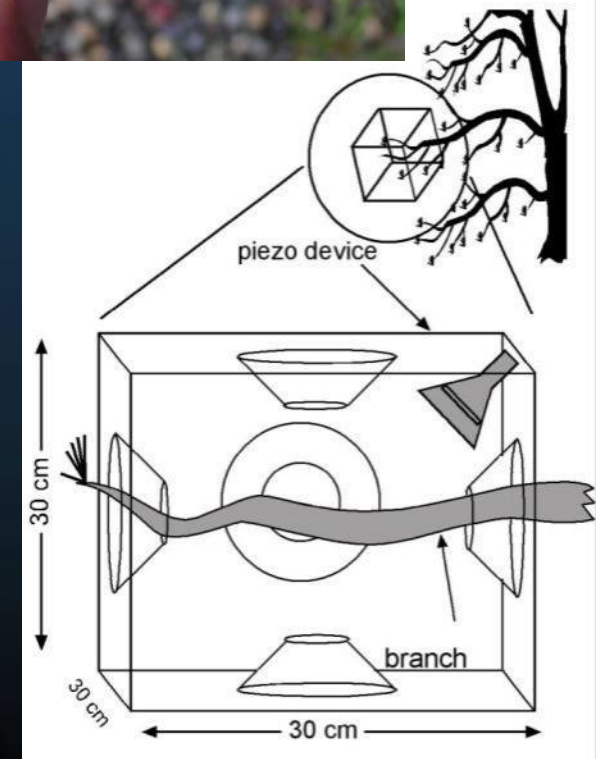
Bioassay



Sound production in *Leptoglossus*

63

Bioassay



Infrared Radiation Detection in *Leptoglossus*

- Cones heat up more than surrounding foliage
- Hot bodies emit more Infrared Radiation (IR)



Photo: Steve Takacs

Infrared Radiation Detection in *Leptoglossus*

65

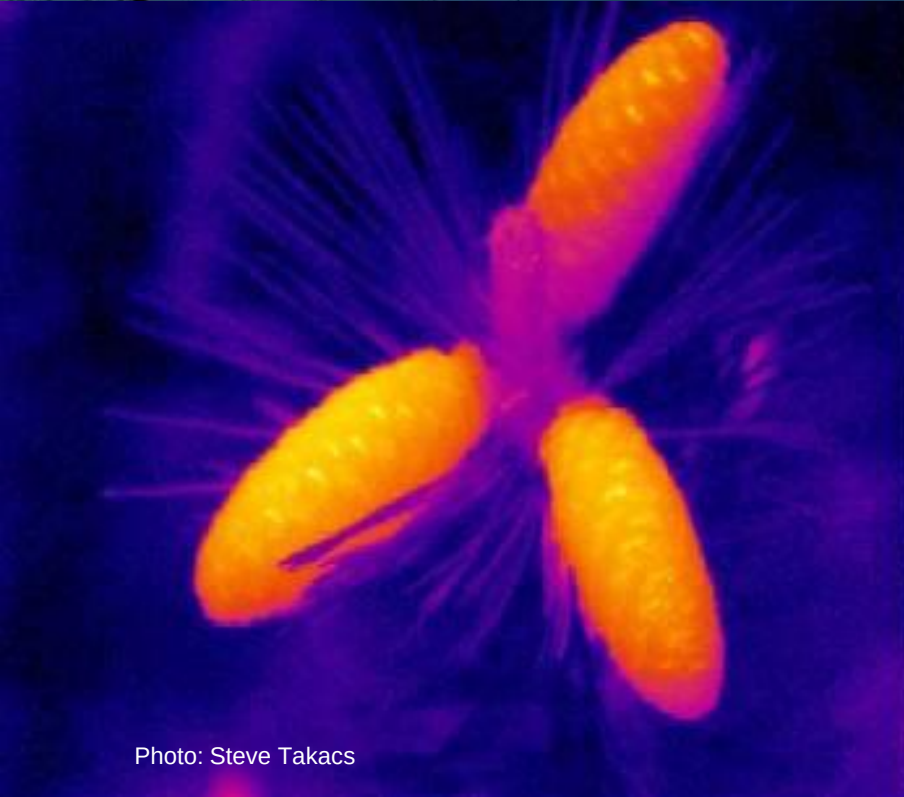


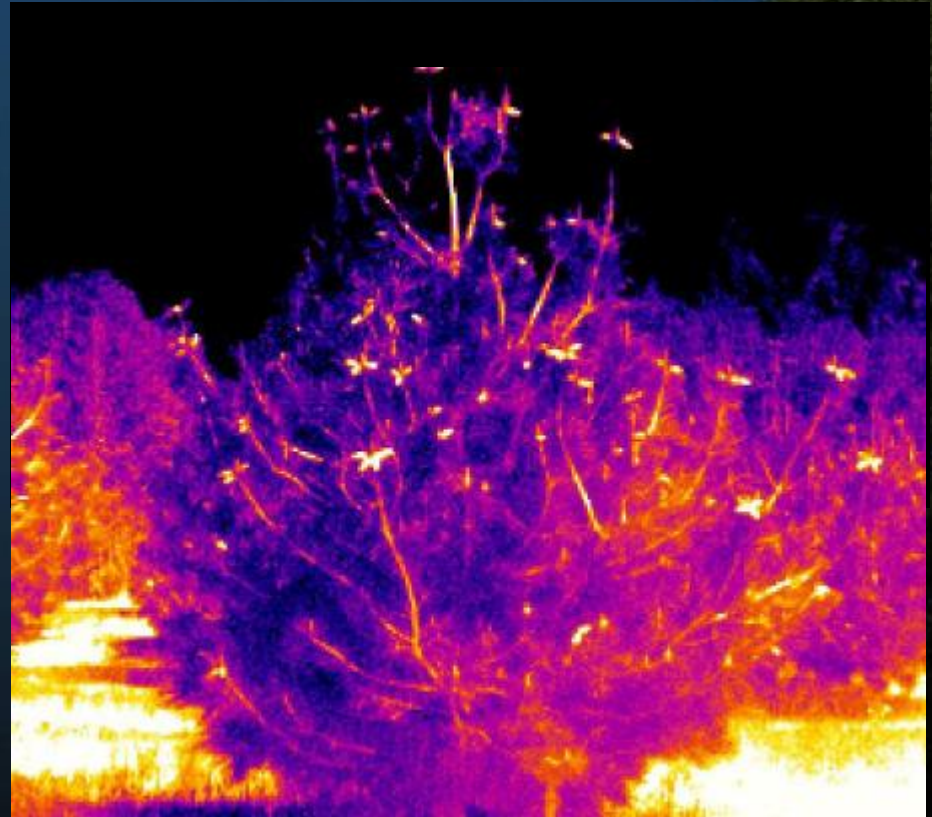
Photo: Steve Takacs



Do Leptoglossus use IR as a host-finding cue?



Photos: Steve Takacs



Lepto moved towards IR in the lab

67

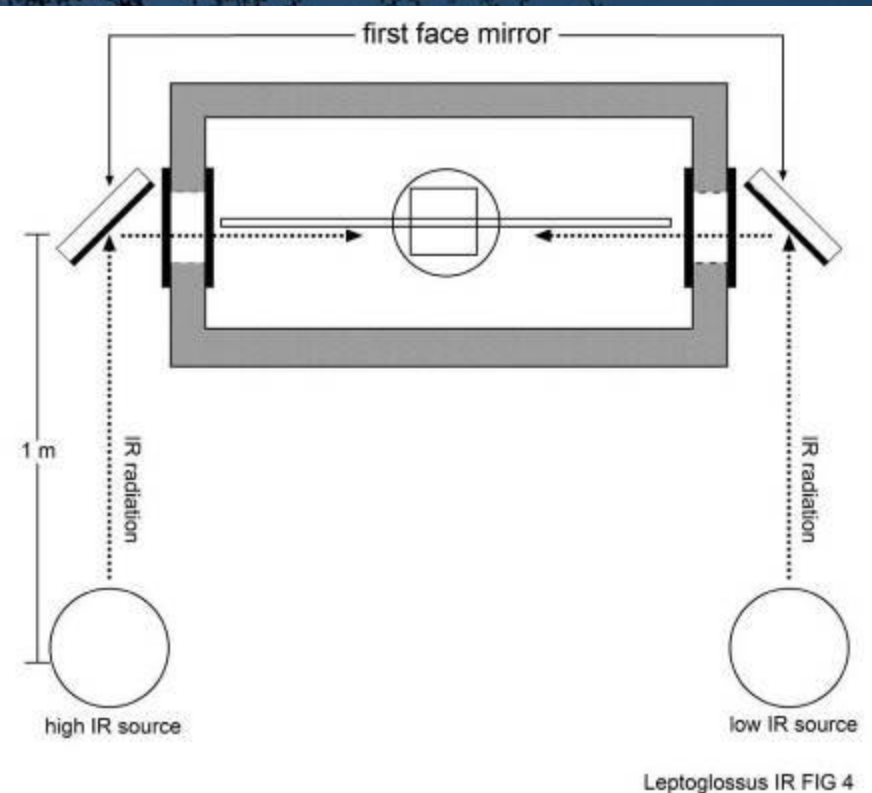
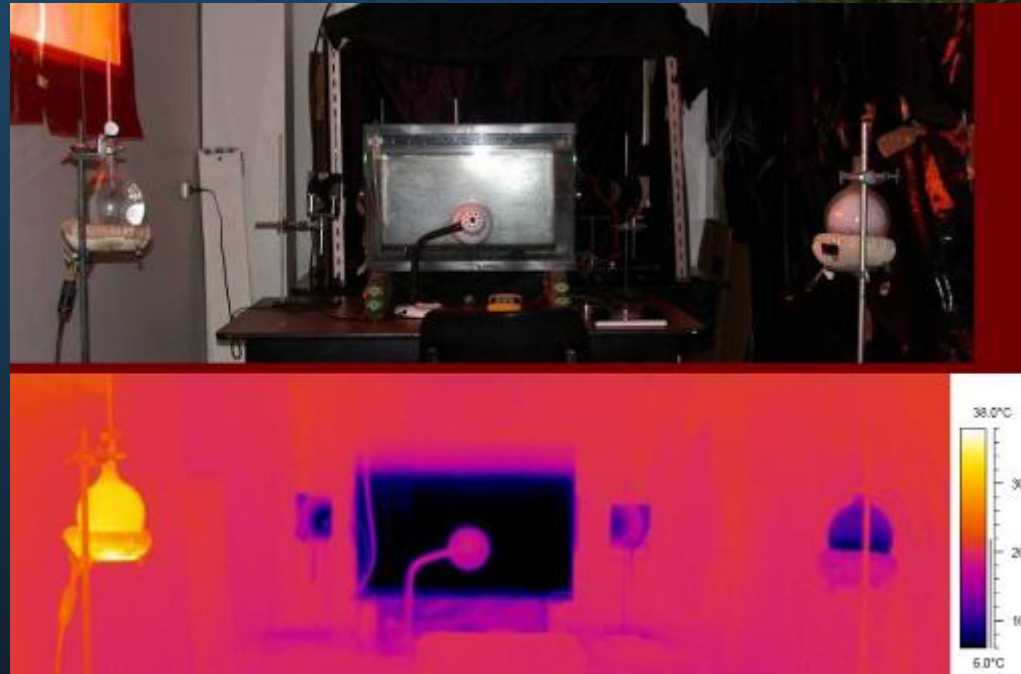
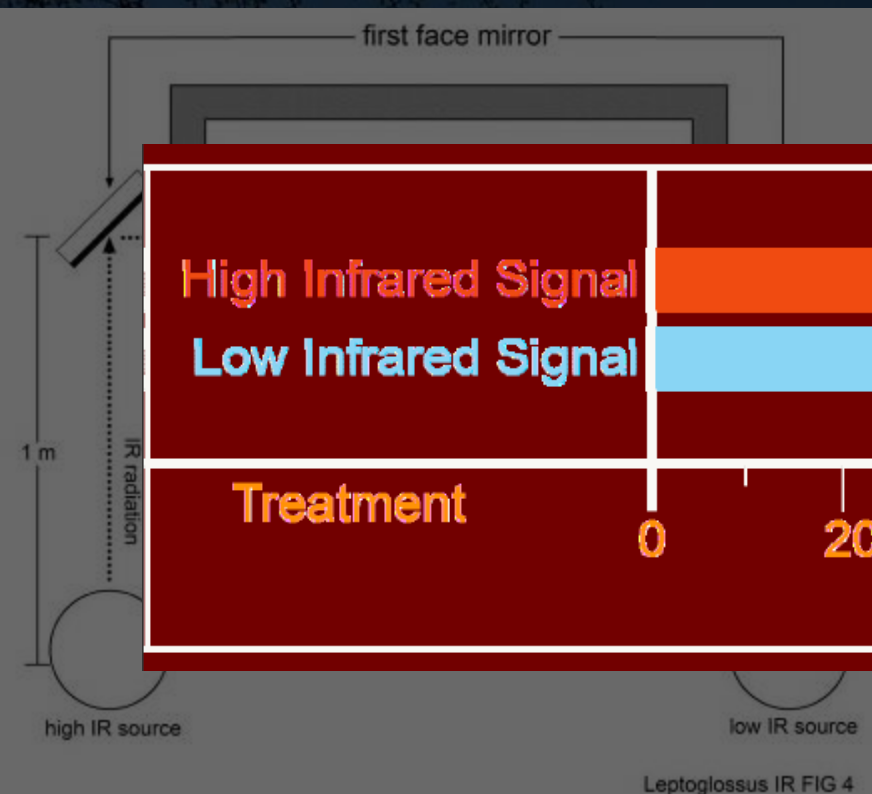
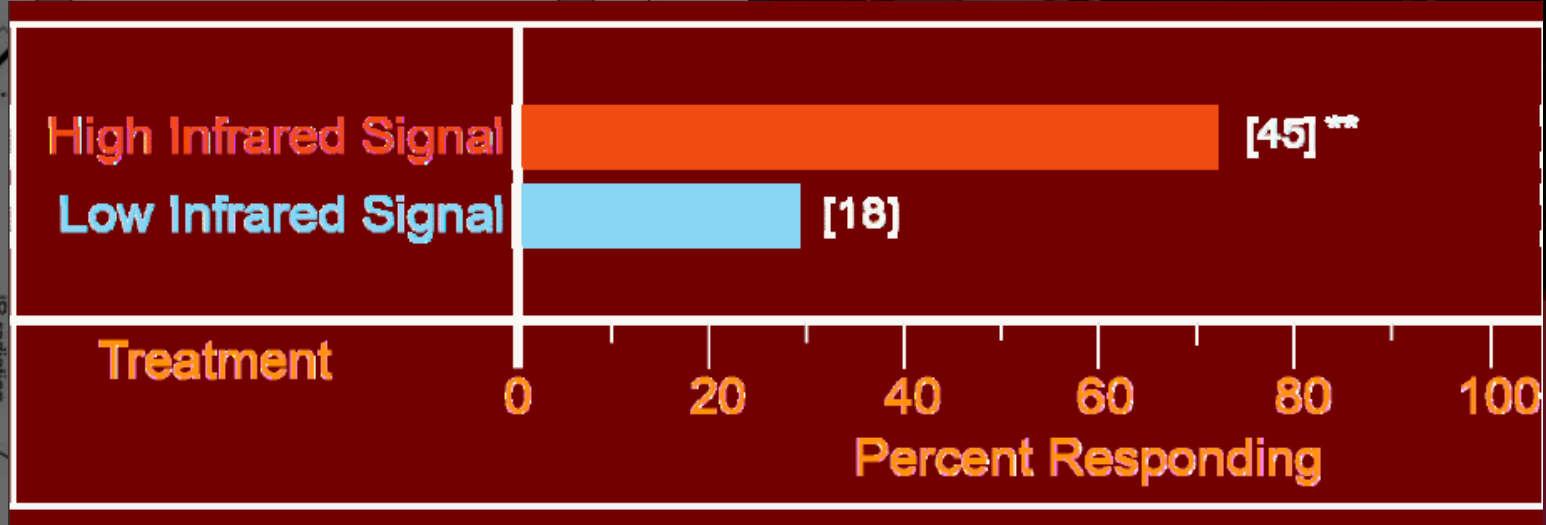
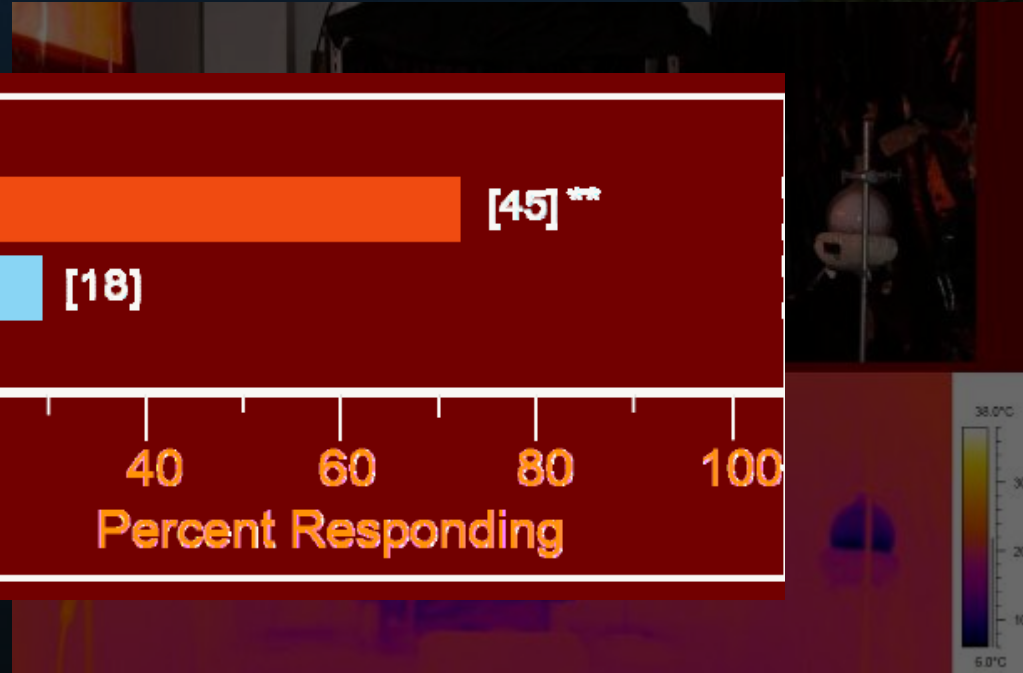
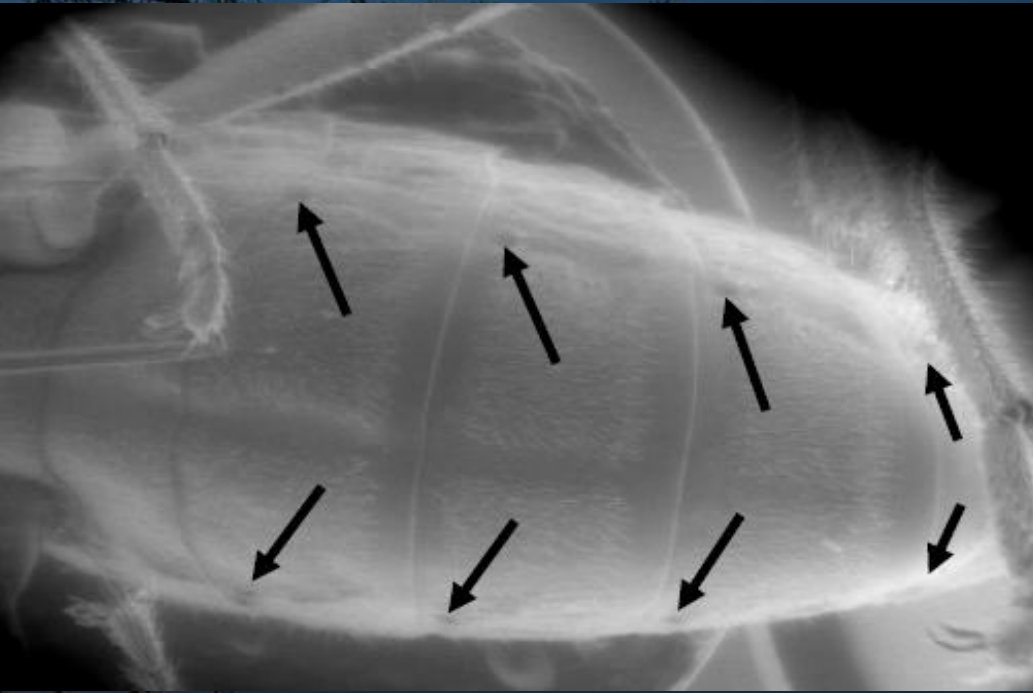


Photo: Steve Takacs

Lepto moved towards IR in the lab

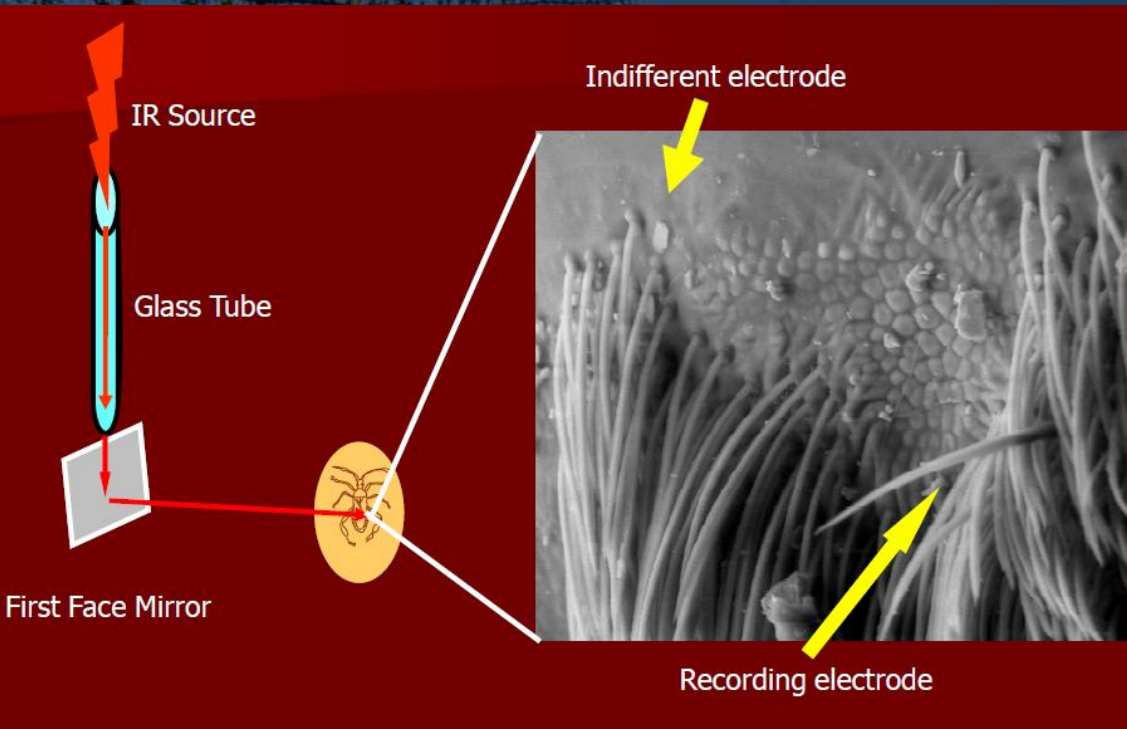


Infrared-sensing structures found on abdomen



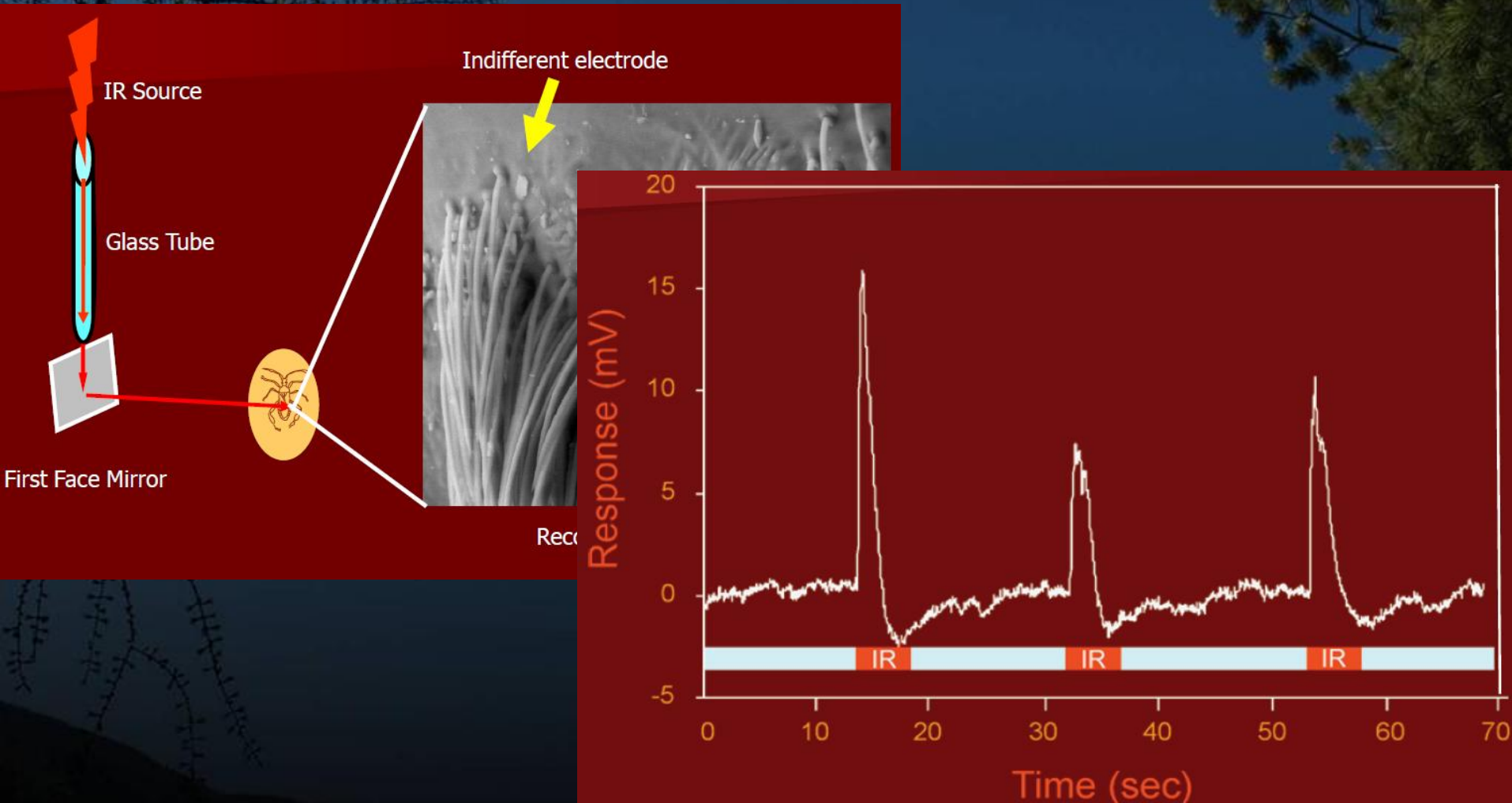
Testing Infrared Structures for IR receptivity

70



Testing Infrared Structures for IR receptivity

71



Taking visual cues to the next level: Trapping, visible light, and other orchard pests

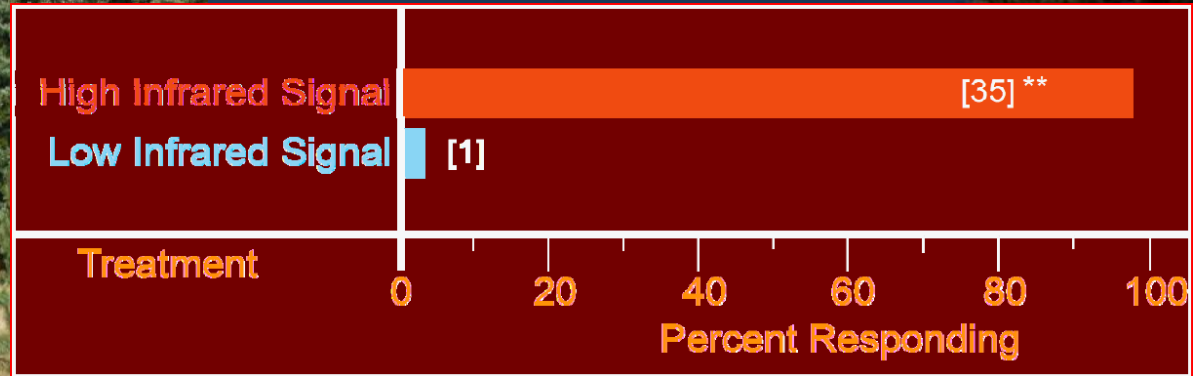
Partners: Gerhard Gries & Tracy Zahradnik, SFU



Photos: Steve Takacs

Taking visual cues to the next level: Trapping, visible light, and other orchard pests

Partners: Gerhard Gries & Tracy Zahradnik, SFU



Photos: Steve Takacs

Trapping Leptoglossus

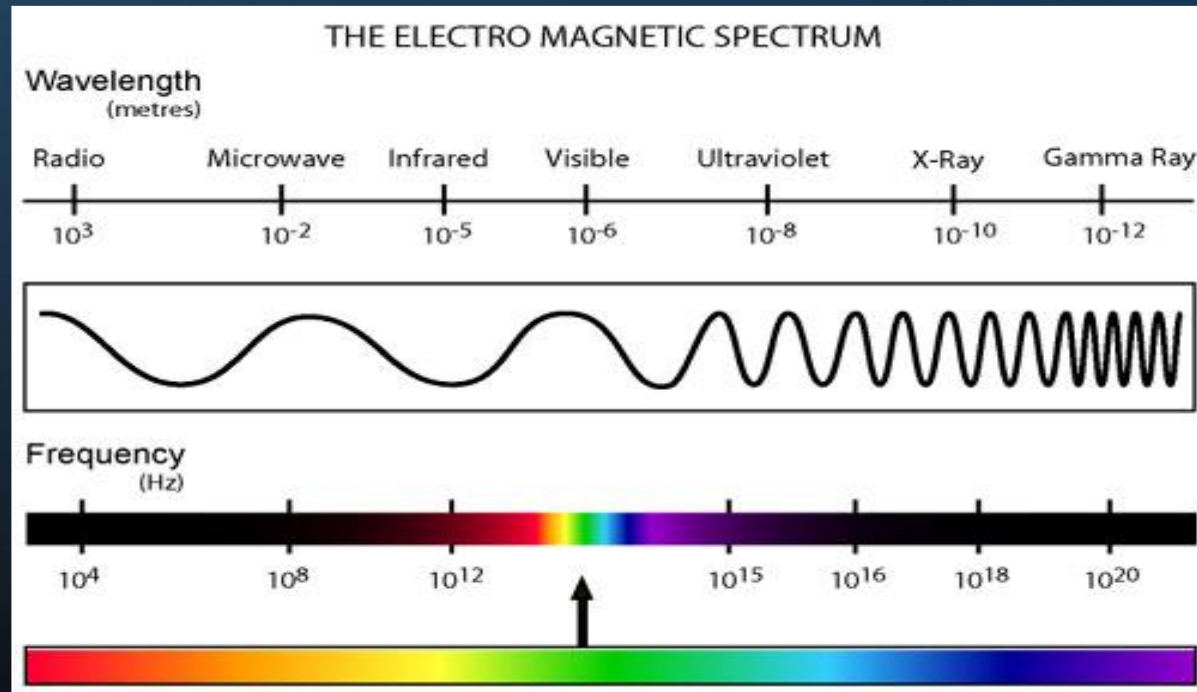


Results equivocal

- Wrong trap design?
 - size
 - shape
 - capture ability
- Multi-modal cues required?
 - IR
 - Sound
 - Visual
 - Odour

Visible light attraction in *Leptoglossus*

- Partners: Gerhard Gries lab, SFU
- Grad Student Tracy Zahradnik



Visible light spectrum:

Leptoglossus electro-retinogram

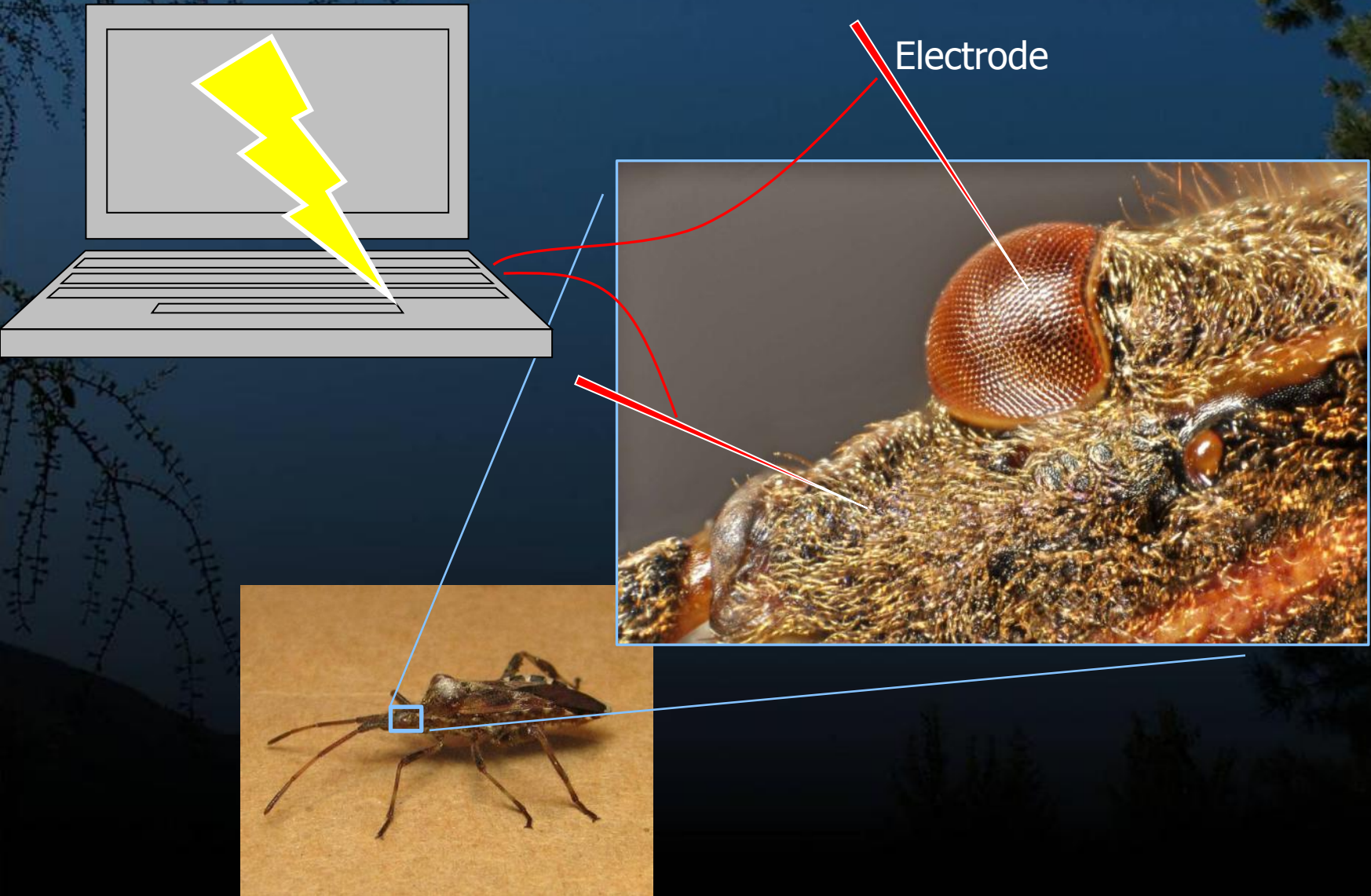
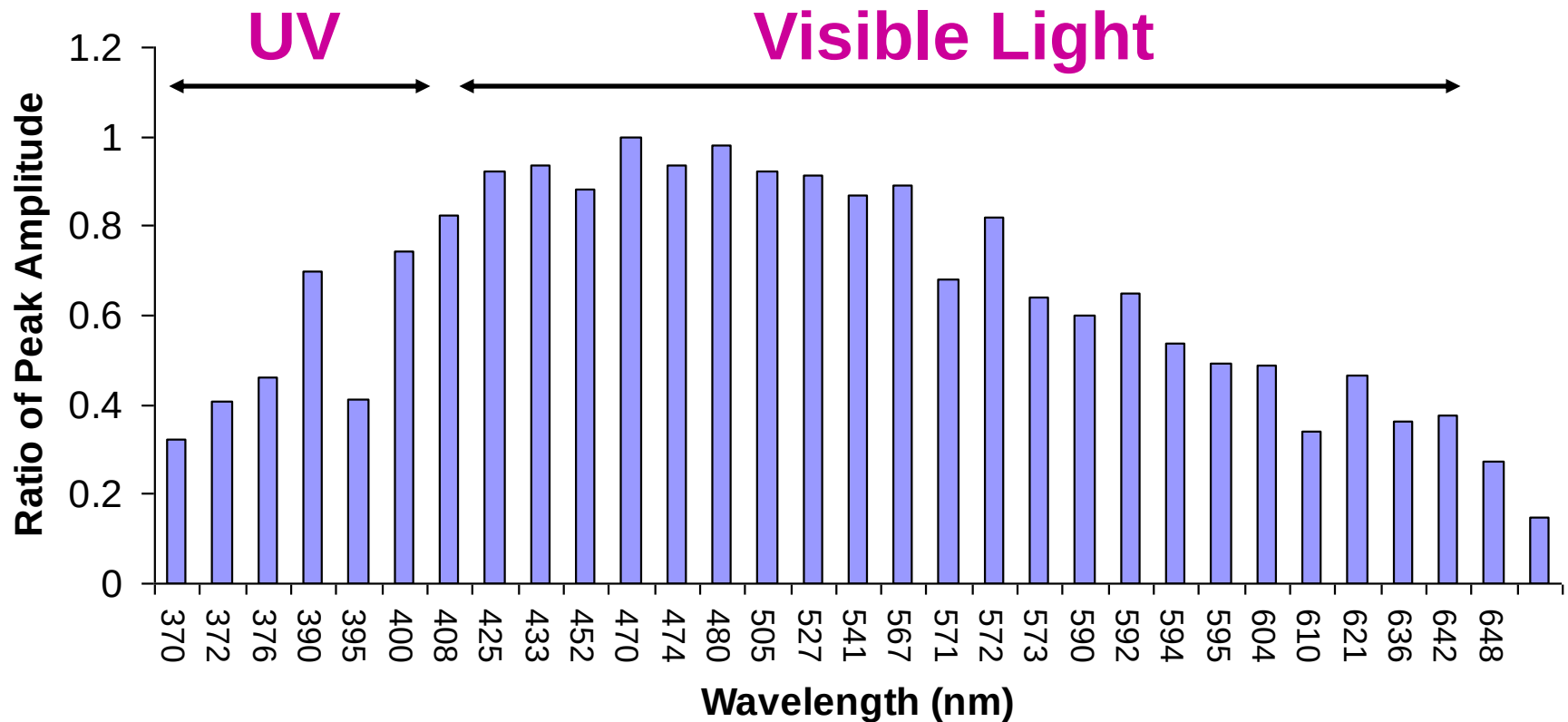


Photo: Tracy Zahradnik

Visible light spectrum: *Leptoglossus* electro-retinogram

Average Responses of Male and Female *Leptoglossus*
to Various Wavelengths



Future directions in Colour / IR work

Working with 3 pest taxa:

- Determine behavioural responses to different wavelengths
- Continue developing IR-based traps
- Test colour and size of traps
- Assess combinations of IR, colour, sound, and host volatiles
- Ultimately use these for monitoring and control



Photo: Tracy Zahradnik

GREAT BIG THANK-YOU_s TO:

- **Collaborating institutions:**

UBC, SFU, UNBC, UBC-O, UA, Canadian Forest Service, Laurentian U, UC-Riverside

- **Funding Agencies:**

Forest Genetics Council of BC, MITACS, NSERC

- **Graduate Students:**

Tamara Richardson, Caroline Whitehouse, Babita Bains, Tracy Zahradnik, Natasha Mandryk, Hannah Bottomley, Iisak Andreller

- **Seed orchard personel:**

Robb Bennett, Jim Corrigan, Seed orchard managers, field staff.

