Leveraging plasticity of thermal tolerance in *Megachile rotundata* and *Pteromalus venustus* as a potential parasitoid mitigation strategy

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Parasitoids in *Megachile rotundata*

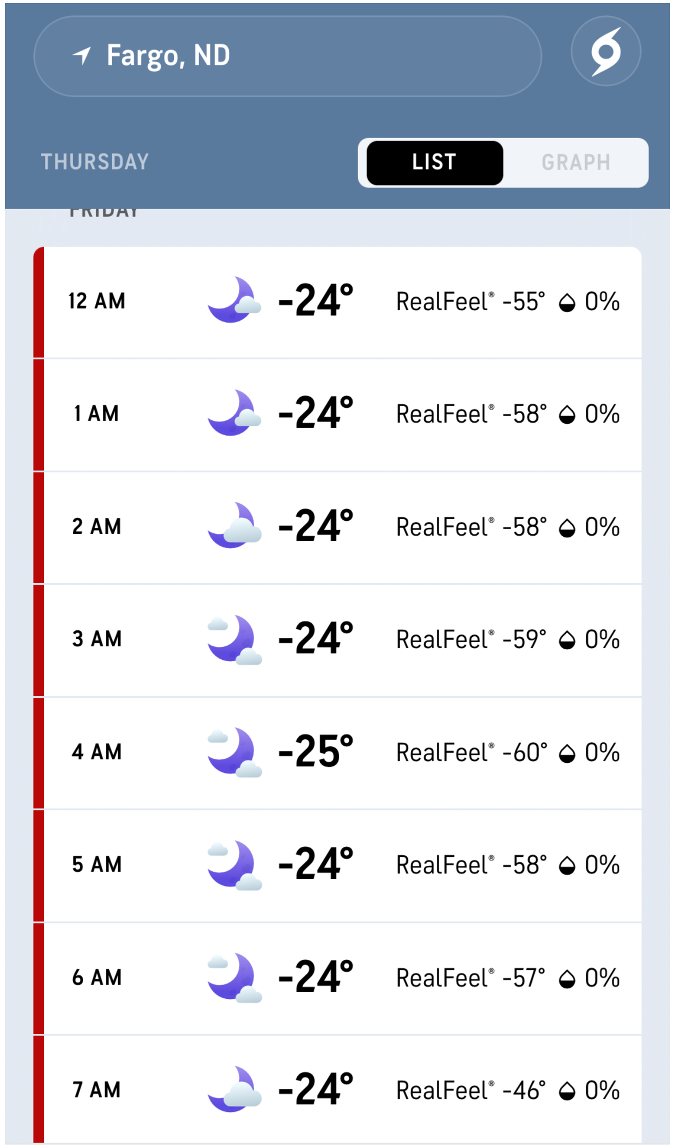
- *Pteromalus venustus* is a major economic threat to commercial *M. rotundata* production
- Canada banned dichlorvos pest strips in August 2023
- No effective chemical options remain once parasitoid eggs are oviposited

Parasitoids in *Megachile rotundata*

- U.S. alfalfa seed growers rely on Canadian bee suppliers
- Multiple parasitoid species that can cause significant mortality
- Critical need for non-chemical mitigation strategies

Fargo is in the parasitoid game!

- USDA-ARS and North Dakota State University
  - Studying *M. rotundata* for nearly two decades
    - Thermal biology
    - Diapause physiology
    - Field biology
    - Biochemistry and genetics
    - Cryopreservation
    - Selective breeding
- Parasitoids
  - Alfalfa pollinator research initiative grant
  - Now a component of our 5-year research plan



Thermal tolerance as a management strategy

- Thermal treatments can exploit differences in temperature tolerance between host and parasitoid
- Recent work in the tobacco hornworm shows parasitoids can have lower heat tolerance than their hosts[1]
- Thermal approaches offer practical, non-chemical alternatives

[1]Malinski, K. (2023) – Journal of Experimental Biology

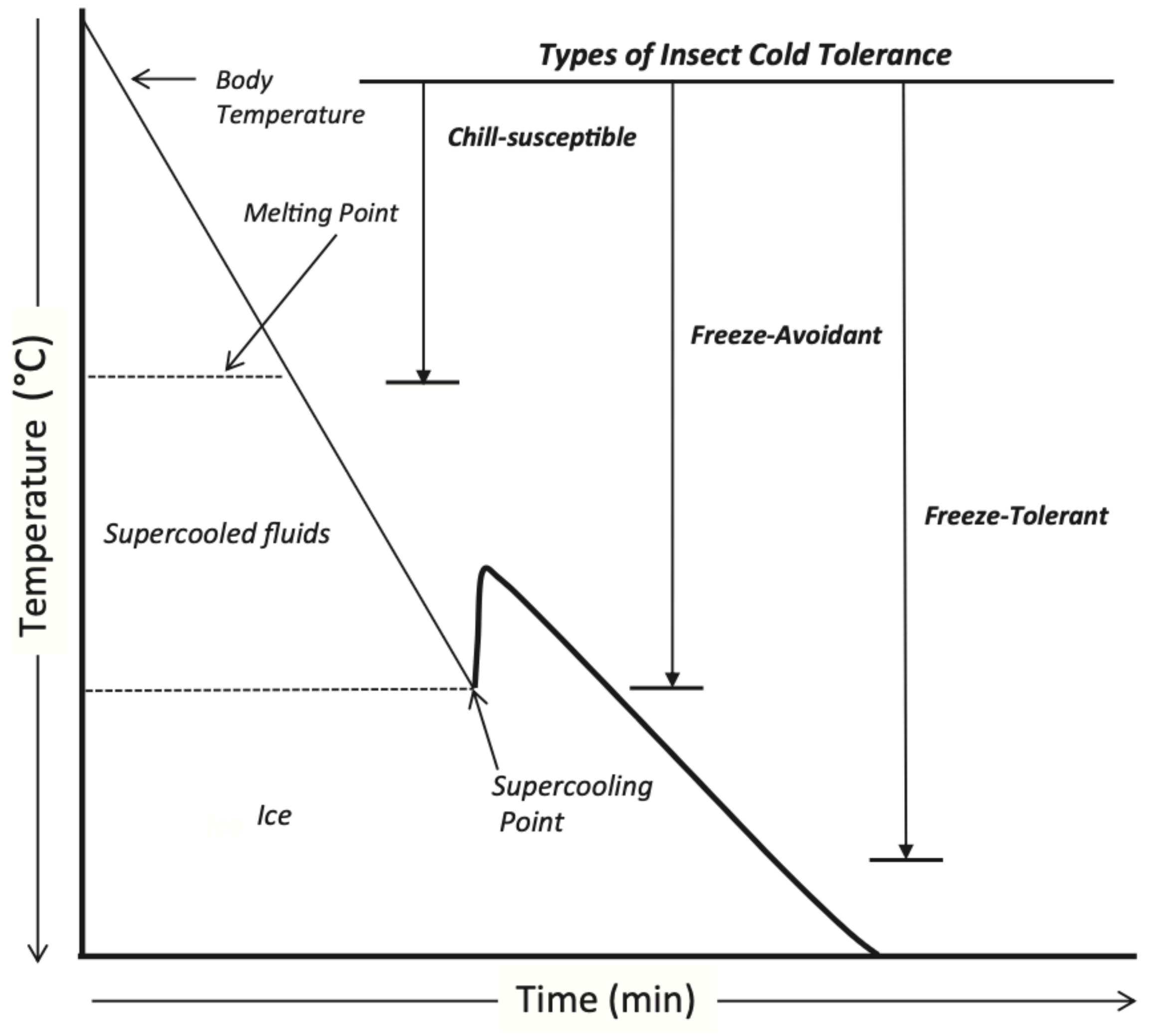
Year one: APRI

Objective:

Quantify cold tolerance in *M. rotundata* and *P. venustus* during diapause across various thermal pretreatments to identify temperature ranges for targeted *P. venustus* mortality.

- Determine cold tolerance strategy for *P. venustus*
- Measure lethal limits of each species
- Measure survival of extended sub-lethal chilling in both species

Measuring cold tolerance strategy in *P. venustus*



Sinclair et al., 2015

Both species are freeze-avoidant

- Both species have similar supercooling points (~-29°C)
- Both die upon freezing (‘freeze avoidant’)
- Parasitoids show more variation
- Freezing treatments not viable
  - Can't selectively kill parasitoids without killing bees
- Cooling rates are important!

Torson *et al.*, in prep

Species differ in low-temperature survival

- Parasitoids survive slightly better at extreme cold (-25 °C)
- At -10°C: bees 74%, parasitoids 42% ($p = 0.019$)
- At -15°C: significant but smaller gap ($p = 0.036$, not pictured)
- Different physiological mechanisms for coping with cold stress

Torson *et al.*, in prep

Survival rates at -10°C and -15°C

- -10°C provides most consistent yielded differential mortality
- However, 42% parasitoid survival still too high for practical management

Torson *et al.*, in prep

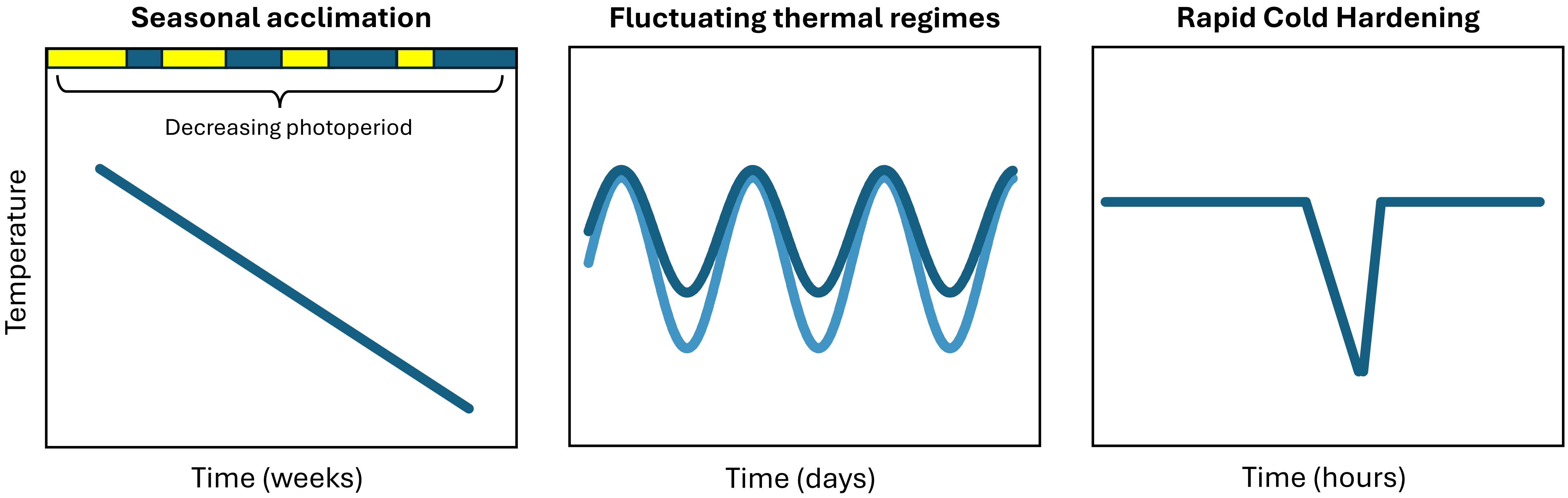
Year two: APRI *(pending)*

Objectives:

1. Determine whether thermal acclimation pretreatments can enhance cold tolerance of *M. rotundata* relative to *P. venustus* at -10°C
    - Can we increase parasitoid mortality to levels suitable for practical management?
2. Evaluate heat treatments (40-45°C) as an alternative thermal control strategy
    - Test whether temperatures that *M. rotundata* can tolerate cause lethal stress to *P. venustus* in parasitized brood cells.

Leveraging 'plasticity' in thermal tolerance

- We don't have to rely on differences in 'baseline' thermal tolerance, we can induce the differences or make them larger using pretreatments



Obj. 1: Cold acclimation

- **Autumn-like acclimation:** Gradual cooling over 6 weeks (photoperiod + thermoperiod)
- **Rapid cold hardening:** Brief -5°C exposure before treatment
- **Thermoperiod:** Daily fluctuating temperatures (6-18°C)
- **Goal:** Widen bee-parasite survival gap, drive parasitoid mortality to <10%

Obj. 2: Heat treatments

- *M. rotundata* tolerates 40°C for 8 days, 45°C for 2 days
- Establish baseline *P. venustus* heat tolerance
- Test differential mortality in parasitized vs. unparasitized brood cells
- Assess bee survival and flight performance

Torson *et al.*, in prep

Future Directions

- Field validation with commercial growers
  - Apply most effective treatment to heavily parasitized commercial brood cells (n=500)
  - Track survival, emergence, parasitism rates, bee quality metrics
  - Direct grower recommendations and implementation protocols
- Expected outcomes:
  - Identify treatment with <10% parasitoid survival, >90% bee survival
  - Peer-reviewed publication
  - Extension bulletin for growers
  - Presentation at 2027 Western Alfalfa Seed Grower Association meeting

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- *M. rotundata* and *P. venustus* images (https://www.gov.mb.ca/)

Questions?