When *halys* freezes over: Cold hardiness of BMSB

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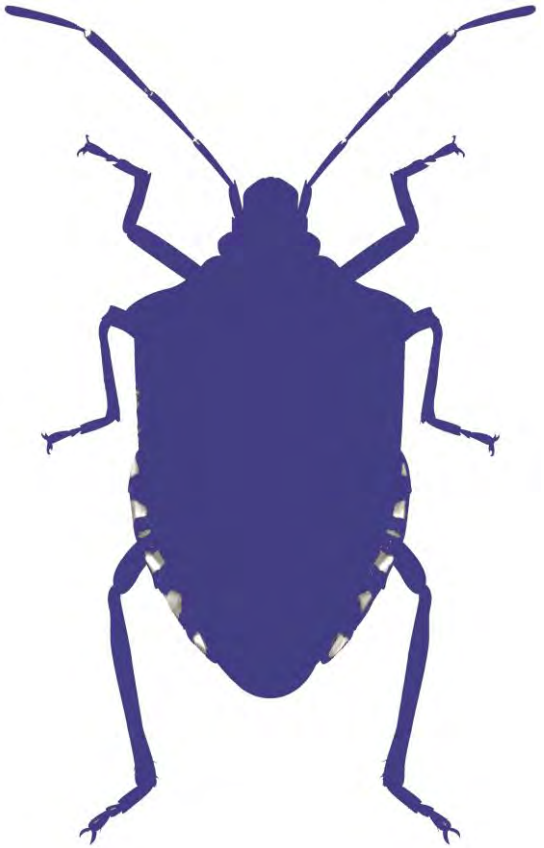
Outline

- Basics of insect cold hardiness
- BMSB cold hardiness
- Future directions
- Question/comments



How to study cold?

- Short term (acute) cold
- Long term (chronic) cold
    - What stage overwinters?
    - Where does it overwinter?
    - Does it acclimate, diapause?
    - What is its overwintering strategy?
    - Low temperature limit?

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- Short term (acute) cold hardiness
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BMSB stats:

Insect cold hardiness

Overwintering strategies

Insect cold hardiness

Avoid the cold

- Migrate
- Aggregate
- Seek shelter

Prevent freezing

- Supercool
- Void ice nucleators
- Accumulate cryoprotectants (e.g. antifreeze proteins)

Survive freezing

- Control the formation of ice in the body

Not mutually exclusive

Photo credits L to R: David R. Tribble, Pennsylvania Department of Conservation and Natural Resources, IronChris wikipedia.org

Lee 2010, Salt 1961

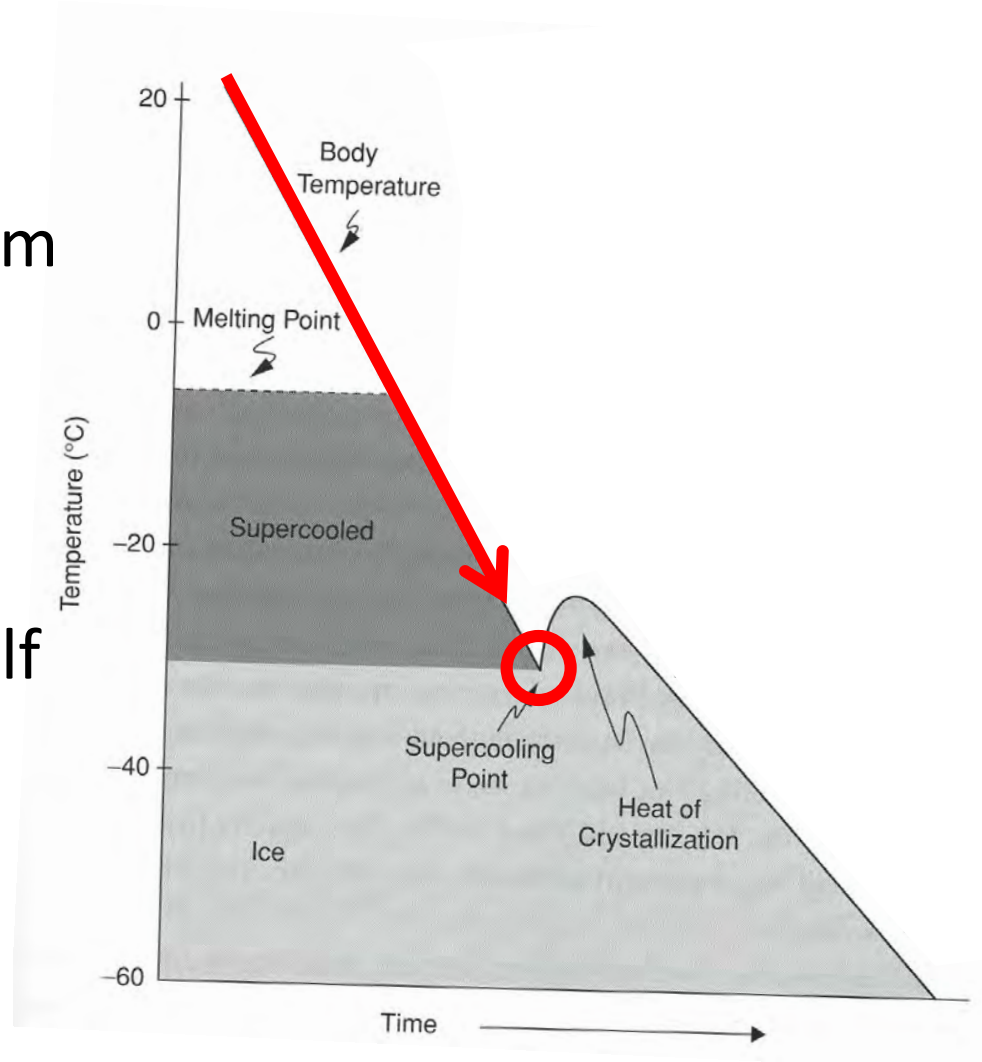
Insect cold hardiness

Measurements

Supercooling point (SCP) =
lowest temp before exotherm which indicates freezing

Mortality =

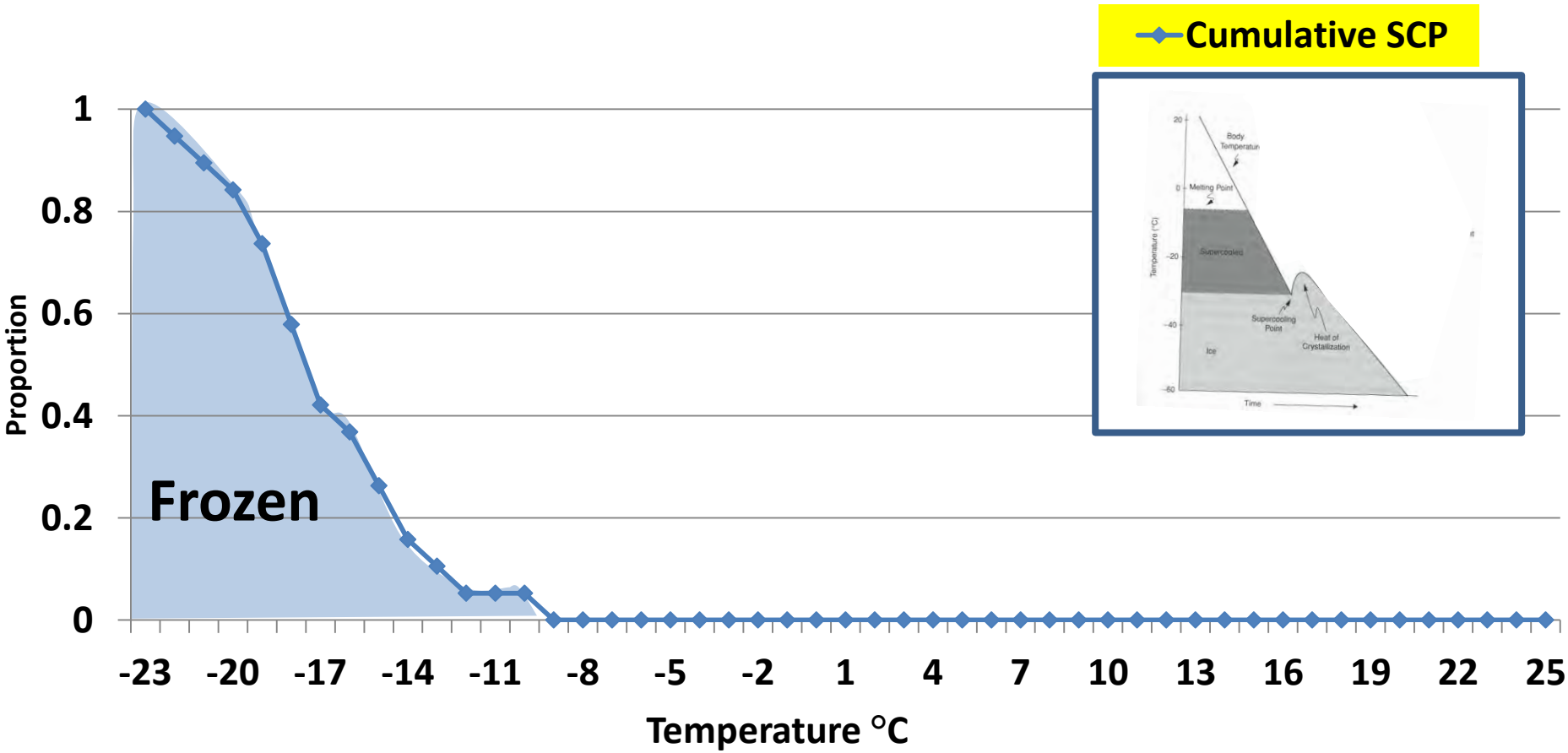
inability to walk or right itself



Denlinger & Lee 2010

Insect cold hardiness

Hypothetical data



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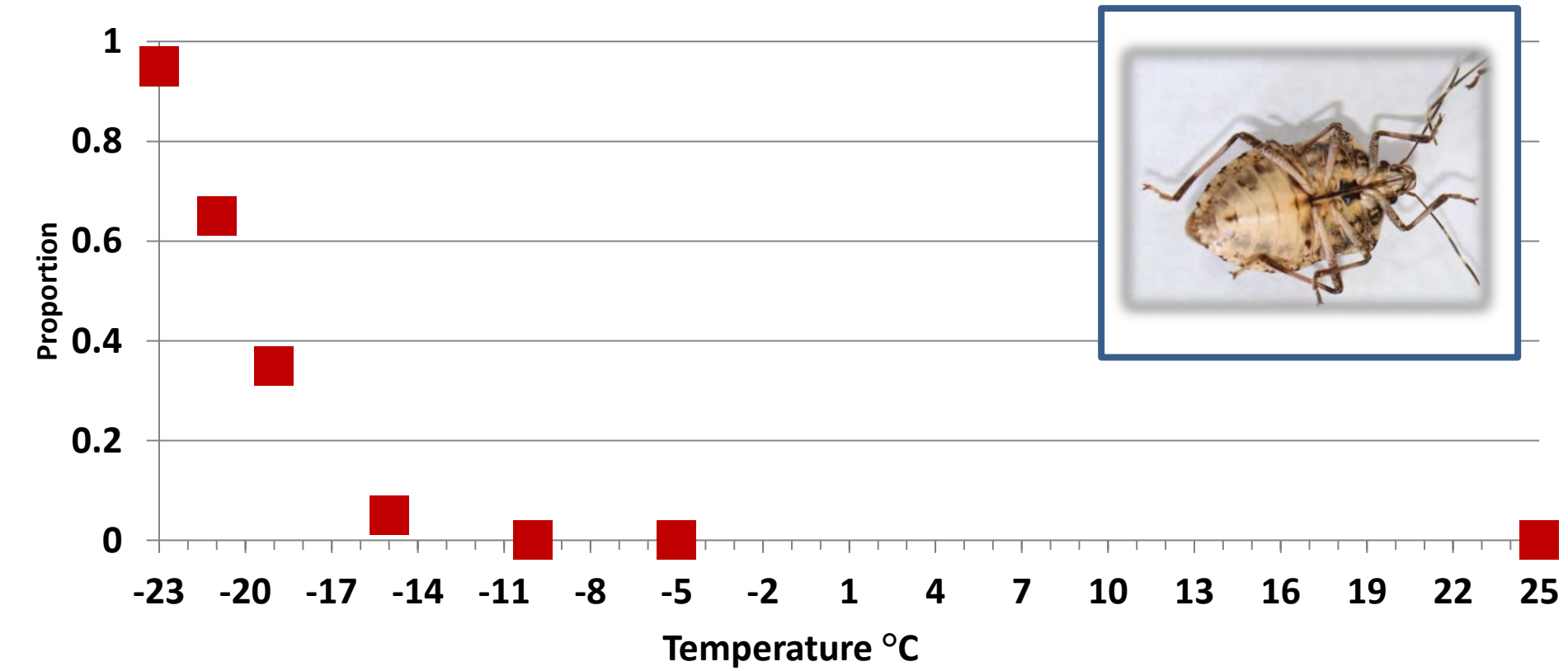

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Insect cold hardiness

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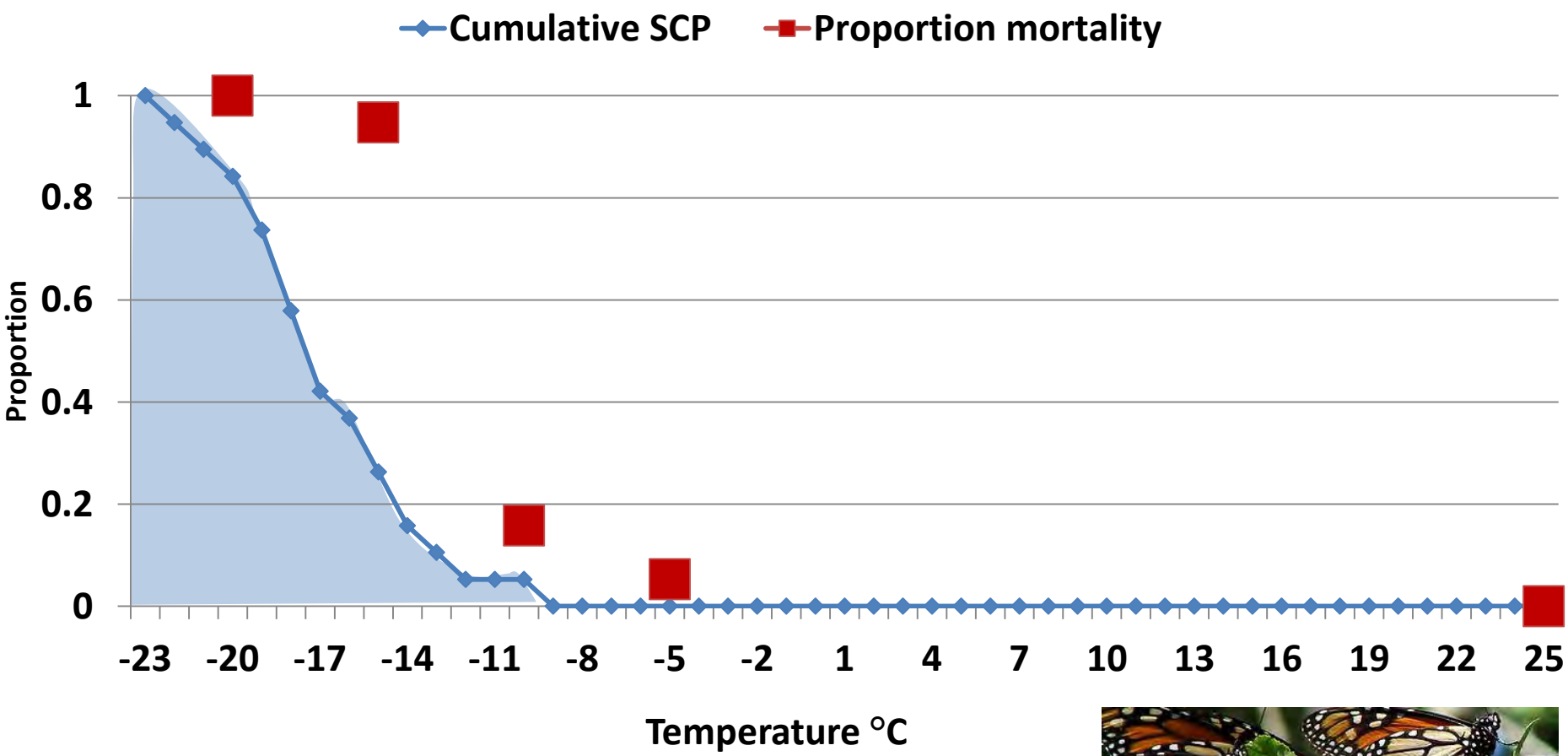

Chill Intolerant

Lee 2010, Salt 1961

Insect cold hardiness

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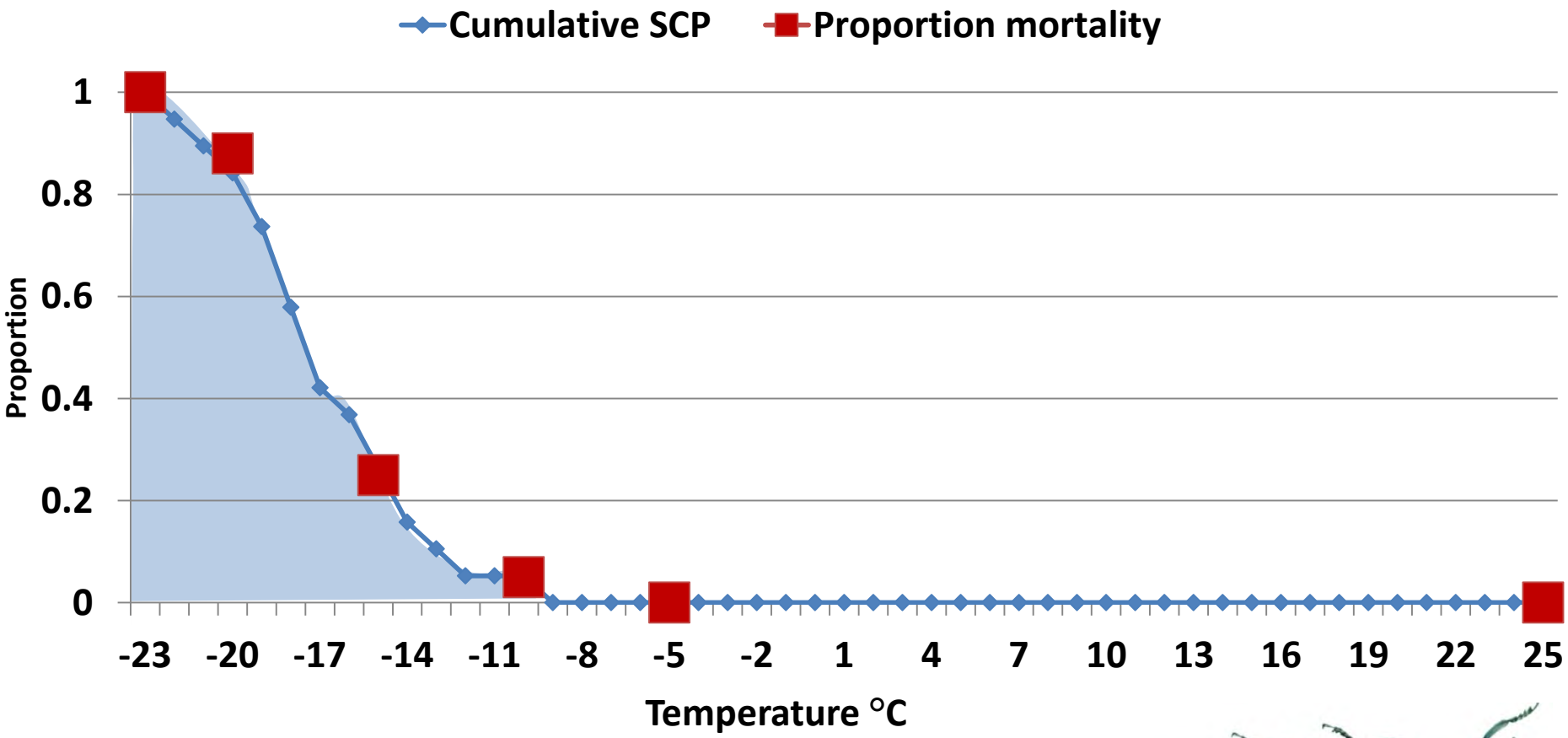

Freeze Intolerant

Lee 2010, Salt 1961

Insect cold hardiness

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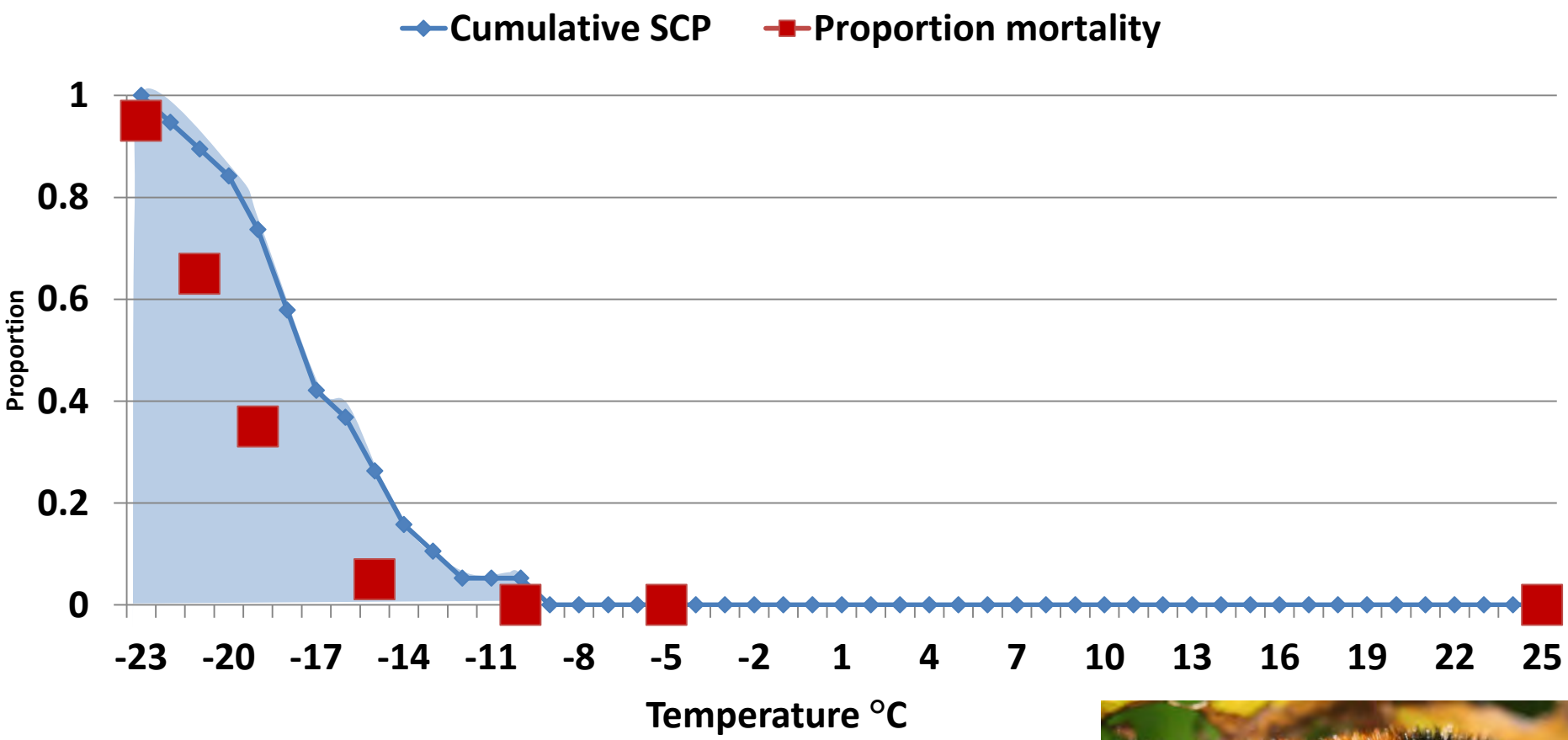
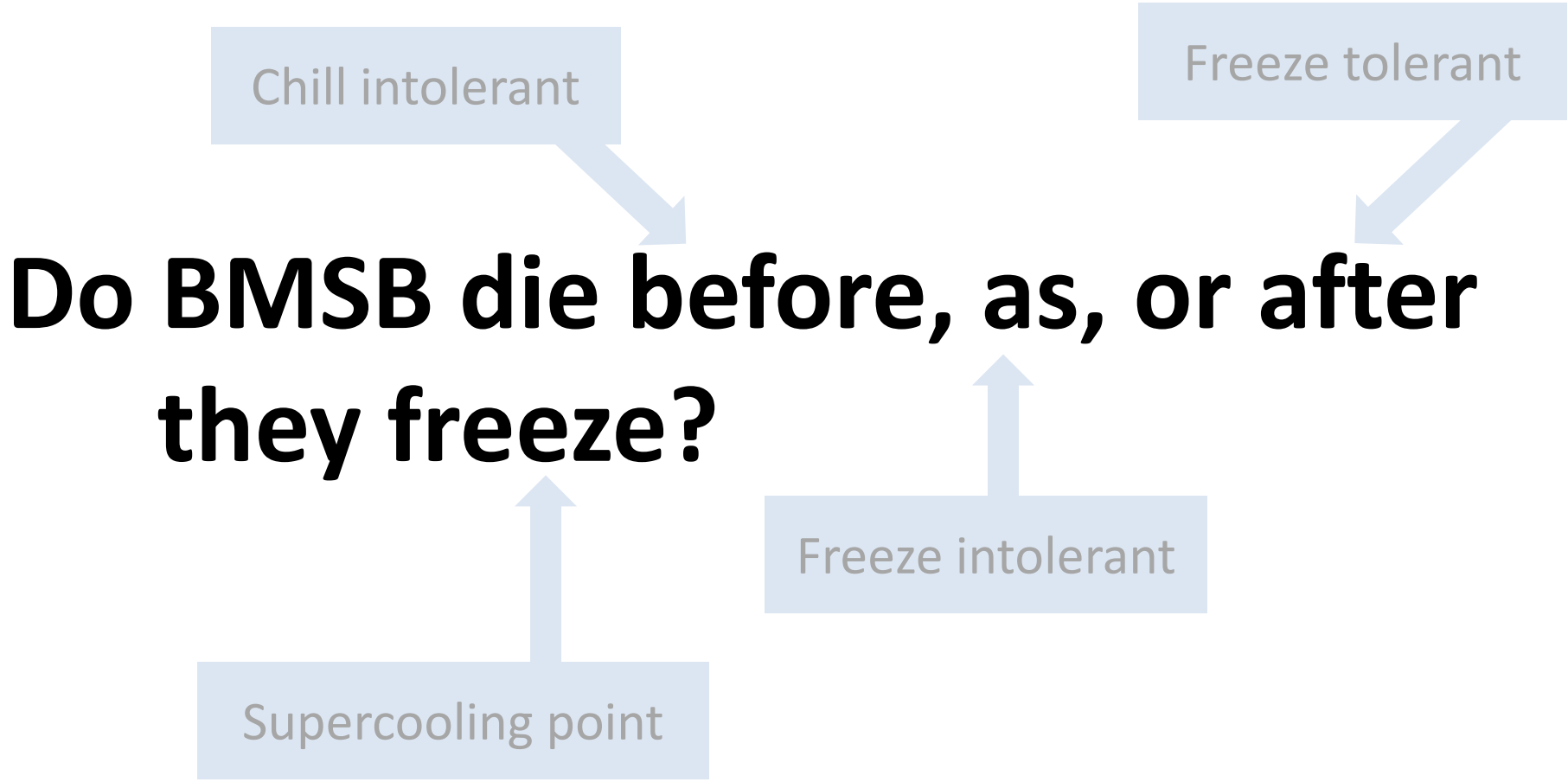
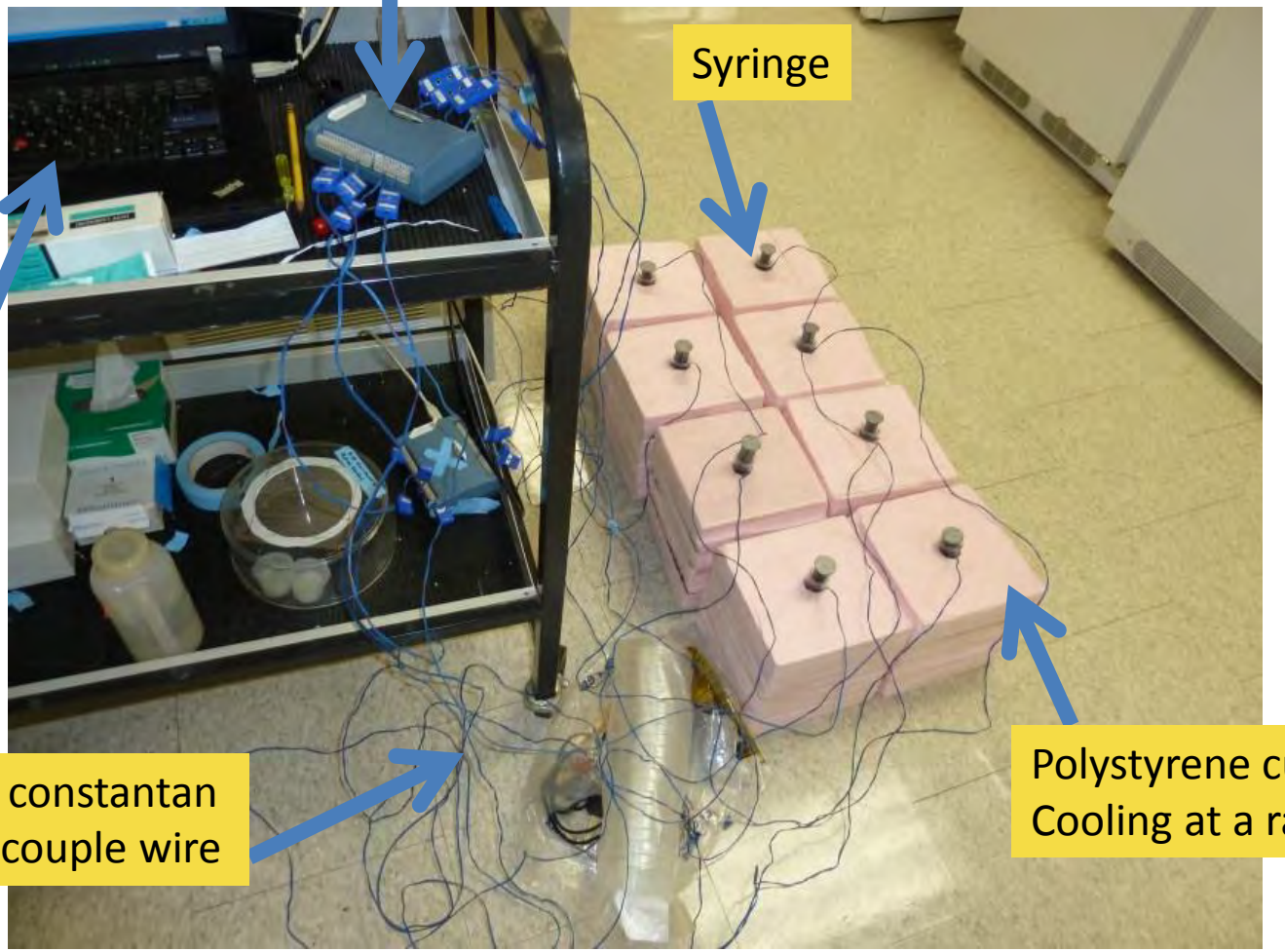


Freeze Tolerant

Lee 2010, Salt 1961


Chill intolerant
Freeze tolerant
Do BMSB die before, as, or after they freeze?
Freeze intolerant
Supercooling point

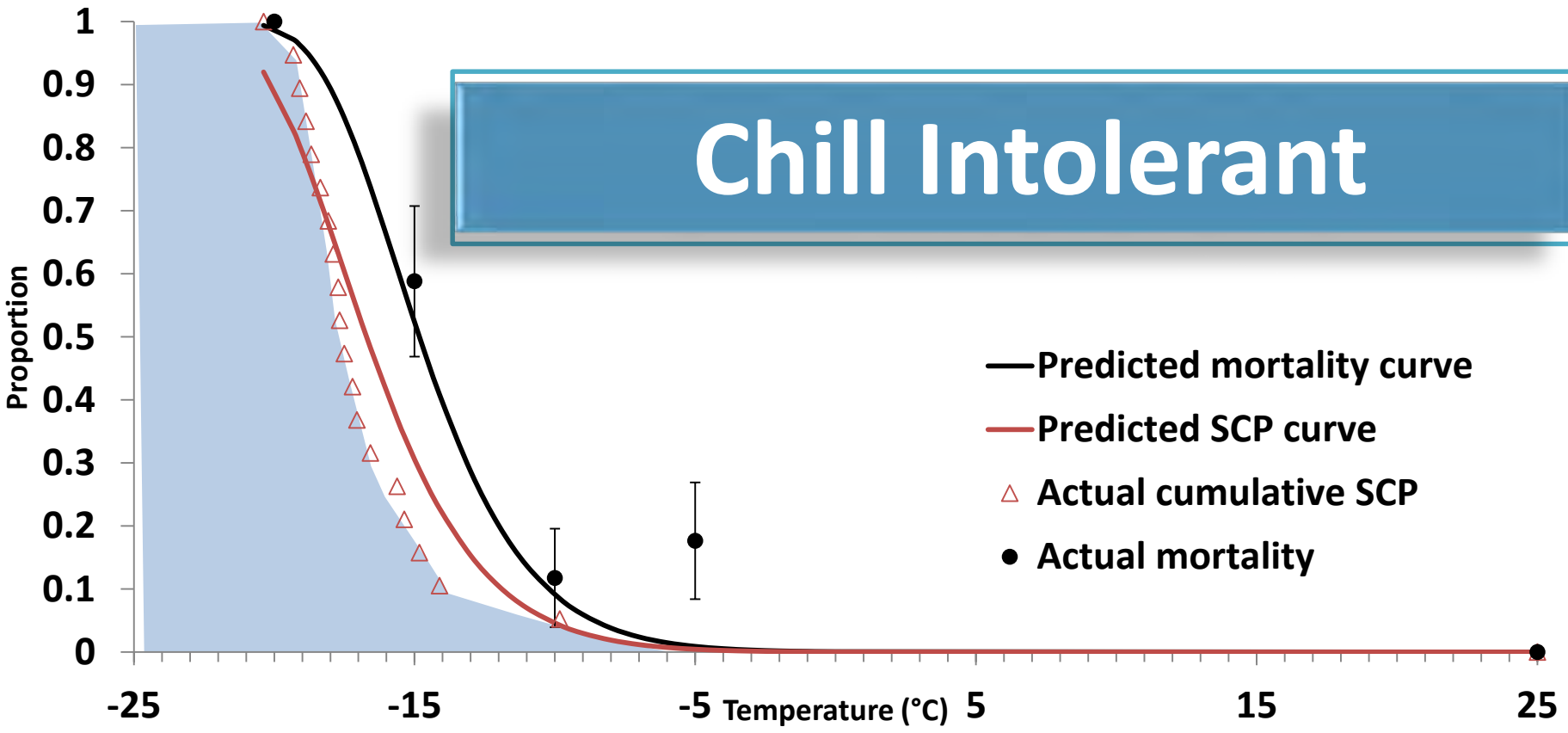
Methods



Carillo 2004

Results

Predicted and observed BMSB: Cumulative SCP & proportion mortality



SCP: n=19 bugs
Mortality: n=17 bugs/each temp (mean ± 95% confidence interval)
Regression curves fitted with a Weibull distribution

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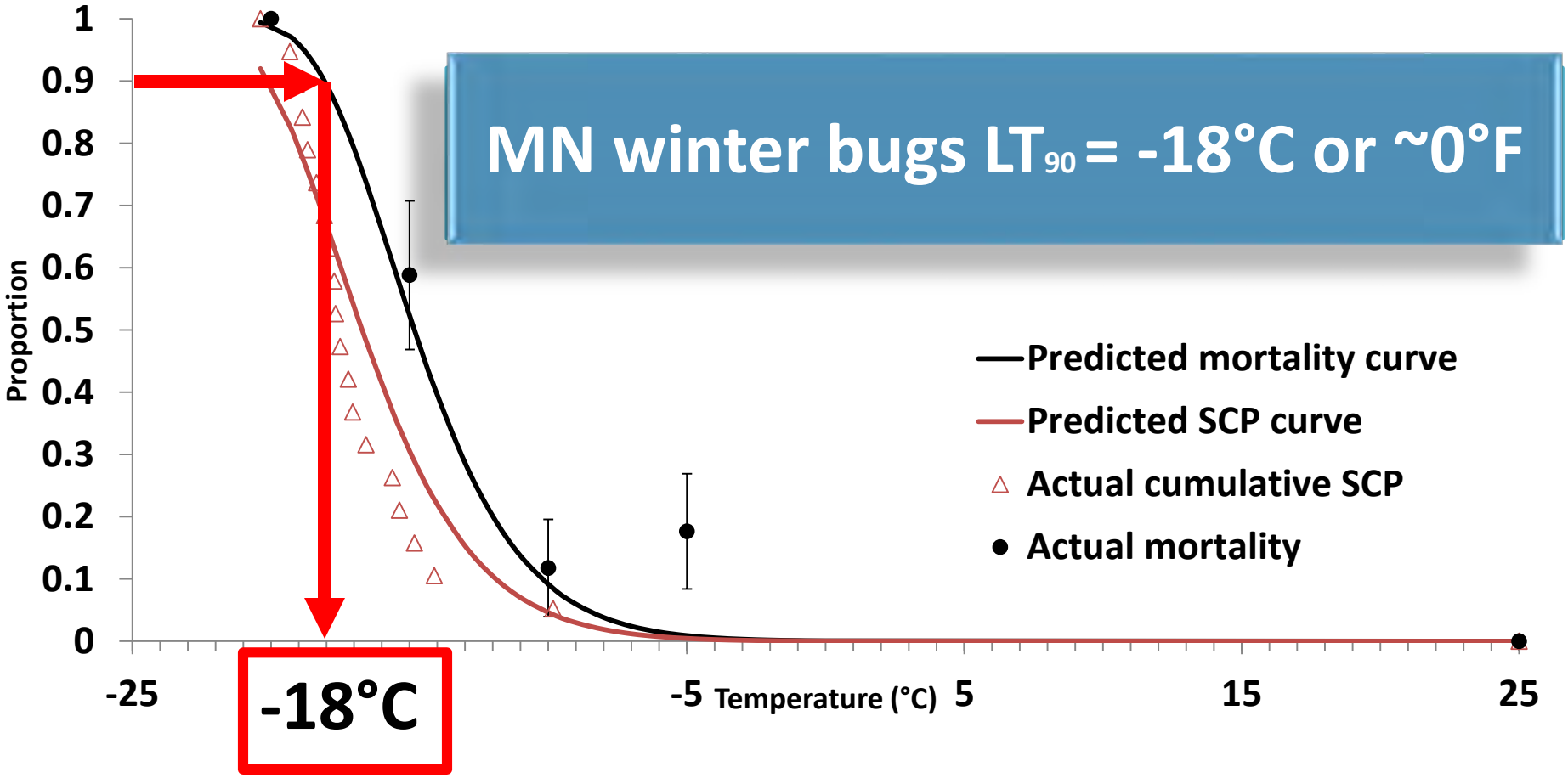

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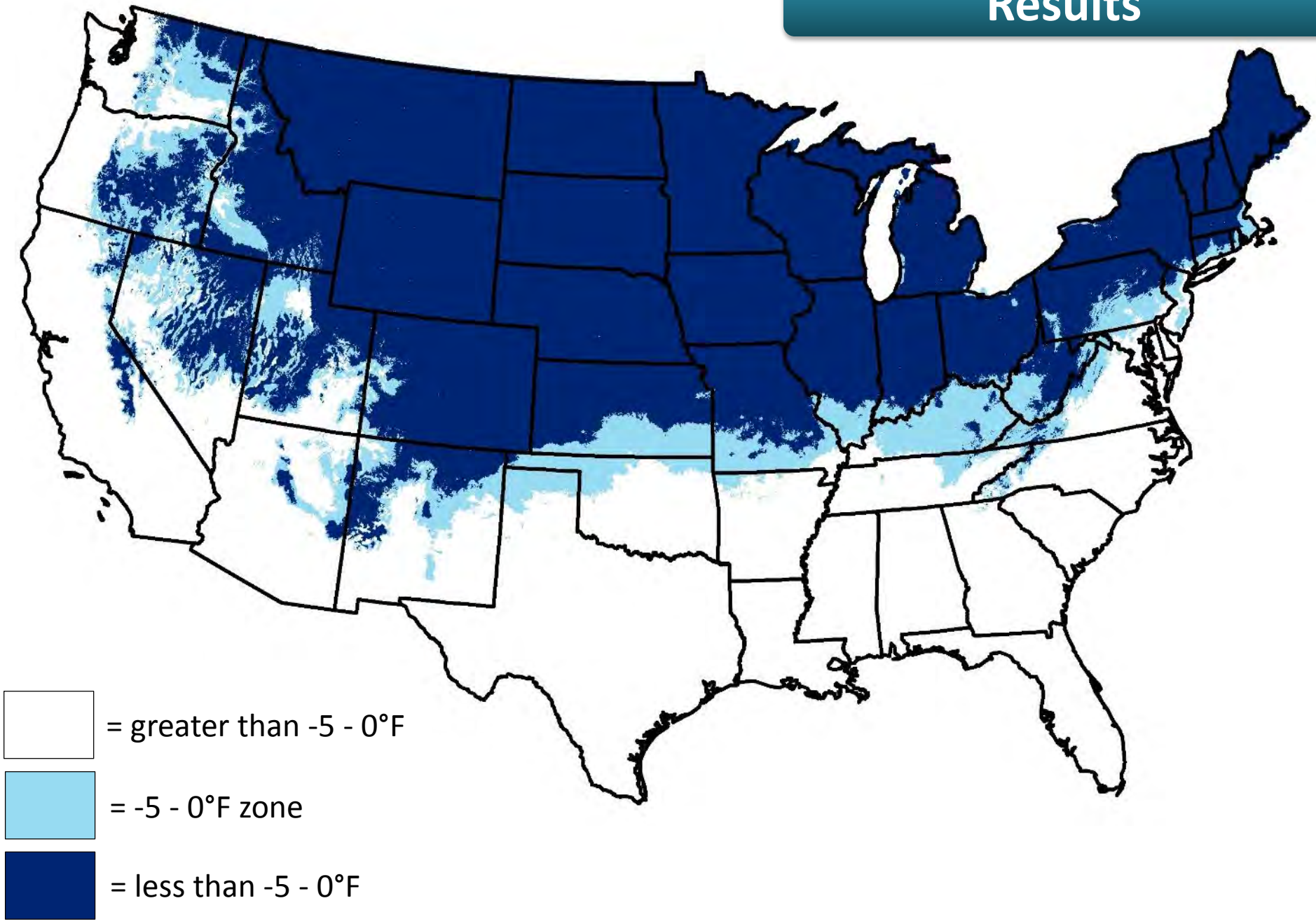

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  - Low temperature limit? — **?**

Do the following effect BMSB cold hardiness?

1) Season tested
2) Acclimation location
3) Sex

Methods

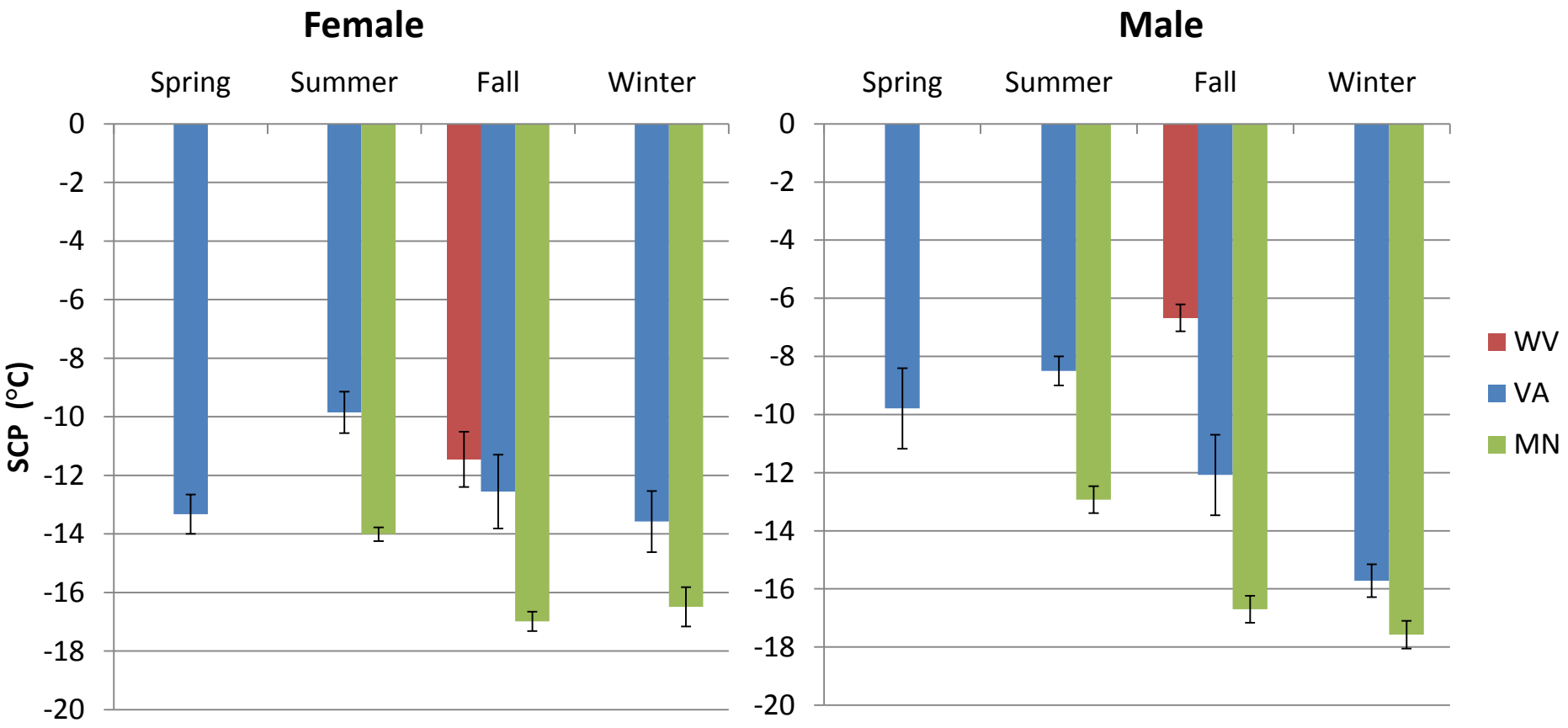
Season: Spring = April and May
Summer = June, July, and August
Fall = September, October, November
Winter = December and February

Location: Blacksburg, VA
Harper's Ferry, WV
St. Paul, MN

Sex: Male
Female

Results

Mean supercooling points (±SEM)of BMSB



Assumptions tested with a Levene test and Shapiro-Wilk test and transformed according to Box-Cox
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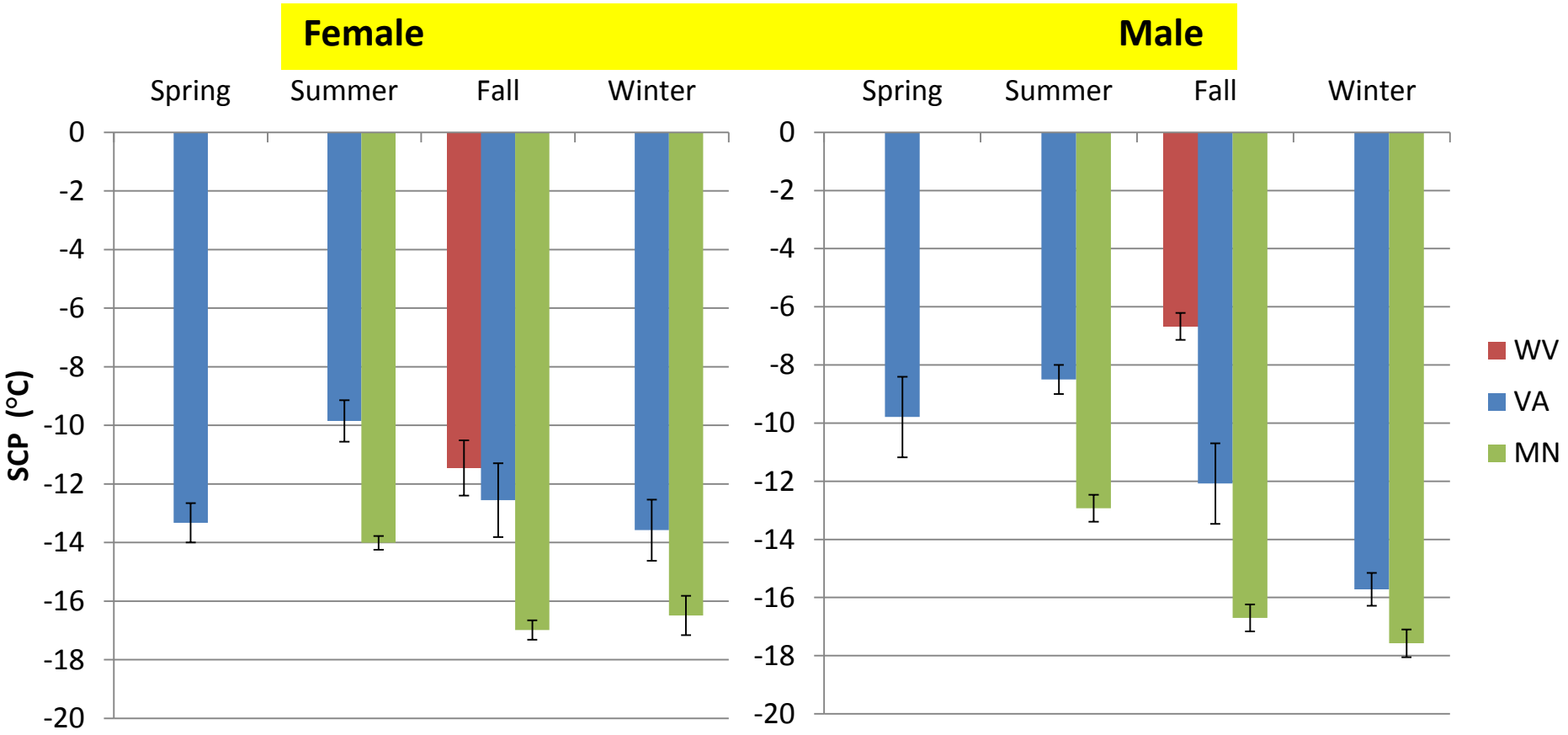

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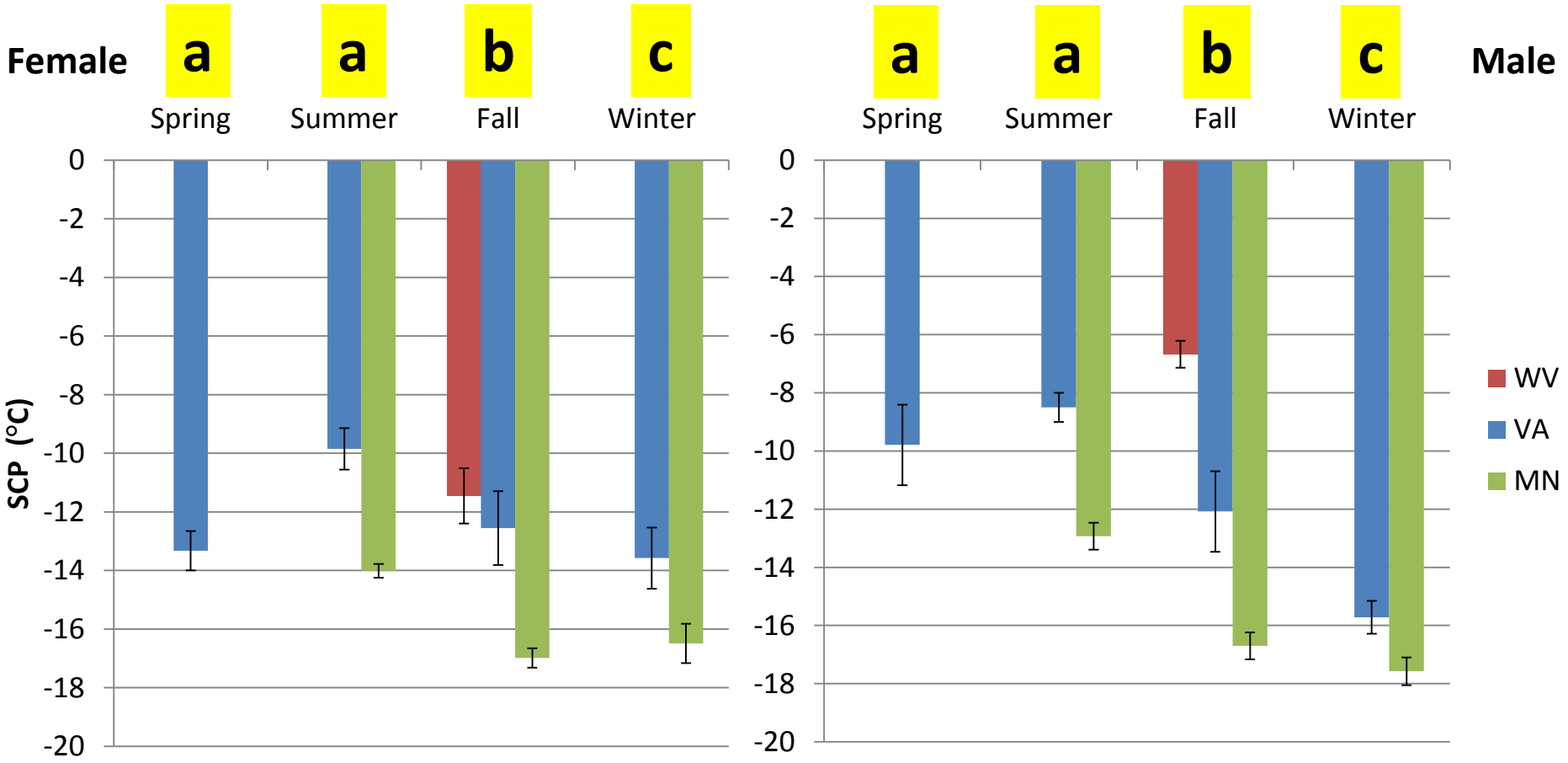

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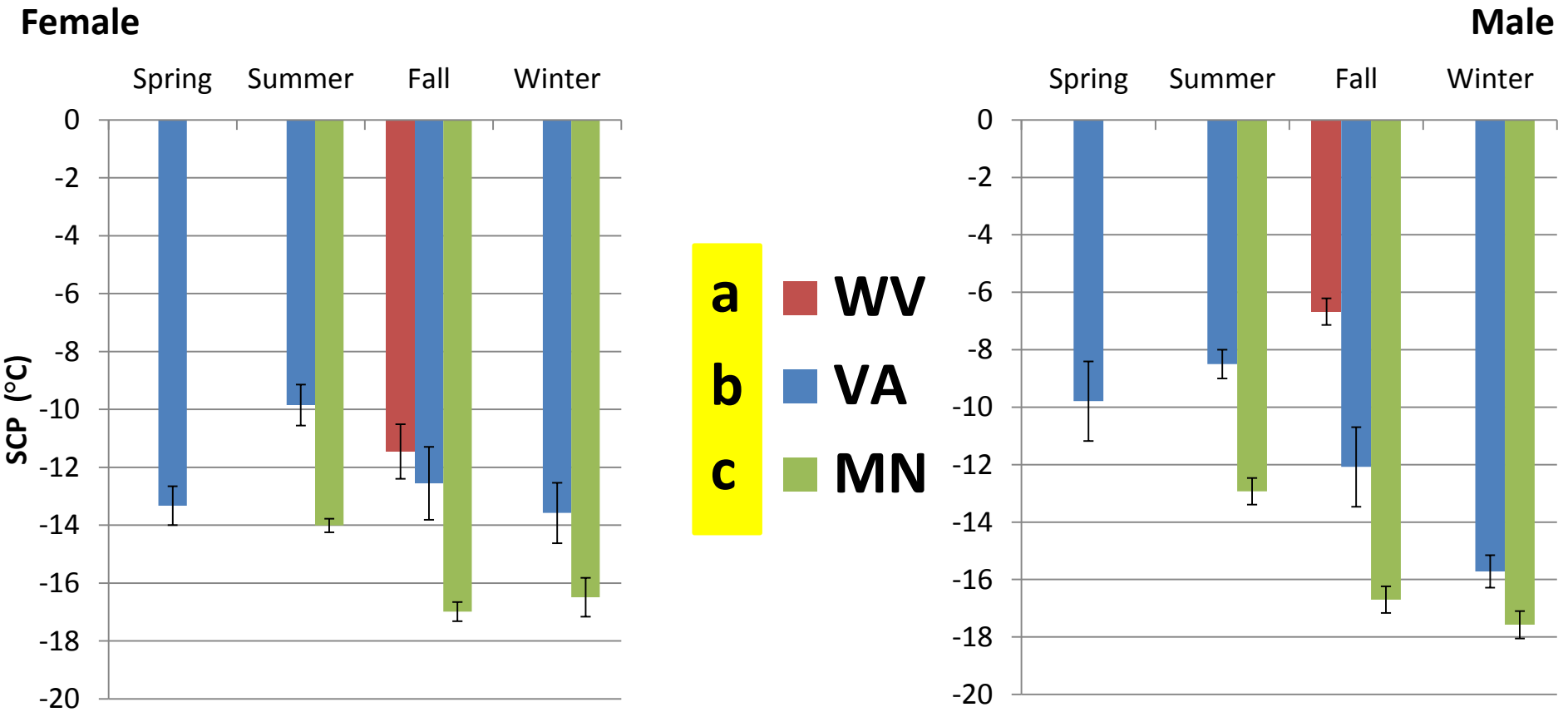

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  - Low temperature limit? — **Varies by location, season, sex**

That’s great, but BMSB numbers are only increasing

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Adults

Aggregations, sheltered areas

Yes & no

Chill Intolerant (dies before freezing)

Varies by location, season, sex

Conclusions

- **Cold drives behavior**
  - Study the triggers for overwintering behaviors
  - Study feeding at colder temperatures

- **Cold can be directly lethal (but ecological relevance?)**
  - Develop an estimate for what % of population is exposed to it (remains outdoors in winter)
  - What shelters are sufficient buffers

- **Sublethal effects of cold may be more important for BMSB**
  - Investigate fitness effects of sublethal temperatures
  - Investigate effects of multiple stressors (e.g. insecticides, time)

- **Indications of phenotypic variability in cold hardiness potential**
  - Understand the overall variability in cold tolerance
  - Investigate mechanisms for variability (e.g. diet, genes)
  - Predictions need to account for geographic acclimation

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Questions?