NOT ICE-OLATED :

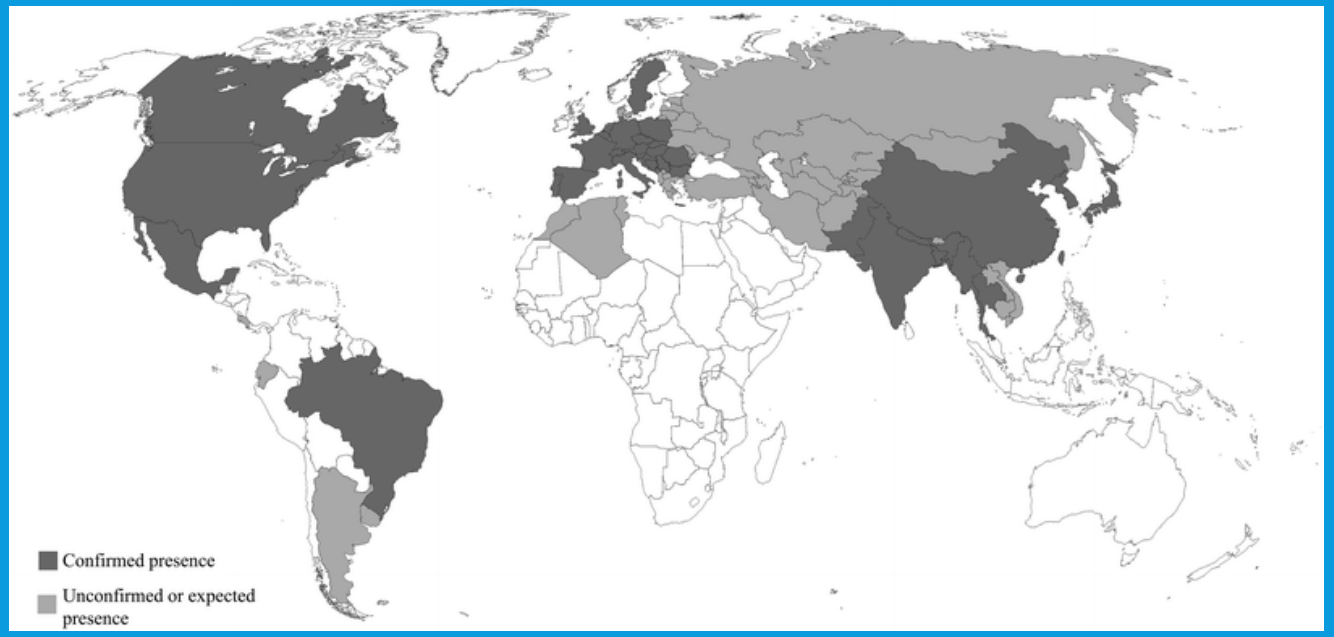
INTERACTING OVERWINTERING STRATEGIES AND THE EFFECT OF EXPERIENCE ON SURVIVAL

Loeb Lab, Cornell University – NYSAES, Geneva, NY

Dara G. Stockton, Greg M. Loeb, & Steve F. Hesler

PRESENCE IN NORTHERN CLIMATES

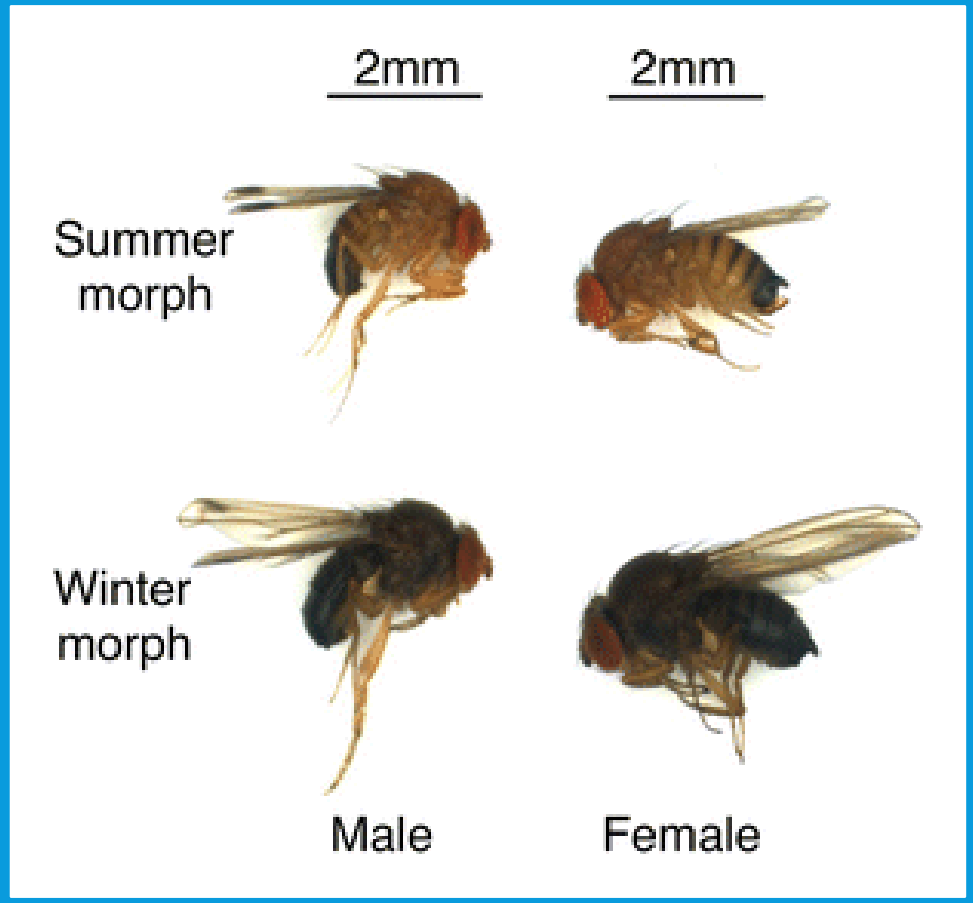
- Described in Japan in 1916
- Found in the US in 2008 along the West coast in Oregon and California
- Known populations have since spread to fruit production regions as far as Canada, Michigan, and Maine.



Estimated distribution of *D. suzukii* (Asplen et al., 2015)

SURVIVING COLD CLIMATES

- In adults acclimation results in cold tolerance
  - Low temperature + short day length
  - Short-term adult acclimation vs long-term developmental acclimation
- Survive low temperatures
  - 0-5 C for 1 year
- Dietary sequestration of sugars
  - carbohydrate rich foods like fruit
- Trehalose acts as a cryoprotectant in *D. melanogaster*



D. suzukii morphotypes (Shearer et al., 2016)

CRYOPROTECTANTS

- Freezing in the extracellular environment causes concentration of solutes.
- To reach homeostasis, the water inside the cell leaches out.
  - This leads to cell death.
- Cryoprotectants such as glucose and trehalose accumulate inside the cell to correct for the imbalance of solutes.
  - Derived from diet

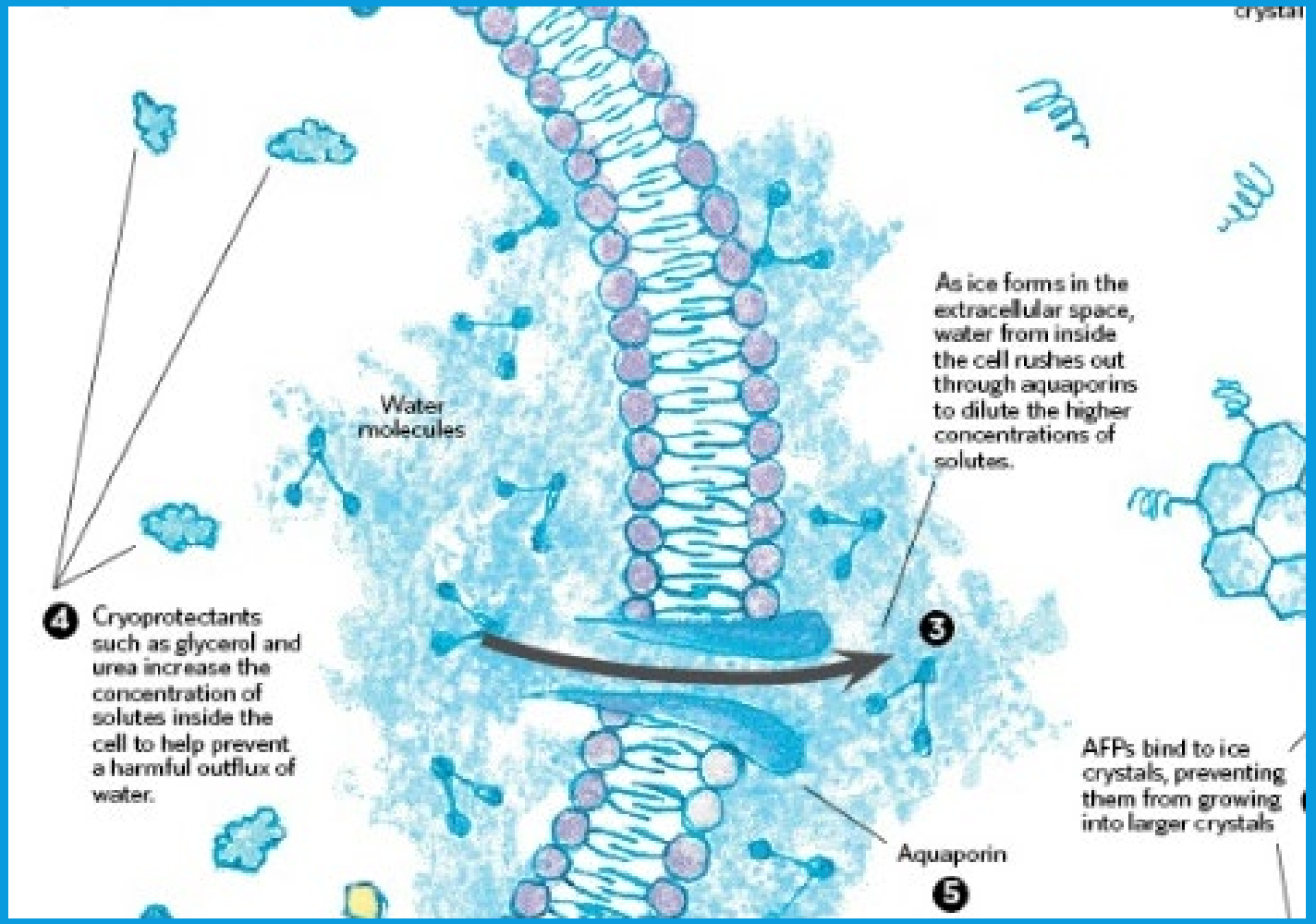
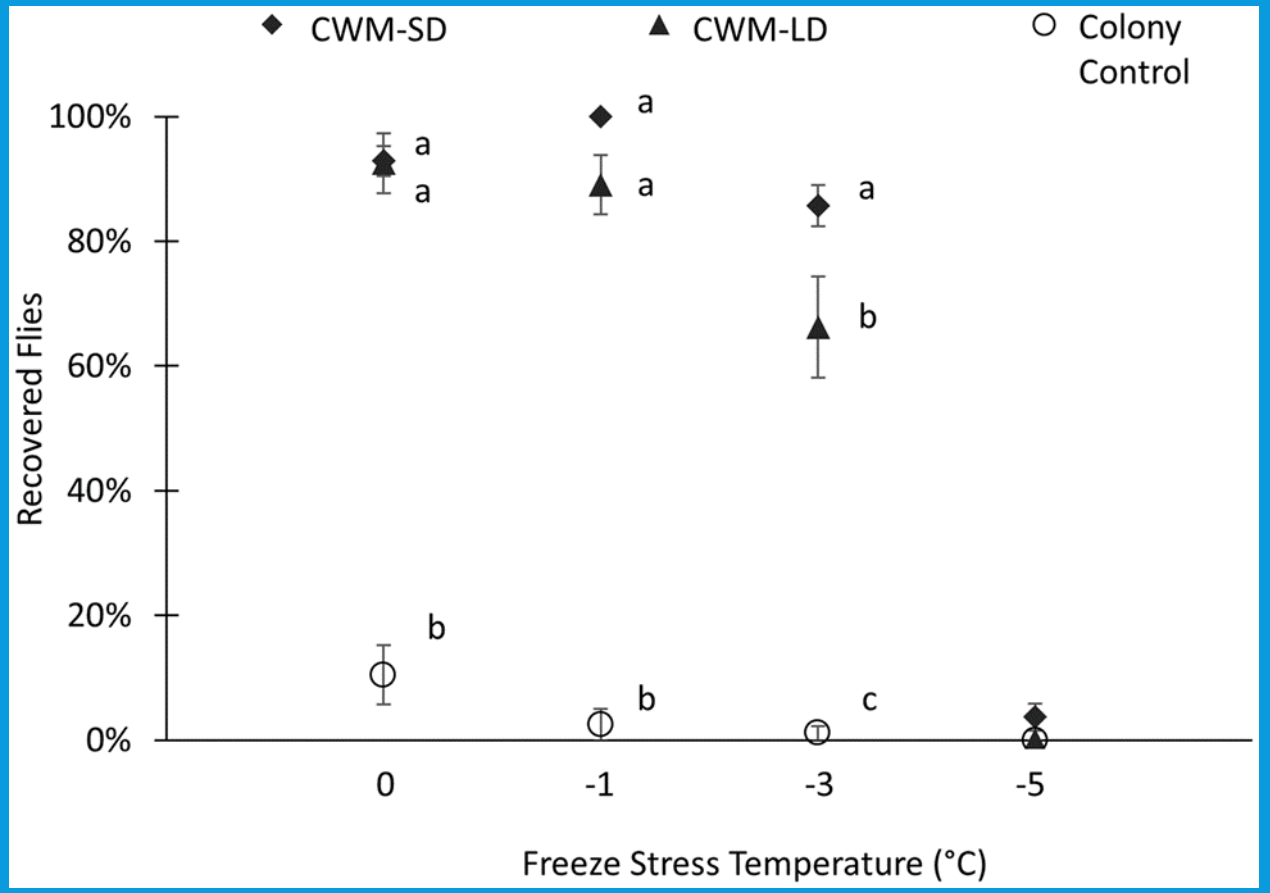


Image credit: https://www.the-scientist.com/?articles.view/articleNo/34223/title/Freezing-Cells/

ADULT SURVIVAL

- Adults appear well suited to cooler temperatures above freezing
- Adult reproduction functions best at ~ 25 C (77 F), above 28 C (82 F) reproduction declines
- Can survive long periods of quiescence at temperatures between 0-10 C (32-50 F)
- There is a report from the Walton lab of flies surviving nearly a year at 0- 5 C

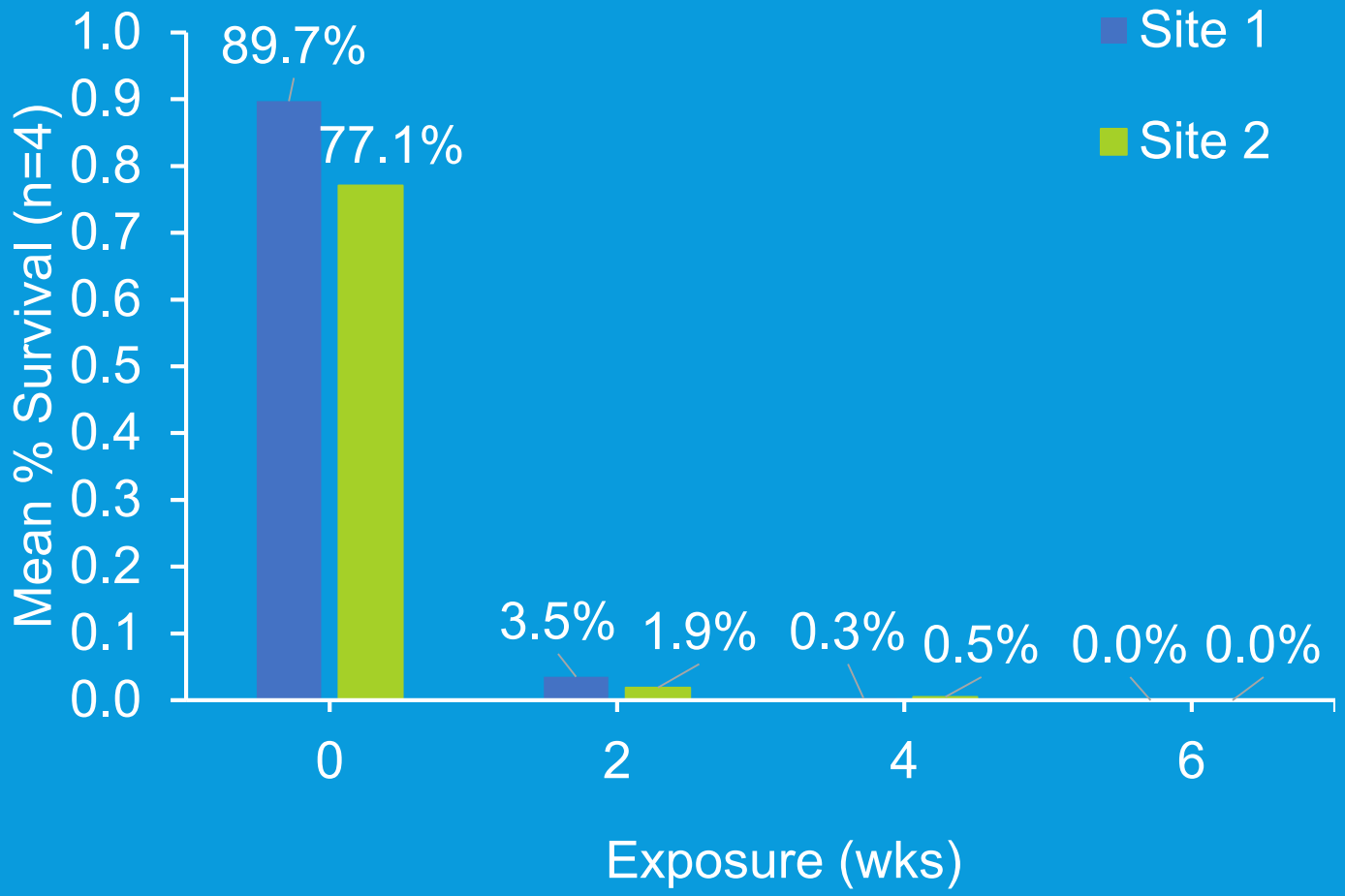


Wallingford & Loeb (2016) Developmental Acclimation of Drosophila suzukii (Diptera: Drosophilidae) and Its Effect on Diapause and Winter Stress Tolerance. Environ Entomol. 2016;45(4):1081-1089. doi:10.1093/ee/nvw088

2017-2018 FIELD TRIAL

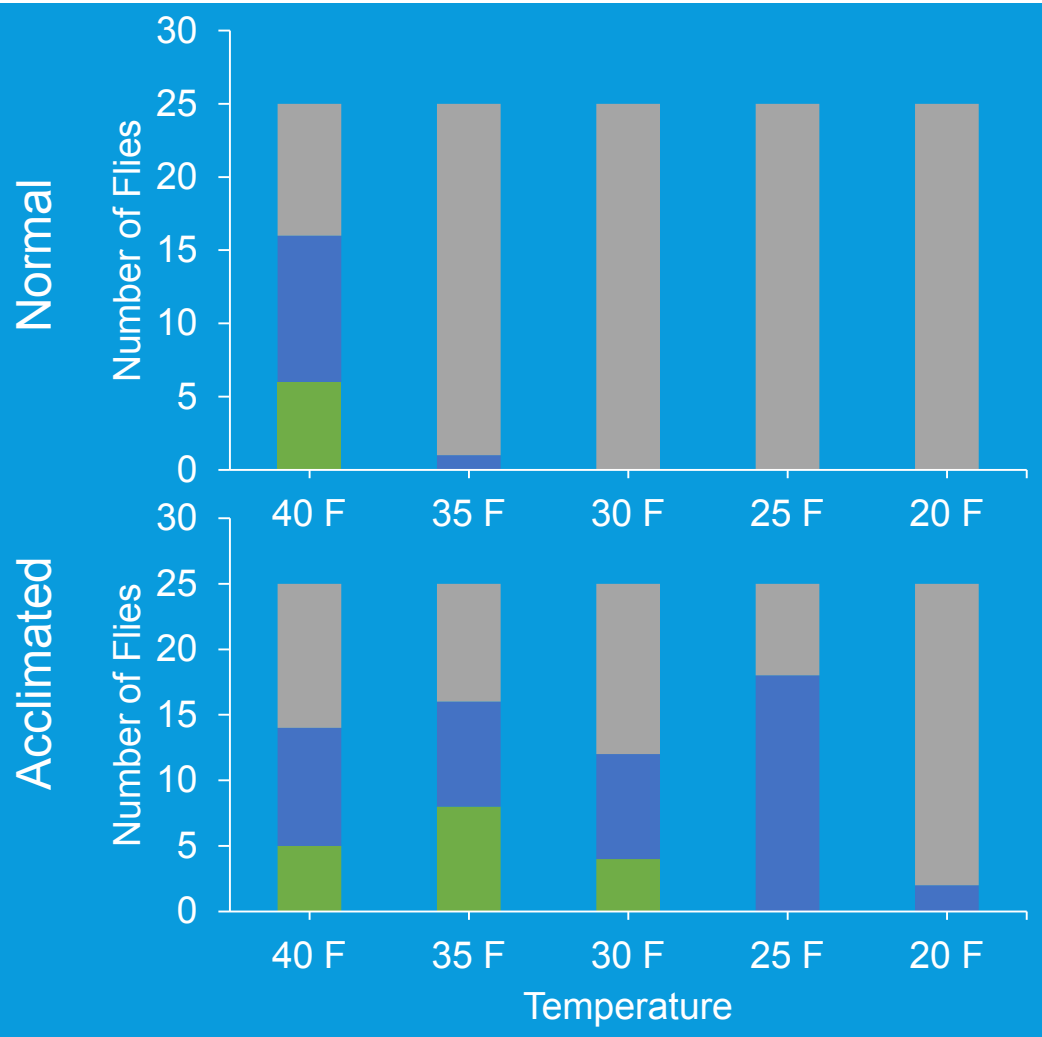
- However, in overwintering field trials we get very short-term survival at extreme temperatures
- It was approx -7 C during this experiment

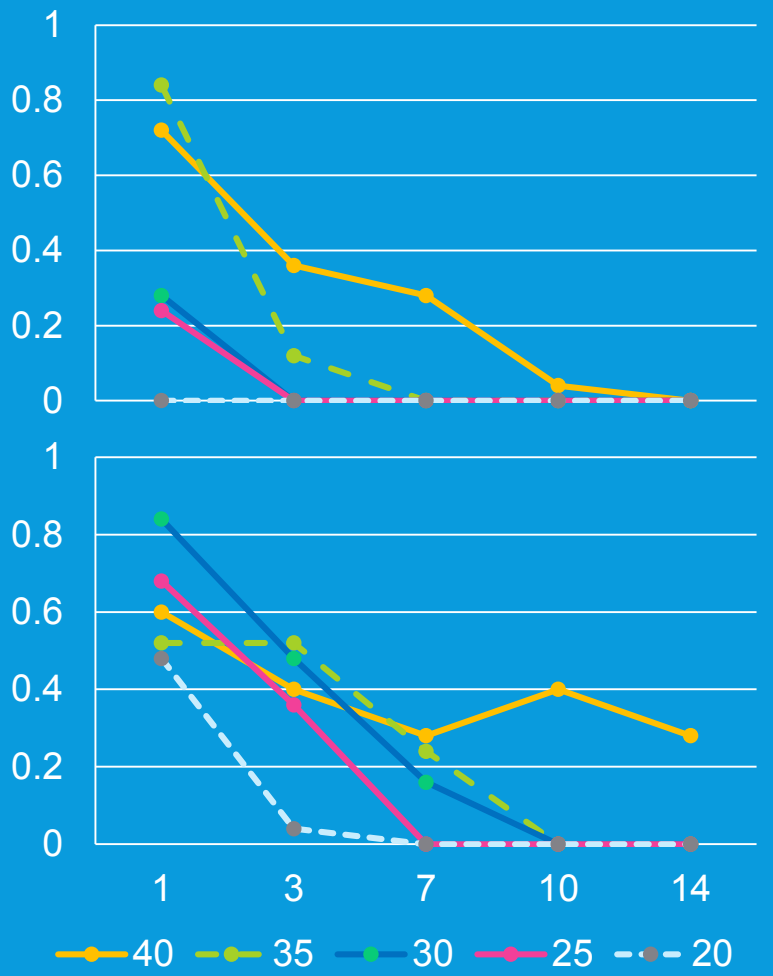
Leaf litter habitat assay 2017-2018



PUPAL SURVIVAL

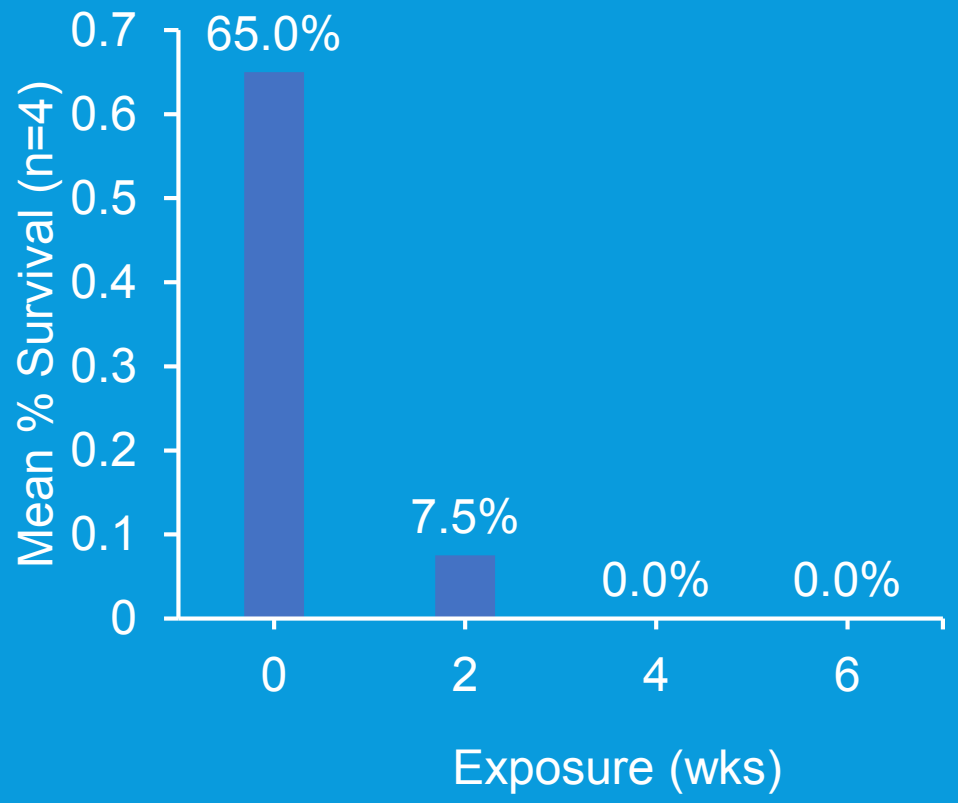
- In corroboration with other lab's reports, pupae appear less robust
- Cannot survive colder temperatures as well as adults
- Acclimation does improve survival
  - Allows development to continue below o C



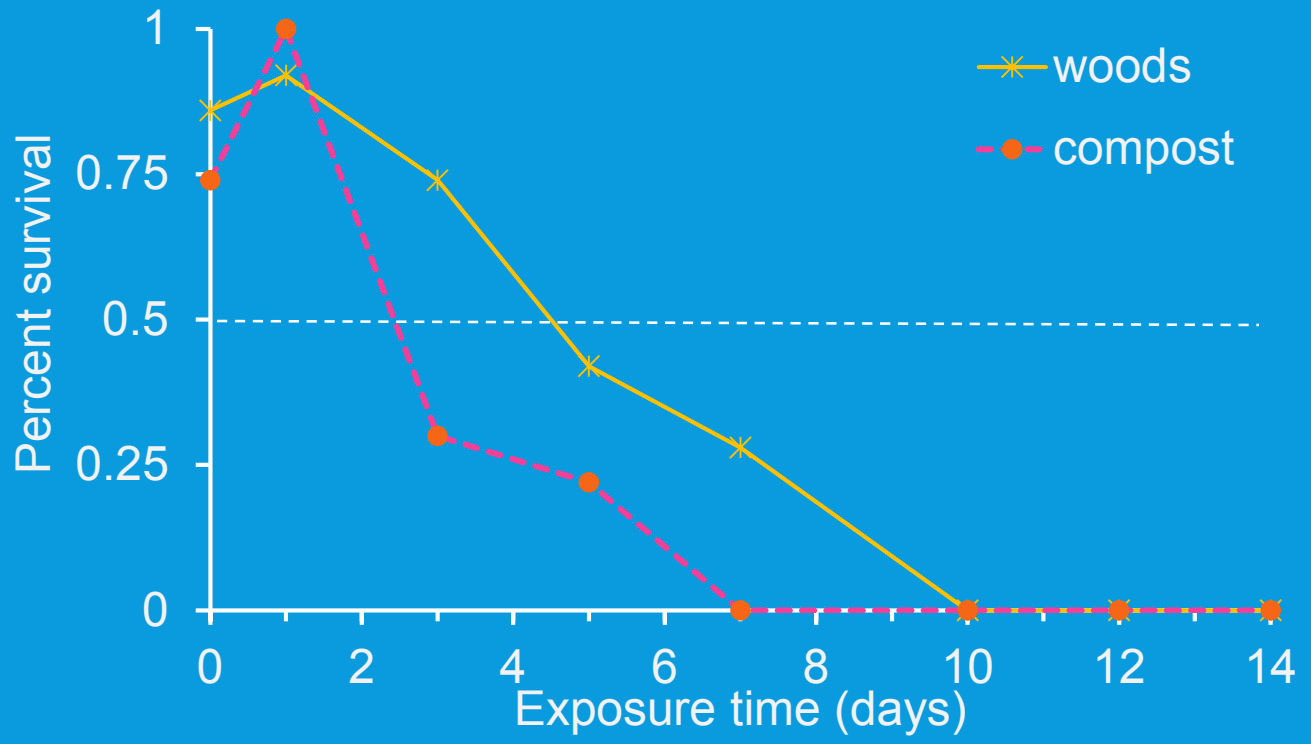


2017-2018 PUPAL HABITAT TRIAL

- In leaf litter we found poor survival below freezing after several weeks

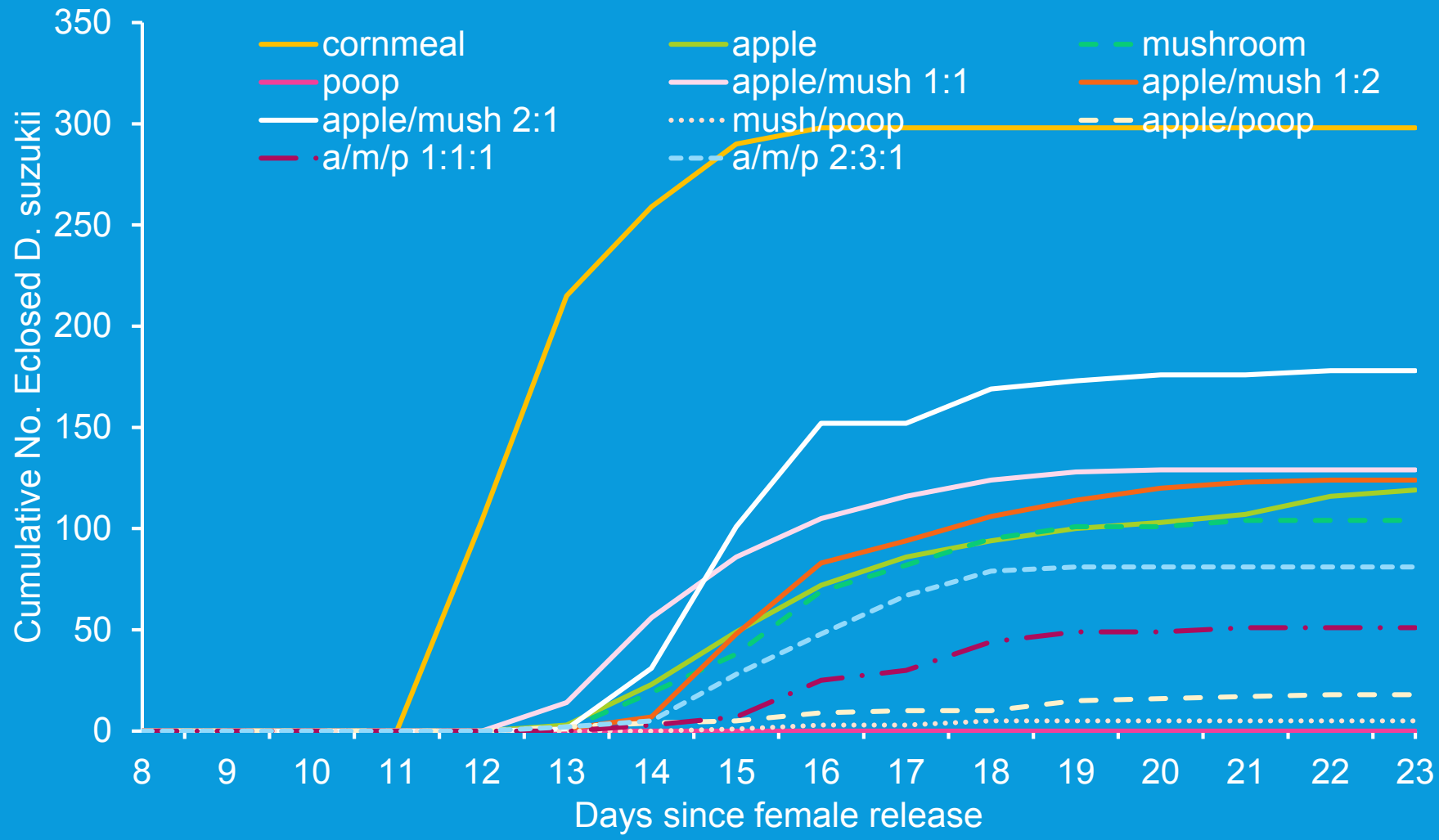


- Currently running an alternative assay investigating survival in leaf litter vs compost



EFFECT OF DIET ON OVERWINTERING

- Carbohydrates are important for survival overwinter
- Diet has effects on development
- Can reproduce on mushroom and bird manure
- Manure may provide cryoprotectant proteins



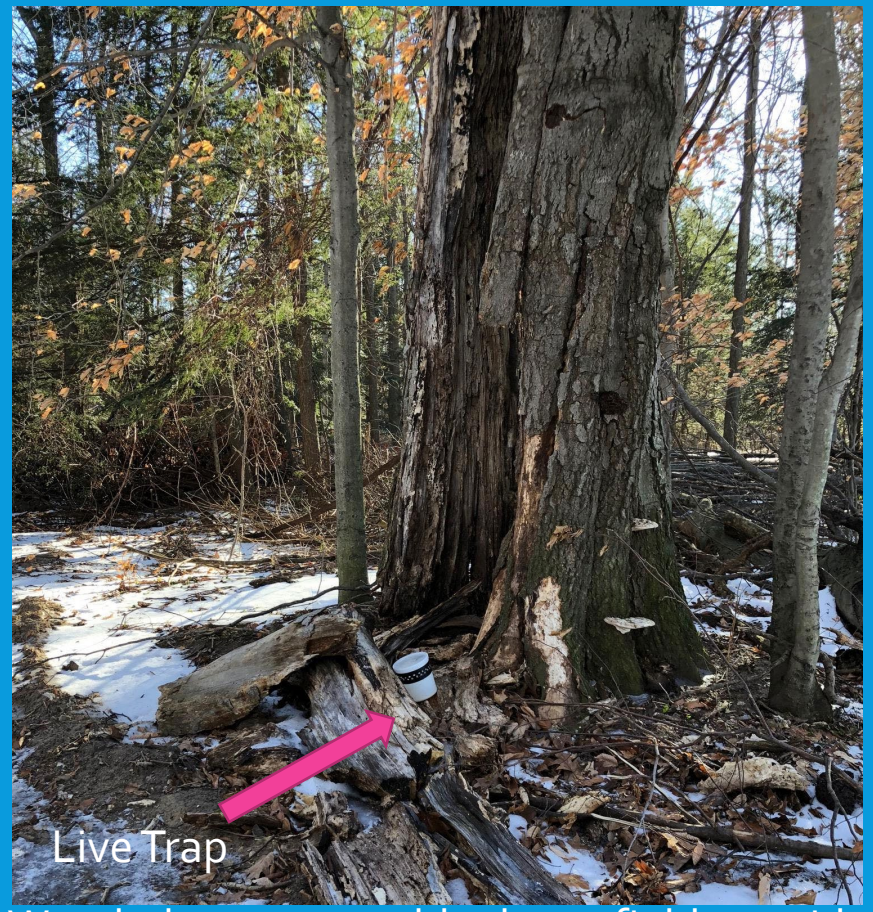
INTERMITTENT QUIESCENCE

- Winter warm-up periods likely important for survival
- Do not appear to store carbohydrate resources for long
  - need regular feeding
- Undergoes a shallow diapause
  - Come out to feed on warmer days

diet	*treatment*	*wk 0*	*wk 1*	*wk 2*	*wk 3*	*wk 4*
cornmeal agar	never	40	NA	NA	NA	34
cornmeal agar	1/ wk	40	32	31	18	13
cornmeal agar	2/ mo	40	NA	24	11	5
cornmeal agar	1/ mo	40	NA	29	NA	13
agar + water	never	40	NA	NA	NA	0
agar + water	1/ wk	40	30	11	0	0
agar + water	2/ mo	40	NA	4	0	0
agar + water	1/ mo	40	NA	10	NA	0

WORKING HYPOTHESES

1. *D. suzukii* overwinters locally in northern climates
2. Most overwintering flies are adults
3. It may be possible for a low level of reproduction and development to occur in compost piles and wooded areas
4. During the winter, adults flies are likely feeding on apples and pears, etc…
5. Alternative resources may include mushrooms and bird manure



Wooded area near a blueberry field, outside Geneva, NY; Winter 2017-2018.

FUTURE DIRECTIONS

1. Overwintering habitat field trials
   - Adult and pupal survival in leaf litter and compost
2. Lab assays on diapause
   - How diet influences survival during warm-up periods
3. Temperature, diet, and fecundity
   - Fitness costs of overwintering
   - How does that affect population rate increase in the spring?
4. Winter-time trapping
   - Differential attraction in wintermorphs
   - Can we trap winter populations to reduce population further?

Large compost pile and potential fly refuge near Geneva, NY 2018

ACKNOWLEDGEMENTS

- Loeb lab staff
  - Steve Hesler
  - Karen Wentworth
  - Molly Cappiello
  - Shin-Young Cha
  - Gabrielle Brin-d'Amore
- Collaborators in other labs
  - Walton Lab - Oregon
  - Chiu Lab - California
  - Gut Lab – Michigan
  - Issacs Lab – Michigan
  - Drummond Lab – Maine
  - Rodriguez-Saona Lab – New Jersey
  - Burrack Lab – North Carolina