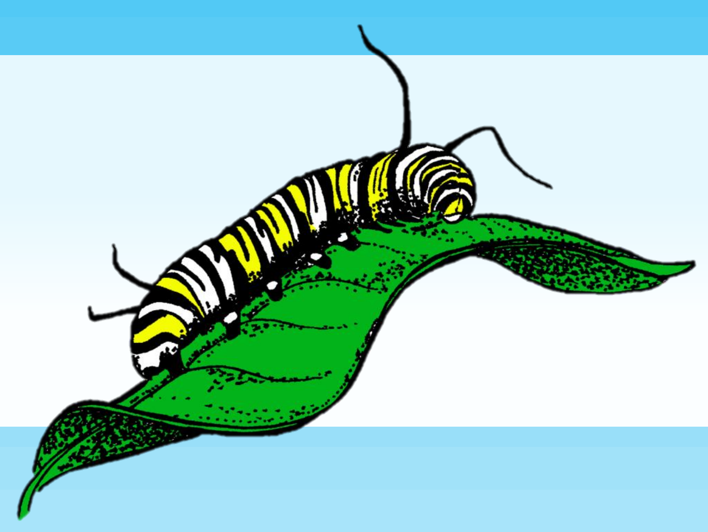
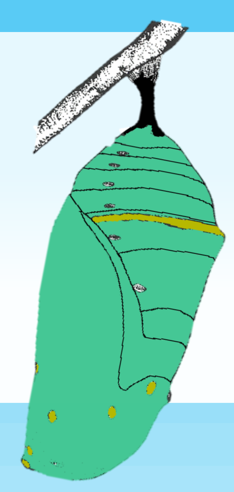


Cold Tolerance of Immature Monarchs

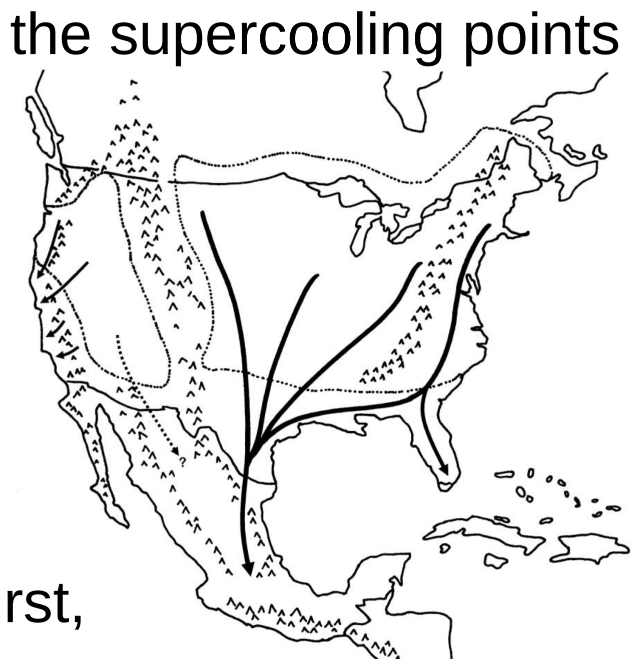


Kelly Nail and Karen Oberhauser
University of Minnesota, Conservation Biology Program, University of Minnesota,
187 McNeal Hall, 1985 Buford Avenue, St. Paul, MN 55108, USA

Introduction

Eastern North American Monarchs (*Danaus plexippus*) make a yearly fall migration that typically takes them to overwintering sites in central Mexico. However, monarchs have been reported breeding throughout the winter along the U.S. Gulf Coast (Howard et al., 2010). These monarchs are more likely to be exposed to lethal cold temperatures. While the freezing points of adult monarchs are known (-7.7°C for dry adults and -4.2°C for wet adults), little is known about the cold tolerance of immature monarchs (Anderson and Brower, 1996).

This study determines the supercooling points (freezing temperature) of monarch eggs, larvae, and pupae. Additionally, the lower lethal temperature (temperature at which monarchs die) was determined for eggs, first, and third instar larvae.



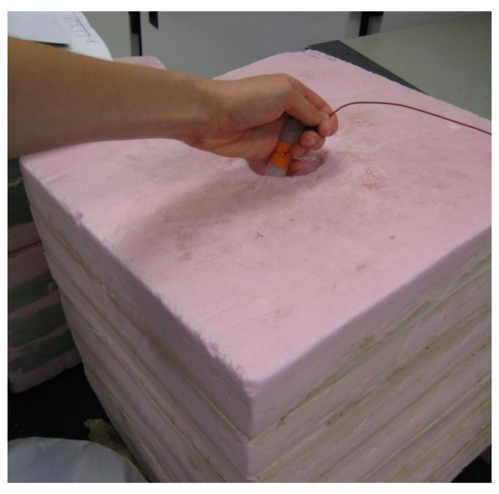
Fall migration path of eastern North American monarchs.

Methods

Experimental monarchs were offspring of wild-caught individuals from Minnesota and Wisconsin in 2011. Eggs were laid on tropical milkweed and larvae were fed common milkweed. Monarchs were raised in incubators (LD 15.5 : 8.5 h photoperiod; 22°C : 20°C)

Supercooling points (SCP) were obtained using contact thermocouple telemetry and lowering the temperature by approximately 1°C/min (Carillo et al., 2004).

Lower lethal temperatures (LLTemp) were obtained for eggs, first and third instars. Monarchs eggs and larvae were attached to a thermocouple and cooled to a particular temperature at a rate of approximately 0.3°C/min and then immediately removed (Carillo et al., 2004). Monarchs were warmed up gradually and survival was assessed by maximum number hatched (eggs) or by number alive after one day (larvae).



Monarch larvae in a calibrated Styrofoam box for LLTemp cooling.

Results

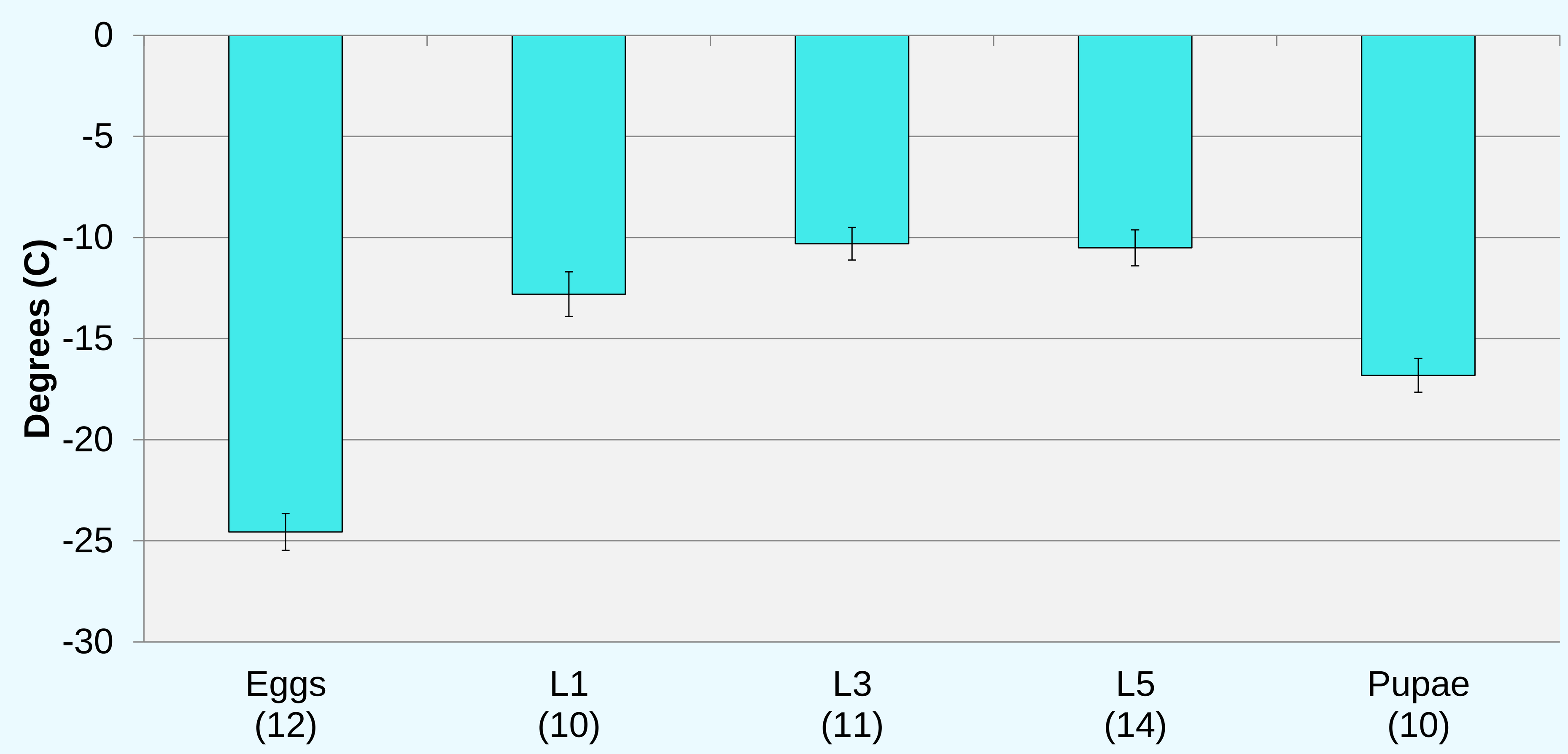


Figure 1. Supercooling points of immature monarchs at 5 different stages of development (mean temperature ± SE). Sample sizes are listed in parentheses.

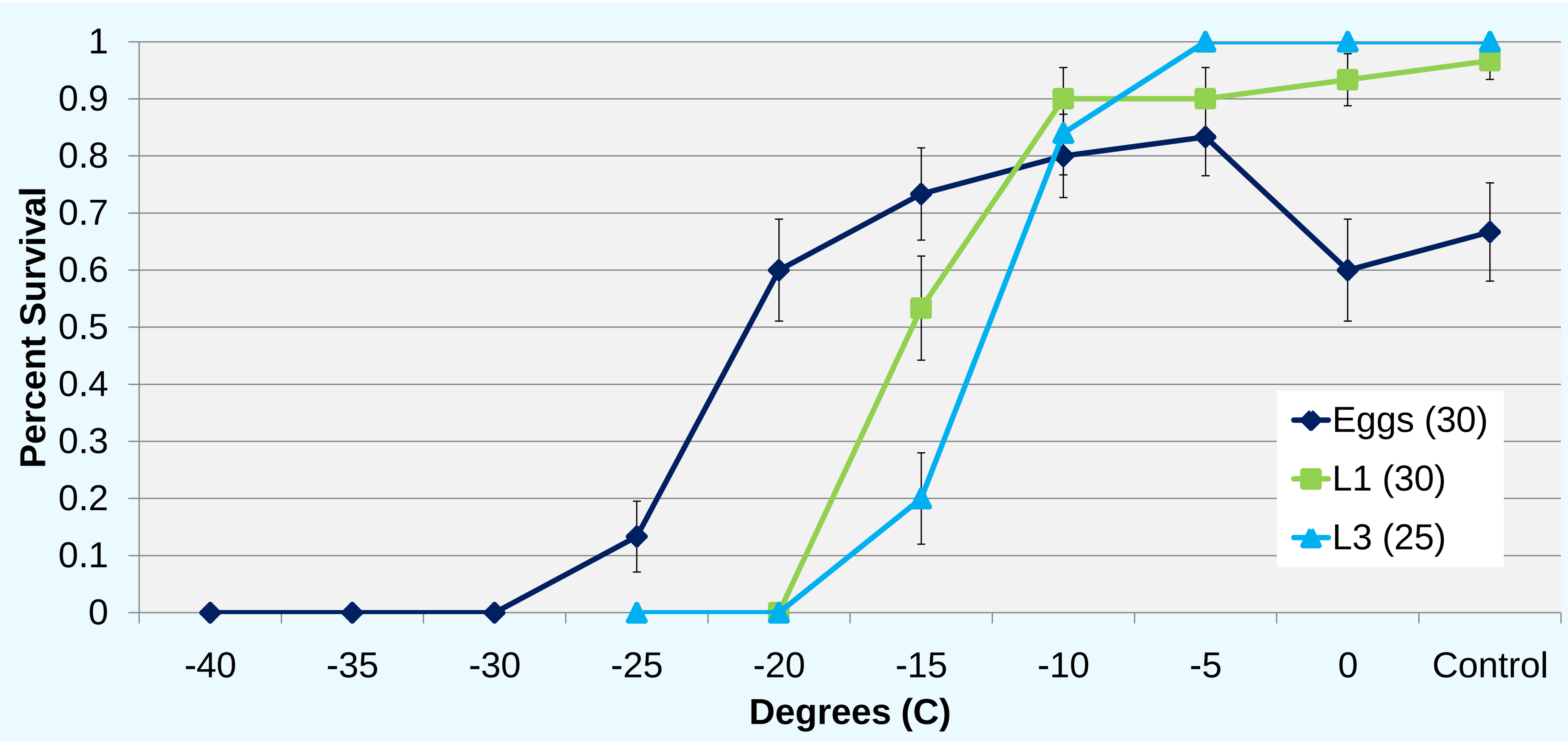


Figure 2. Lower lethal temperatures for monarch eggs, first and third instar larvae (mean survival ± SE). Sample sizes for each temperature are listed in parentheses.

Discussion

All stages of immature monarchs tested appear to have lower supercooling points than overwintering adults. Eggs have the lowest supercooling point, at -24.6°C, followed by pupae at -16.8°C. Temperatures this low are almost never seen, particularly for extended periods of time, along the U.S. Gulf Coast.

Larval survival appears relatively consistent above the supercooling point. However, there is little to no survival for the stages tested once the temperature reaches the supercooling point. This suggests that immature monarchs are chill tolerant, but not freeze tolerant.

These results suggest that immature monarchs overwintering along the U.S. Gulf Coast are likely to survive even the coldest temperatures to which they are likely to be exposed.

Future research includes establishing the lower lethal temperatures for pupae and fifth instar monarchs, as well as determining the sublethal effects of cold on all monarch stages; establishing lower lethal times (how long monarchs can survive at a particular temperature) would be useful, and determining whether monarchs undergo rapid cold hardening.

Literature Cited:

Anderson, J.V. and L. P. Brower. 1996. Freeze protection of overwintering monarch butterflies in Mexico: critical role of the forest as a blanket and an umbrella. Ecological Entomology 21: 107-166.

Carillo, M. A., N. Kaliyan, C. A. Cannon, R. V. Morey, and W. F. Wilcke. 2004. A simple method to adjust cooling rates for supercooling point determination. CryoLetters 25: 155-60.

Howard, E., H. Aschen, and A.K. Davis. 2010. Citizen science observations of monarch butterfly overwintering in the southern United States. Psyche 2010: 1-6.

Acknowledgements:

Thank you to Steve Kells and Marc Eaton for allowing me to use and assisting me with the freezing chamber. A special thanks to my undergraduate assistants for their help with rearing. Additionally, I appreciate the assistance of the UMN Monarch Lab for their help reviewing this poster.

Funding Sources:

University of Minnesota Conservation Biology Graduate Program
NSF
The Xerces Society for Invertebrate Conservation