Melanie Frazier
University of Washington, Seattle, WA

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Insect Population Growth: Hotter is Better

Introduction

Abstract

To understand ecological issues such as biological diversity, food web dynamics, and biotic responses to climate change, we likely need to understand how temperature affects organismal physiology as well as their ability to adapt to divergent thermal environments (Clarke 2003). One of the primary goals of my research is to study how evolution has altered physiology to optimize function at different temperatures and the limitations that may prevent organisms from fully compensating for their thermal environment.

The Debate

Evolutionary physiologists have long debated whether species can evolutionarily compensate for the kinetically depressing effects of low temperature.

Side 1: The "thermodynamic school" maintains that Hotter is Better because species living at cold temperatures cannot evolutionarily overcome the kinetically depressing affects of low temperature. Thus, a cold adapted species will have lower fitness than a warm adapted species.

Side 2: The "biochemical adaptation school" argues that adaptation at the macromolecular level can compensate for low body temperatures.

Methods

To resolve this debate, Raymond B. Huey, David Berrigan, and I examined the relationship between maximum rates of population growth (r_{max}) and optimal temperature (T_o) for 65 insect species using data we compiled from the literature.

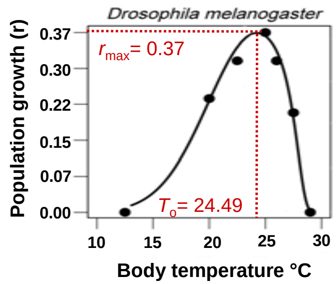
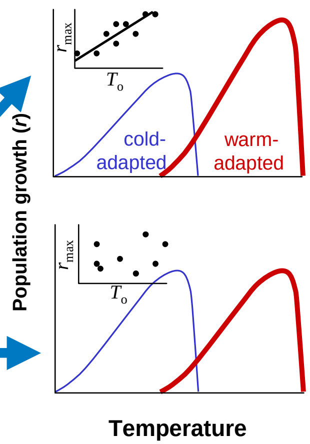


Fig 1. Example of a thermal fitness curve we obtained from the literature.

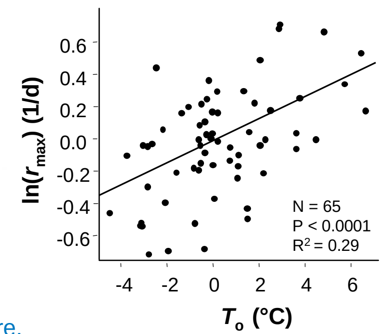
Prediction



If "Hotter is Better," r_{max} will increase with T_o and thus, warm-adapted species will have higher intrinsic rates of population growth due to increased kinetic energy at higher temperatures.

If the Biochemical Adaptation Hypothesis is correct, then r_{max} will be independent of T_o, because evolutionary adaptation can fully overcome the rate limiting effects of low temperature.

Results



Warm adapted insects have faster population growth rates according to a phylogenetic analysis that corrects for non-independence of species. This supports the "Hotter is Better" hypothesis that organisms cannot fully overcome fundamental thermodynamic constraints to adapt to divergent thermal environments.

Analysis also showed that species living in warmer environments had higher T_o (P<0.001). However, the relationship between mean environment temperature and T_o was not one-to-one, a 1 °C increase in environment temperature was associated with only a 0.16 °C increase in T_o.

Impact of Research

We've shown that warm adapted insect species have higher rates of population growth than insects adapted to colder temperatures. This information will help researchers predict the affects of introduced species with different thermal optima on their environment. A better understanding of the affects of temperature on organismal physiology as well as their evolutionary capacity to adapt to divergent thermal environments will also help us develop better models to understand the biotic response to climate change.

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