



The Urban Heat Island's Impact on Ecdysone Levels Throughout Development of the Western Black Widow

Claire Moen, Jennifer Hackney, J. Chadwick Johnson

School of Mathematical and Natural Sciences Arizona State University



Introduction

- Rapid urbanization has caused the environment of many organisms to change drastically, and little is known about the potential long term consequences [1].
- Built structures retain heat leading to elevated temperatures (Urban Heat Island (UHI)) [2].
- The Western black widow (*Latrodectus hesperus*) is a medically important urban pest species.
- Urban widow populations are 30x more densely populated than desert counterparts [3].
- Surprisingly, current work demonstrates that Phoenix's urban-desert nighttime temperature differential in July (33°C vs 27°C, [4]) is associated with higher spiderling mortality, lower mass throughout development, and delays in molting [5].
- Here, we hypothesize that UHI temperatures are negatively affecting the ability of *L. hesperus* to regulate hormone levels.
- Molting is controlled by a variety of hormonal and environmental factors, with the hormone Ecdysone (20-hydroxyecdysone "20E") initiating the molting process [6].
- Delayed development has been associated with decreased 20E levels in many arthropods including flies, hornworms, and silkworms [7,8,9].
- We predict spiders raised at 33°C will 1) have a significantly lower mass, 2) produce lower levels of 20E through development, and 3) delay 20E production to trigger molting.

Methods

- Adult females were collected from four sites across the urban Phoenix Area at least 2 km apart to minimize genetic relatedness.
- 100 eggs from each female's first egg sac were weighed (μg), placed in individual boxes (4.13x4.13x5.56 cm), and stored at room temperature.
- On day 44, surviving spiders (ranging from 62 to 88) were divided into 27°C and 33°C.
- One spiderling from each treatment was weighed and frozen until day 72 of development.
- Each spiderling was ground in methanol and centrifuged to extract 20E.
- Hormone concentrations were determined via an Enzyme Immunoassay based on competition between sample 20E and an enzyme-linked 20E molecule that produces a measurable yellow-colored product (Ellman's Reagent).
- Samples were read on an ELX808IU Ultra Microplate Reader, and 20E concentrations were determined by comparison with a 20E standard curve.



References

[1] Hawkes et al., 2004. *Applied Meteorology* [2] Kim 1991. *Intl. Remote Sensing* [3] Johnson et al., 2012. *Midland Naturalist* [4] Johnson, unpublished data [5] Johnson et al. in prep [6] Krishnakumaran 1970. *Biol bull* [7] Tennessen & Thummel, 2011. *Current Biology* [8] Schwartz & Truman, 1983. *Developmental Biology* [9] Jindra & Riddiford. 1996 [10] Ishimoto & Kitamoto, 2011. *Fly* [11] Hirashima, Rauschenbach, & Sukhanova 2000. *Bioscience, Biotechnology, and Biochemistry*

Results

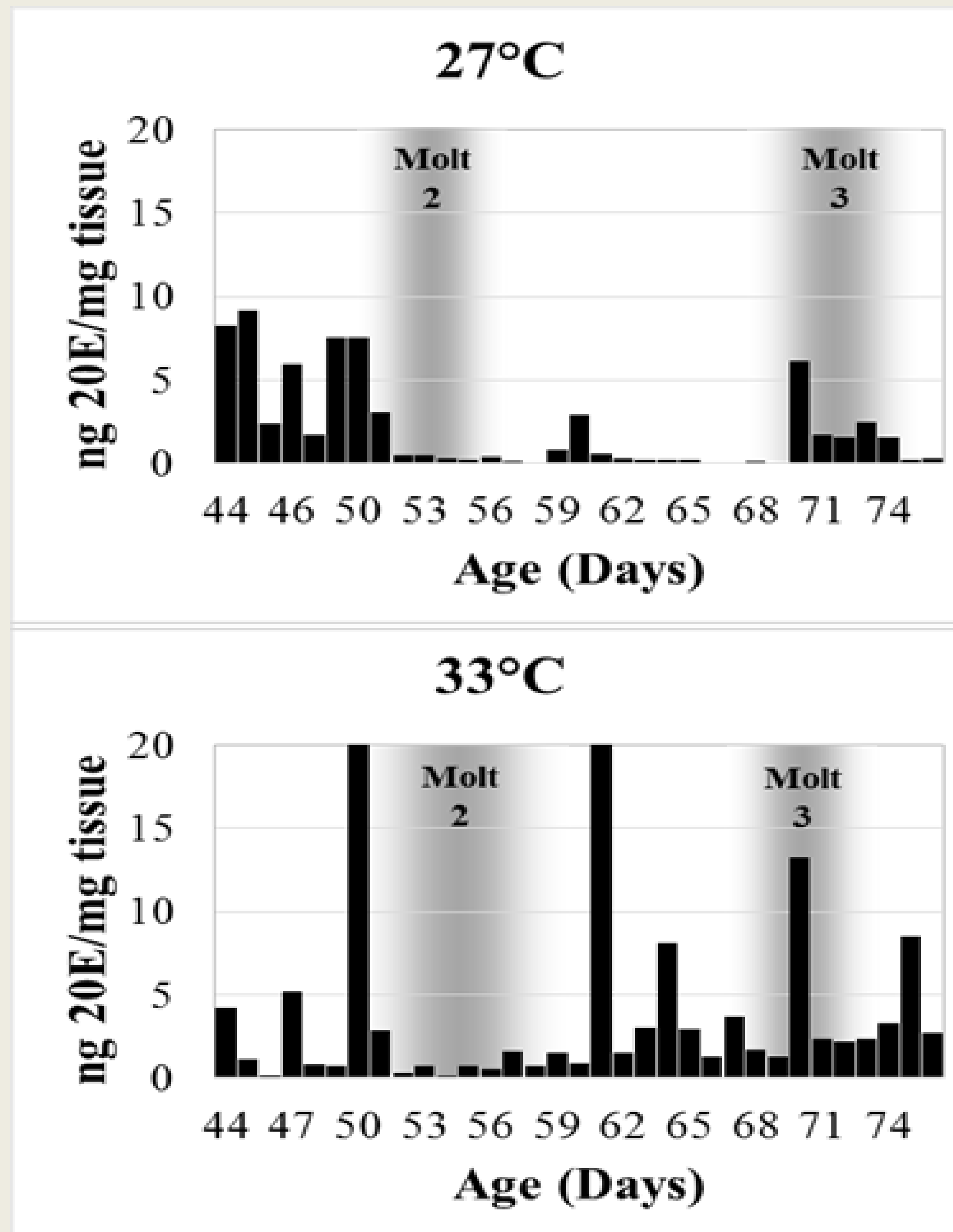


Figure 1: Ecdysone Levels Throughout Development

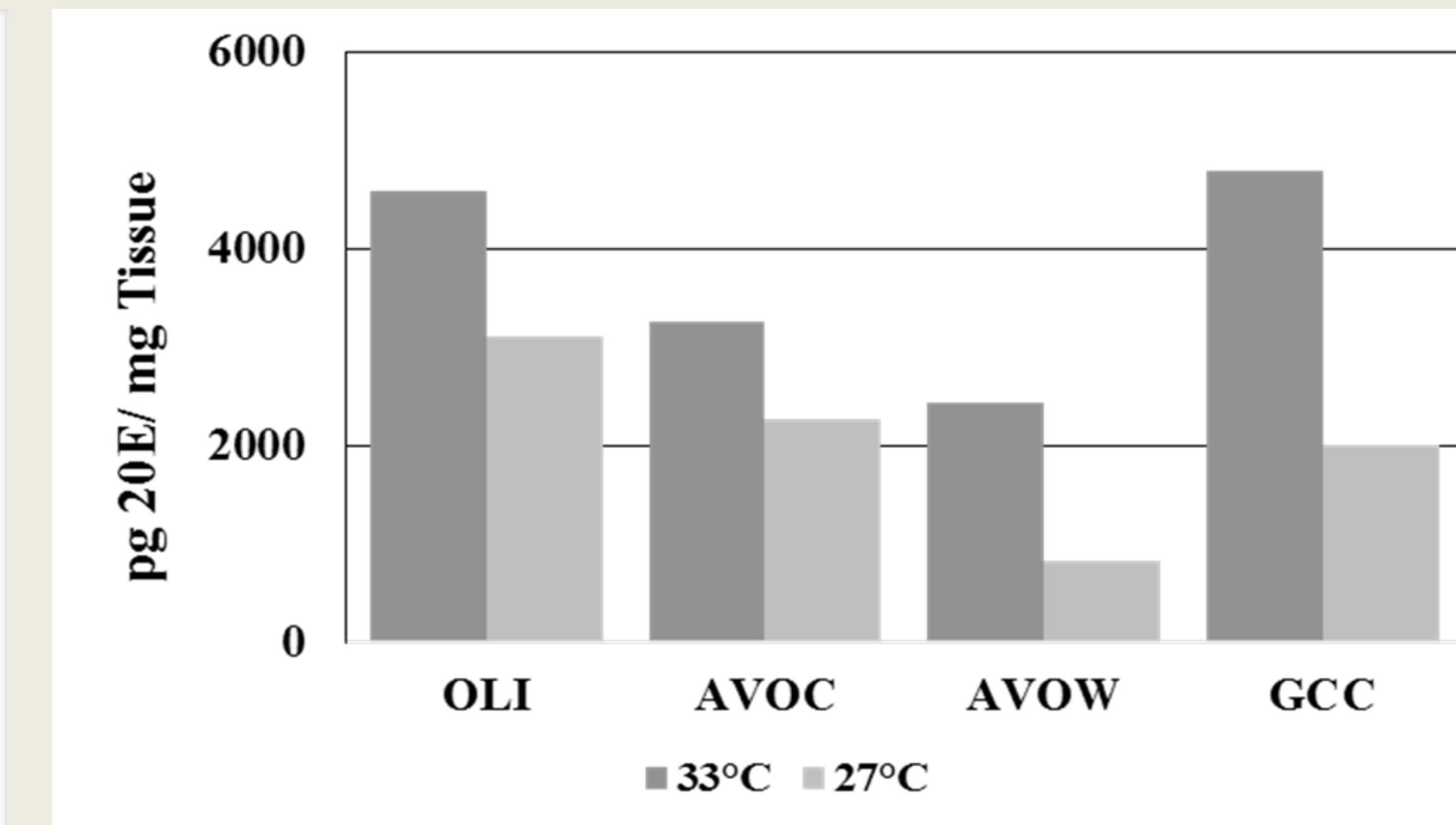


Figure 2: Average Ecdysone Levels Five Days Prior to Third Molt

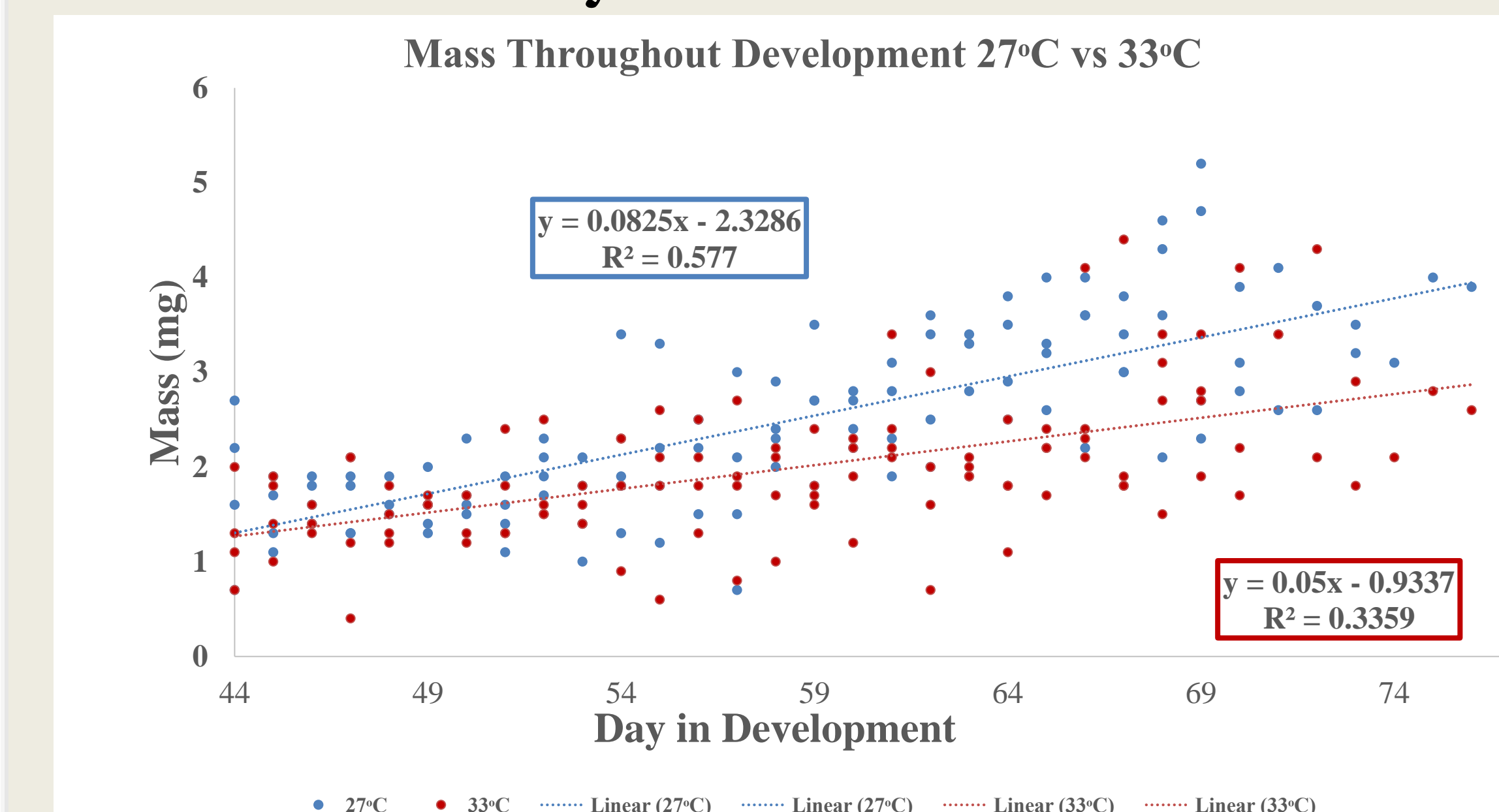


Figure 3: Mass Throughout Development

Discussion

- Temperature plays a critical role in determining the timing and amount of 20E produced at UHI temperatures leading to a consistently higher concentration of 20E, as well as additional peaks that are unrelated to molting.
 - This suggests that the UHI is causing the hormonal network to drastically increase production of 20E much like it would in the case of starvation or other stressors [10,11].
- Significant familial variation in 20E concentrations indicates a strong interaction between genes and the environment that affects the ability of *L. hesperus* to thrive and develop at elevated temperatures.
 - Families with a smaller increase in 20E production at 33°C should be best adapted to changing temperature conditions, and therefore, will be selected for in urban settings.
- Our work has focused on using an integrative ecological and physiological standpoint to understand the effects of the changing urban environment on the mechanisms that have allowed *L. hesperus* to thrive in the UHI, furthering our understanding of how organisms are adapting to the rapidly expanding urban environment.
- Future work will look at development across a finer range of microclimate temperatures (e.g. 29 & 31°), and use PCR to assess the expression of 20E targets and biosynthesis genes to explore the mechanism by which temperature modulates endocrine function.