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

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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 (33ºC vs 27ºC, [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 silkmoths [7,8,9].
- We predict spiders raised at 33ºC 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 27ºC and 33ºC.
- 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] Hawkines 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 *Midland Naturalist* [4] Johnson, unpublished data [5] Johnson et al.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

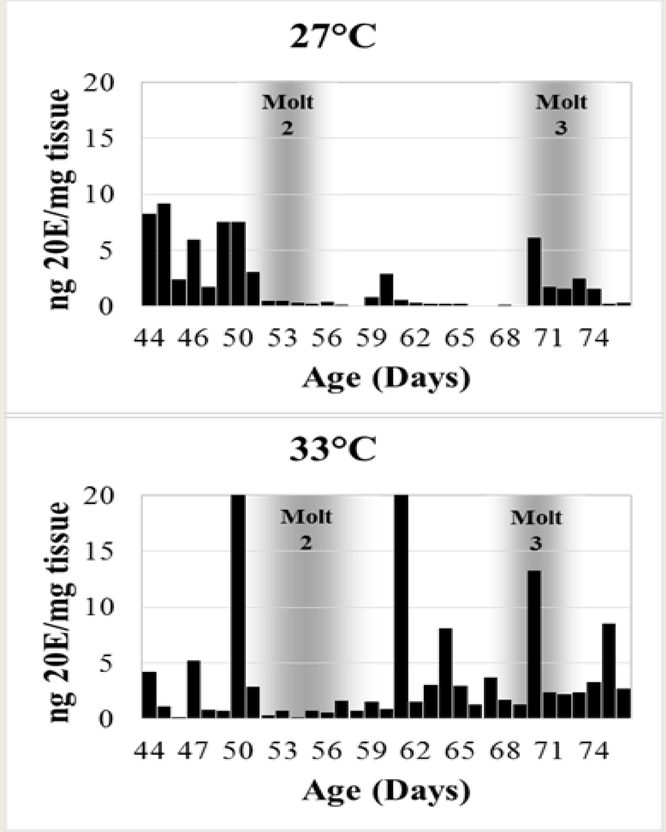

Figure 1: Ecdysone Levels Throughout Development

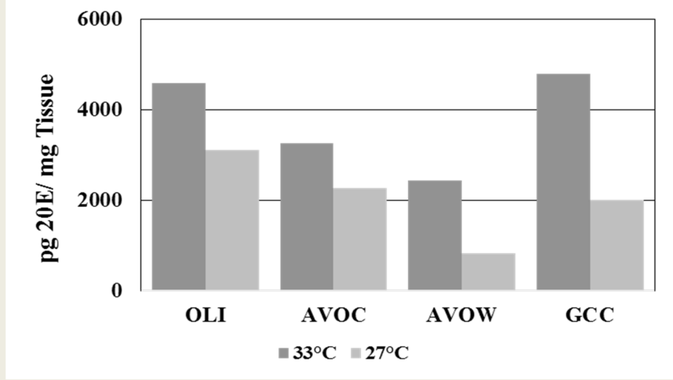

Figure 2: Average Ecdysone Levels Five Days Prior to Third Molt

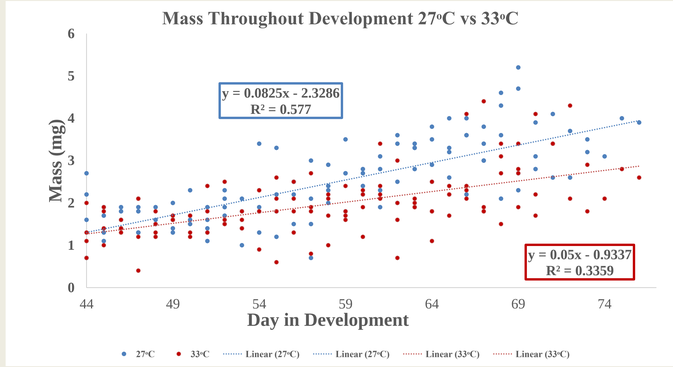

Figure 3: Mass Throughout Development

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 33ºC 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.