Urban Heat Island Effects: How Temperature Influences Male Development and Behavior in the Western Black Widow Spider

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INTRODUCTION

- The urban heat island (UHI) causes temperatures to be warmer in urban areas when compared to rural areas, due largely to built structures trapping heat [1].
- While some species are negatively affected by urbanization and the UHI, others thrive and are more successful than their rural counterparts [2], e.g., black widow spiders, *Latrodectus hesperus*.
- Temperature and terrestrial arthropod body mass are inversely correlated [3].
- Black widow males must mate while avoiding sexual cannibalism.
- Male competition leads to the female mating preference of larger black widow males [4].
- We predict increased temperatures cause males to develop more rapidly, have a lesser mass, and be more voracious when foraging and courting females.

METHODS

- We studied 359 male spiderlings that were F1 laboratory reared from gravid urban- and desert-collected females.
- Fifty eggs were processed from each F1 egg sac and split evenly between 27º and 33º treatments after 44 days at 24ºC.
- These temperatures represent average July nighttime temperatures in desert (27ºC) and urban (33ºC) microhabitats for black widows (JCJ, unpubl. data).
- Developmental trends (molting, mortality) were recorded daily.
- Foraging voracity was scored incrementally for two hours and conducted with two flies for six feedings after each male's penultimate molt.
- Courtship activity (♂) on a fresh web was scored every 5 minutes for three hours after each male's ultimate molt.

RESULTS

- 33º males reach their penultimate molt 14 days quicker than 27º males ($F_{1,354}$=10.549, p=0.001) (Fig 1).
  - Familial effect on development is also present ($F_{33,322}$=4.874, p<0.001).
- On average, 33º males weighed 2.0mg less than 27º males ($F_{1,14.2}$=60.516, p<0.001) (Fig 2).
- 33º males were significantly more voracious than 27º males when foraging for both the first fly ($F_{1,19.9}$=8.637, p<0.01) and the second fly ($F_{1,15.8}$=19.236, p<0.001) (Fig 3).
- In addition, foraging behavior proved to be highly repeatable for both first fly (intra-class correlation coefficient=0.593, $F_{240,1200}$=2.457, p<0.001) and second fly (intra-class correlation coefficient=0.509, $F_{241,1205}$=2.036, p<0.001).

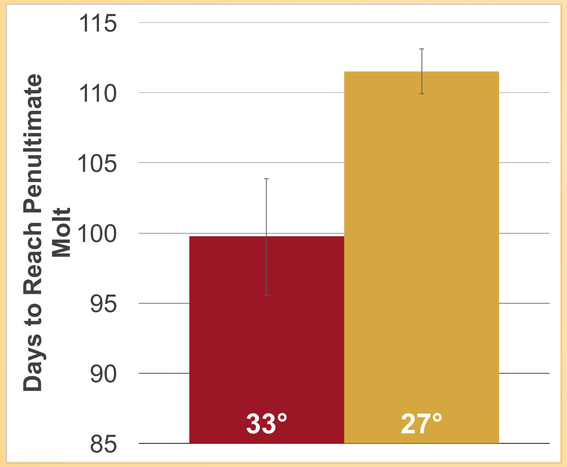

Figure 1. Temperature Effect on Developmental Trends.

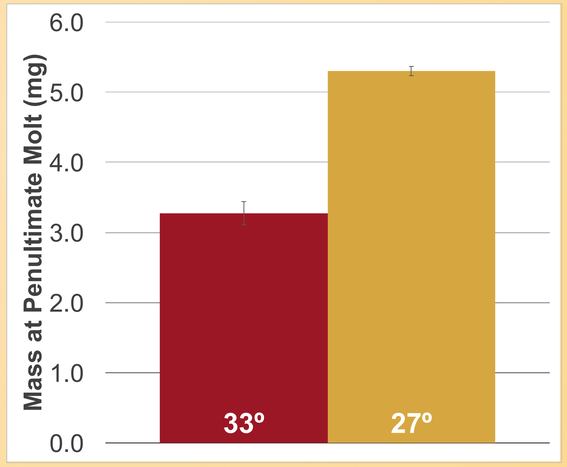

Figure 2. Temperature Effect on Mass at Penultimate Molt.

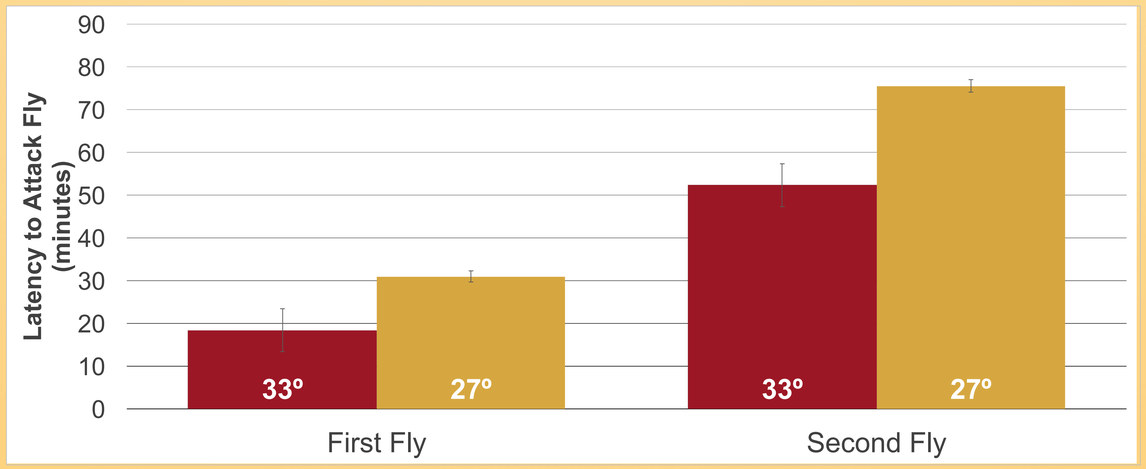

Figure 3. Temperature Effect on Latency to Attack First and Second Flies.

DISCUSSION

- UHI temperatures expedite development, reduced body mass, and promoted foraging voracity.
  - Thus males exposed to UHI temperatures were able to court females before 27º males.
- Strong familial effects are present in our effect of temperature on development.
- While 66 males reached maturity in the 27º treatment, only 1 male reached maturity in the 33º treatment (and he died 1 day after).
  - Thus potential temperature effects on male courtship activity could not be assessed.
- For many exothermic arthropods, increased temperatures lead to increased metabolisms [5].
  - This might explain the increase in foraging voracity at UHI temperatures.
- However, in urban environments, spiders experience an increased prey abundance [6].
  - Future studies will ask whether the combination of UHI temperatures and prey abundance allow black widows to thrive.

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