Plasticity of pigmentation and thermoregulation of the harlequin bug, *Murgantia histrionica*, in response to developmental temperature

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Abstract

Sustaining homeostasis in a changing environment relies on an organism’s ability to maintain an internal temperature within a specific range through thermoregulation. When temperatures fall outside an optimal range, metabolic, reproductive and behavioral functions can be impaired. As poikilothersms, insects must rely on mechanisms other than metabolic heat production to protect themselves from extreme temperatures.

Many insects, such as the harlequin bug *Murgantia histrionica*, demonstrate phenotypic plasticity in body color, possibly taking advantage of solar radiation to warm and cool their bodies. On its dorsal side, the harlequin bug displays geometric patterns resulting from a juxtaposition of black and color, and this ratio may show variation among individuals. Previous studies demonstrated that both thermoperiod and photoperiod play an influential role in determining this pigmentation. In order to investigate the impact of photoperiod on pigmentation patterns, we reared 4th instar harlequin nymphs in two thermal environments, mimicking the seasonal temperatures observed in their natural geographic range, and quantified the black to color ratio using digital imagery. In order to assess whether there is a relationship between degree of melanization and thermoperiod alone by rearing in a 4th instar thermoperiod environment, we observed evidence of melanin plasticity in several different insect species.

In temperate environments, where temperature and sunlight differ greatly over the course of the year, maintaining homeostasis through thermoregulation may be one of the key factors determining species survival. Poikilothersms such as insects, who are unable to sustain body temperature within an optimal range exclusively through metabolic heat production, must rely on other mechanisms to protect themselves.

The theory of thermal melanism suggests that insects can alter their coloration by increasing production of the pigment melanin in colder environments, thereby enabling the body temperature to reach higher temperatures (Trullas et al. 2007).

Methods

- Twenty-two adult male bugs (*n = 22*) from Eastern VA were placed in a 26°C environmental chamber under an until lamp. After 3 minutes the light was activated for 8 minutes. We recorded bug temperature and air temperature every 20 seconds (Figure 3).
- Bugs used in our rearing experiment were the first filial (F1) offspring of adults collected from Athens, OH. When bugs molted to the 4th instar we randomly distributed nymphs between two thermoperiod conditions, a “fall” chamber (*n = 25*) set at 12°C and a “summer” chamber (*n = 25*) kept at 26°C both on a 12hr:12hr light:dark cycle. Both summer and fall chambers were equipped with basking lights. Upon molting to adulthood, we photographed bugs for pigment analysis. Melanization was quantified as percent black patterning of the total dorsal surface area.
- For our temperature trials, we performed a linear regression on percent black surface area against body temperature increase per gram of bug weight. For our rearing experiments, we performed a 2-sample t-test on the average summer and fall percent black surface area.

Discussion

- We found that melanization may influence body temperature, as more melanized individuals reached higher body temperatures than less melanized individuals. If this trait is indeed under selection, it must confer a fitness advantage. Darker individuals that are able to withstand colder conditions may have larger periods of activity, and consequently more success in acquiring mates, food, and escaping predators (Trullas et al. 2007).
- Cold can retard growth:--> Active later into season and hatch earlier into spring
- We were unable to induce greater melanization by exposing 4th instars to different thermoperiods. These experiments suggest that melanization may either be determined before the 4th instar, may be a result of photoperiod rather than thermoperiod, or may be a result of a combination of both thermoregulation and photoperiod. Unfortunately, the high mortality of the summer treatment reduces our certainty in the reliability of our results.

Results

- Our results indicated that there is a relationship between melanization and body temperature. Bugs with a greater proportion of black in their dorsal pattern were able to increase their body to higher temperatures than bugs with less black (Figure 3, linear regression, *R*² = 0.310, *p* = 0.007 *n* = 22).

Environmental Treatments:

- Contrary to our hypothesis, we found that bug melanization was not influenced by the thermoperiods experienced during the 4th and 5th instars. We observed no difference in percent black between the two treatment groups (Figure 4, 2-sample t-test, *p* = 0.320, *n* = 4, *n* = 11). The average melanization for the fall group was 61.72% black (SEM ± 1.0), while the average melanization for the summer group was 66.06% (SEM ± 3.5). However, due to high mortality rates only a total of 4 summer and 11 fall bugs could be examined.

Introduction

Phenotypic Plasticity of Insects: Mechanisms and Consequences

Temperature Trials:

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- In the future we hope to determine the role of photoperiod in the patterning of *M. histrionica*. While selection favors increased plasticity, unpredictability in environmental conditions may prevent plasticity from producing optimal phenotypes. Thus, photoperiod, which exhibits less fluctuation, may be a more accurate indication of season than temperature (Kingsolver & Huey 1998).
- Eventually, we hope to ask to whether or not this plasticity is genetically determined. While previous studies have suggested familial influence in melanization, this is an exciting and unexplored territory in *M. histrionica* studies (Hazel 2002, Michie et al. 2011, Davis et al. 2005).

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References