The Influence of Sugar Concentration on Bumblebee Thermoregulation: Implications Under Climate Change

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Introduction

- Global temperatures are predicted to rise in the coming decades, while the American west in particular is possibly facing an unprecedented mega-drought.
- High water and heat stress typical of drought expose bumblebees to higher temperatures and decrease the sugar concentration of floral nectar.
- Bumblebees have the physiological capacity to actively transfer heat from their thorax to their abdomen as a means of managing excess body heat.
- No study to date has examined the interaction between nutritional quality, thermoregulatory ability, and heat stress, a scenario that bumblebees are likely to be exposed to in the coming years.
- Here I investigate to what extent the sugar concentration of nectar influences thermoregulation in bumblebees. I assessed the ability of Bombus melanopygus to transfer excess heat from its thorax to its abdomen after the consumption of various sugar solutions.

Methods

- I presented bees with one of five sugar concentrations: 0%, 15%, 35%, 55%, 75% (n=16 per treatment). All five treatments were tested each trial day in haphazard fashion with up to two replicates per treatment per day. A total of 80 bees were used for this experiment.
- After feeding, bees were fastened to a styrofoam pad where a piece of aluminum sheeting was positioned around the petiole to shield the abdomen from the heat application to the thorax.
- Heat was continuously applied to the thorax of bumblebees over a period of 5 minutes. Thoracic (T\textsubscript{th}) and abdominal (T\textsubscript{ab}) temperatures were simultaneously recorded every 30 seconds using a pair of infrared temperature thermometers.
- I calculated the difference between T\textsubscript{th} and T\textsubscript{ab} as (T\textsubscript{d}). I used T\textsubscript{d} as a metric for evaluating heat transfer for bees, with higher values indicating a greater temperature difference between the thorax and abdomen and thus less heat transfer.

Results

- Our response variable was T\textsubscript{d} from 30 seconds to 5 minutes for each trial. % sugar was our explanatory variable. Trial was treated as a random factor in a linear mixed effects model using Anova with type III sums of squares. I used Tukey tests to evaluate specific differences between individual treatments, and to determine saturation points for each treatment by comparing T\textsubscript{d} at each 30 second interval of the trials.
- Higher sugar concentrations increased the thermoregulatory ability (lower T\textsubscript{d}) of live bees experiencing heat stress. The 75% sugar treatment had the lowest average T\textsubscript{d} (2.88 °C) while 0% sugar treatment had the highest (4.83 °C).

Conclusions

- Heat transfer from thorax to abdomen of B. melanopygus was greatest for bees that had consumed highly concentrated sugar solutions. Thus, bumblebees should thermoregulate most efficiently under heat stress after consuming highly concentrated floral nectar.
- Energy rewards serve as the co-evolutionary currency that maintain plant-pollinator interactions. The consumption of highly concentrated viscous nectar would allow a bumblebee to maximize its energy intake and thus forage and adapt to its environment most efficiently.
- Unfortunately, under a climate change scenario, bumblebees may be trapped in a “two-sided climate vise” where higher temperatures increase their energetic needs while simultaneously reducing the quality of energy available to them in nectar.

References


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