Physiological Traits as Predictors of Climate Resistance and Sociality in Female Carpenter Bees

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Introduction

Bee social behaviors range from solitary to eusocial with high interspecies variability [4], and are likely influenced by environmental, chemical, and physiological factors. It is critical to improve scientistic understanding of this phenomenon as it relates to species resilience in a rapidly changing climate. *Xylocopa tabaniformis* is a species of American carpenter bee that displays facultatively social behavior. Sociality is thought to be a function of chemical signaling from exocrine glands such as the Dufour's gland in female carpenter bees [1]. Compounds from the Dufour's gland are strongly associated with ovary size, also thought to indicate sociality. Larger ovary size might indicate "queen-like" behavior. Yellow bodies in ovaries are indicative of reabsorbed oocytes and previous reproduction [3].
We aim to investigate the role of ovary size and Dufour's gland chemical composition in the sociality of female carpenter bees, as well as climate resistance based on physiological and behavioral characteristics.

Methods

33 female Carpenter bees were sampled around UCSB, 26 were tested for the time to recover from cold exposure (chill coma recovery time or CCRT) provide a possible metric for geographic distribution according to their thermal tolerance [2]. The mass, intergtegular distance, and wing wear was recorded. Bees were dissected and the width of the Dufour's gland and the length of the 2 largest ovarioles were taken. The presence of yellow bodies in the ovaries was also noted. Chemical extraction was performed on the Dufour's gland for future chemical analysis in collaboration with Nicholas Saleh at Fresno Pacific University to assess the sociality of bees based on their chemical signal. Statistical analyses were performed in R Studio.

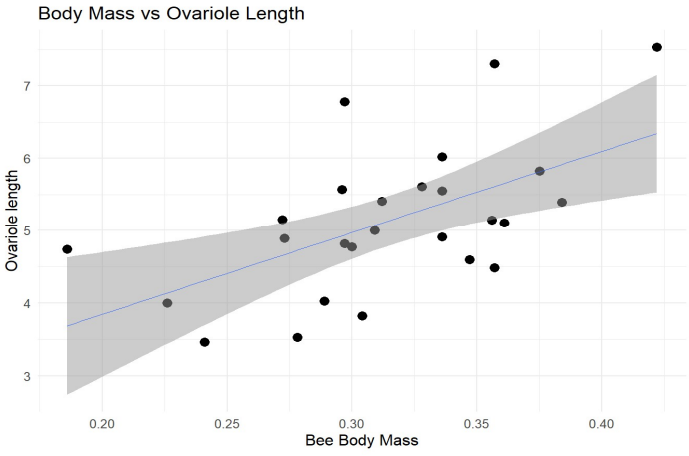

Figure 1. Scatterplot of body mass compared to ovariole length fitted with a 90% confidence interval. There is a positive linear relationship between the two variables.

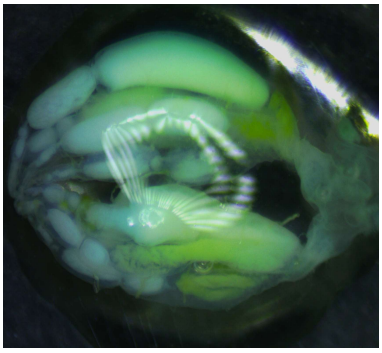

Figure 2. An image of Xylocopa tabaniformis ovaries in water. Oocytes are the discrete opaque sacs pictured. Yellow bodies can be seen as the yellow amorphous tissues.

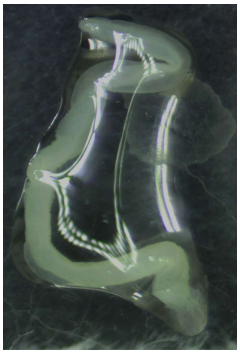

Figure 3. An image of a Dufour's gland prior to chemical extraction in water.

Results

- **No significant association between mass and CCRT (GLM p>0.05)**
- **Mass is a significant predictor of ovariole size with a positive linear relationship (linear model p= 0.00236, adjusted R-squared = 0.30)**
- **Mass is a significant predictor of Dufour's gland length with a positive linear relationship (linear model p = 0.0000662, adjusted R-squared = 0.47)**
- **Uncertain significant of wing damage on CCRT (left wing wear t-test p<0.05, right wing wear t-test p>0.05)**
- **Not enough data to analyze yellow body significance**

Discussion

Statistical analysis shows that bee body mass is a significant predictor of both ovariole length and Dufour's gland length based on linear modeling. Mass was not a good predictor for CCRT, suggesting that other factors have larger influences. Other hypothesized influences on bee thermal tolerance are the individual's sex and phenotypic plasticity as a response to different environmental stimuli [2]. Limitations of this study were the sample size n=26, and the timing of the study. Bees were collected in June when female carpenter bees had already been reproductively active. Further studies should be conducted throughout the entire period of bee activity to give better insight into the seasonal variation of thermal tolerance. As this study serves as preliminary data for chemical analyses, the relationship between Dufour's size, ovary size, and mass should be considered as they might impact the conclusions that can be drawn from exocrine gland chemical analyses. Future studies conducted on a wider range of species will help broaden the understanding of sociality and thermal tolerance as a function of physical and chemical characteristics.

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Acknowledgements
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