Body size trends in historic Indiana bumble bee records

Sarah Baker

PURDUE UNIVERSITY | Entomology

Introduction

Bees are vital to the ecosystem and the economy, functioning as the main pollinators leading to plant reproduction and higher crop yields (Kevan & Phillips, 2001). A shortage of pollinators can greatly affect agricultural success. Presently, research has been showing that pollinators worldwide are shrinking in size, linking it to land-use change (Oliveira et al., 2016). Bee body size is an important trait for flight and mobility, and shrinking in size can mean a change to their access to flowers and water. This limits resource availability. This trait is greatly influenced during the larval stage by the environment (Chole et al., 2019). As part of an initiative to track changes to different insect species over time, there are many museum specimen collections, all of which contain valuable ecological information, including the ability to study morphological traits virtually through digital imaging. The Purdue University Entomological Research Collection (PERC) is one such collection, serving as a collection for research in entomology both at Purdue and across the globe. Entomologists can use this information to predict relationships between body size variation and environmental factors like temperature over time.

This project aims to explore how temperature over a period of time in Indiana has impacted bee body size by analyzing PERC specimens. This could uncover patterns in bee morphology that may indicate the broader effects of climate change on insects. The results of this research are valuable in the common goal of understanding the environmental impacts and thereby informing conservation strategies.

Question: Will fluctuations in mean annual temperature in Indiana during different time periods match trends in changing bumble bee sizes?

Methods

Specimens: Specimens included in this project are from the assembled dataset of the PERC historic collection of Indiana bumble bees. The PERC stores approximately 5,700 bumble bees, with 1,300 of these being collected from Indiana and 1,100 of them being utilized for this project. This data ranges from the 1900s to the 2020s and includes 9 Indiana bumble bee species. The PERC specimens are also stored digitally in the Bee Library via captured images in an online, publicly accessible dataset complete with locality labels.

Intertegular Distance and Measurements: Intertegular distance (ITD) is the width of space between the tegulae, or the point connecting the base of the wing to the body. Using the online images, I uploaded these to ImageJ processing and digitally measured the distance between tegulae in millimeters.

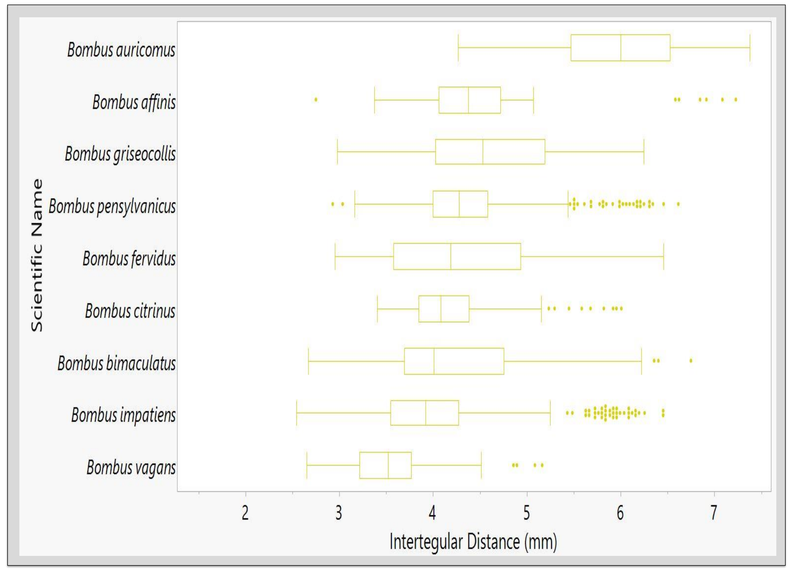
Temperature Data: The mean annual temperature for the state of Indiana was collected from the PRISM Climate Group at Oregon State University.

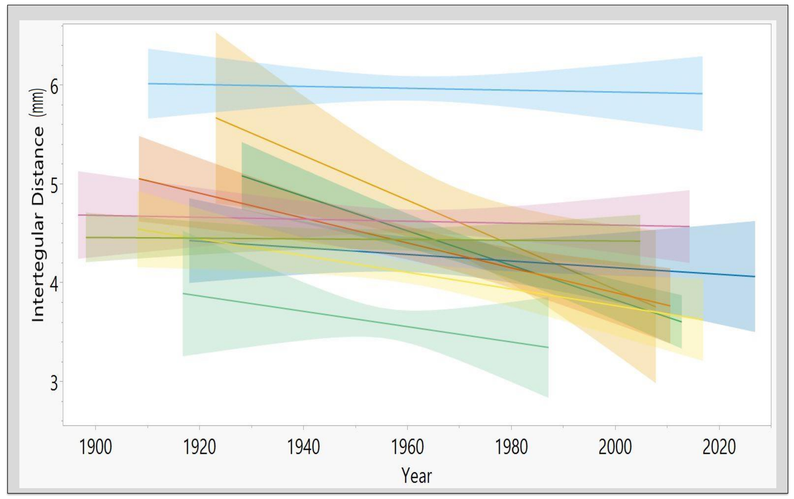
Dataset: From the online images, I eliminated any poor data that might not contribute effectively to my research. Bee images that would be difficult to collect data from, such as blurry photos or specimens on their side, were removed before completing any analysis. Images with missing information on locality were also removed.

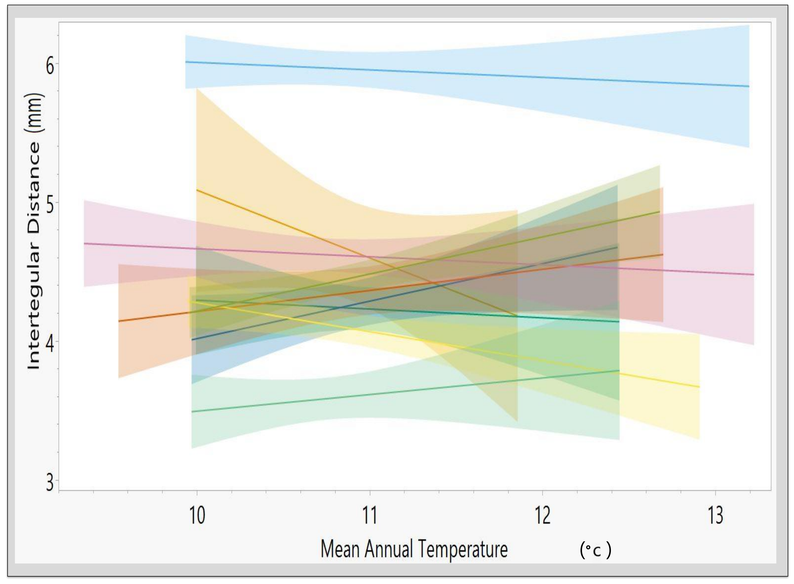
Compiling this information, I used the JMP Pro software application to create a box plot of the ITD among selected species and then ran linear regressions, incorporating year and mean annual temperature as factors.

Legend

- *B. affinis*
- *B. auricomus*
- *B. bimaculatus*
- *B. citrinus*
- *B. fervidus*
- *B. griseocollis*
- *B. impatiens*
- *B. pensylvanicus*
- *B. vagans*







Measuring ITD

Bombus affinis specimen from the PERC, arrows indicate the ITD

Results

The ITD across species showed considerable variation. *Bombus auricomus* exhibited the largest bee body sizes, with a median of 6.0 mm and a maximum of 7.4 mm. In contrast, *Bombus vagans* was the smallest species, with a median of 3.5 mm and a maximum of 4.5 mm. There were also many outliers present in *Bombus pensylvanicus* and *Bombus impatiens*. When examining ITD in relation to the year, a negative trend was observed. This appeared to have a stronger impact on ITD than mean annual temperature, which showed that ITD was more varied between species with little relationship to temperature.

Discussion

Pollinating insects are currently declining, which is concerning from both an economic and a biodiversity standpoint. One way to estimate bee body size and expected flight abilities is through measuring ITD. ITD may vary between species and as a result of environmental factors. From the data, we see that as the years progress, the ITD decreases. This could be interpreted as a land-use change influence, with more land being converted for business development and housing each year, creating habitat loss and fragmentation. The data suggests that year is linked to land use change and influences bee body size. Additionally, there appears to be a non-linear relationship between mean annual temperature and ITD when examining the genus as a whole, though this effect varies by species. From there, it can be inferred that ITD is species-dependent with little to no influence by mean annual temperature. Looking at specific species, we can see that *Bombus impatiens* has been steadily declining in bee body size since the 1920s, while *Bombus affinis,* an endangered species in the United States, exhibits the sharpest decline. Factors such as climate change, land use change, flower and water availability, habitat fragmentation, and pesticides can all have a direct or indirect influence on changing morphological traits in insects, including bumble bees. Understanding these variations in bee traits can help entomologists learn what is helping or what may be hindering populations and diversity and provide valuable insight as to how to support bee populations and yield higher pollination services.

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