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Infection outcomes not significantly affected by thermal variability in a bumble bee host-parasite system

Featured Scientist: Kerrigan B. Tobin, M.S. 2019, School of Biological Sciences, Illinois State University

Birthplace: Normal, IL

My Research: I study how **climate change** influences bumble bee immune function and survival.

Research Goals: I want to continue to use a combination of laboratory and field techniques to address **native pollinator** conservation. I think it's important to understand how human impacts on Earth may have an effect on the organisms around us.

Career Goals: I'm currently a lab technician for the USDA, but eventually I'd like to be an Ecology professor, where I can teach and mentor students from various backgrounds about fascinating relationships in nature and how we can support biodiversity.

Hobbies: Crafts, especially throwing pottery and crocheting.

Favorite Thing About Science: It's so satisfying to find evidence and support for a theory!

Organism of Study: *Bombus impatiens*, the common Eastern Bumble Bee

The Eastern bumblebee, ***B. impatiens***

Field of Study: Ecology

What is Ecology? The study of how living organisms interact with each other and their surroundings. It's an interesting field because we can study ecology at different scales. We can look at how a single organism interacts with its environment or study how complex networks of species interact in a community.

Check Out My Original Paper: "Infection Outcomes are Robust to Thermal Variability in a Bumble Bee Host–Parasite System"

QR Code to original publication

Citation: K.B. Tobin, A.C. Calhoun, M.F. Hallahan, A. Martinez, B.M. Sadd, Infection Outcomes are Robust to Thermal Variability in a Bumble Bee Host–Parasite System. *Integr. Comp. Biol.* 59.4: 1103-1113 (2019).

Research at a Glance: In this paper, we wanted to test whether changes in temperature make it more difficult for a bumble bee to fight off infections. **Climate change** is predicted to make temperatures more variable. These changes are likely to have an impact on many animals and how they interact with their environments. Living creatures have an optimum range of temperatures where their bodies perform the best. Outside of this range, their bodies cannot carry out important tasks. These ideas suggest that **climate change** might hurt animals because they will have to survive outside of the range of temperatures they are used to. Some scientists explain this using the "**beneficial acclimation hypothesis**" or **BAH**. This idea suggests that animals adjust to their environment, which gives them advantages for survival. For example, animals that live in the desert are particularly good at surviving in desert conditions. But, animals from the arctic are bad at surviving in the desert. On the same line of thought, we wanted to know if bumble bees were better at fighting off infections when they were living at the temperature that they were used to, their **acclimation temperature**. We wanted to see if bees living in a temperature outside their normal range were more likely to get parasites than bees kept at their normal temperature. To test this, we used the Common Eastern Bumble Bee as a host and a gut parasite that often infects bumble bees, ***Crithidia bombi***.

In our experiment, we used bees from four different colonies. Each bee was given one week to acclimate, or get used to, a specific temperature. They were acclimated to 21°C, to room temperature (between 25-26°C), or to 29°C. Next, we gave each bee one of two strains of the parasite, ***C. bombi***. This parasite is commonly found in the gut of the bumble bee. We gave the bees the parasite by mixing ***C. bombi*** into sugar water that was fed to them. After parasite exposure, bees were then put in a **performance temperature** of 21°C, room temperature (between 25-26°C), or 29°C. This means that some bees went back to the temperature that they were acclimated to, but others were placed into a different, **mismatched**, temperature. At four and six days after parasite exposure, we checked to see if the bees were infected by collecting their feces and looking for parasite cells inside. Eight days after parasite exposure, we froze the bees and measured how intense the infection was.

We found that the strain of ***C. bombi*** matters, because the two strains of parasites did not infect bees at the same rate. We also found that bees from different colonies had a different susceptibility to infection. This means that some bees are more likely to get an infection based on their colony of origin. Finally, we found that **constant** and **mismatched** temperatures did not impact whether the bees became infected or how intense an infection became. These results mean that we did not find support for the **BAH**. Overall, our results suggest that small changes in temperature are not changing the relationship between bumble bee hosts and their parasites. We also showed that some parasites are better at infecting hosts than others, and some colonies are more likely to get infected than others. More work must be done to really understand how **climate change** might impact bee health, but our study is a good first step.

Highlights: The goal of this research was to test the **BAH** in the bumble bee host-parasite system. The **BAH** says that bees used to one condition, but given an infection with a parasite in different conditions, would have worse outcomes than bees that stayed in **constant** conditions. We tested this by keeping bees in **constant** temperatures or letting them get used to one temperature and then moving them to a new temperature. Then, bees that were kept at **constant** temperature and bees that experienced **mismatched** temperature were each given a dose of parasites. We screened the feces of each bee at 4 and 6 days after parasite exposure. We measured the intensity of the infection eight days after exposure to the parasite by performing

qPCR on the gut of each bee. **qPCR** is a laboratory method that allows us to estimate the number of parasite cells contained in each bee.

We compared temperature treatments and infection over time to analyze our results. **Figure 1** shows the number of bees that had parasite cells in their feces 4 days after they were infected. On day 4, there was no difference between bees that were kept at **constant** or **mismatched** temperatures.

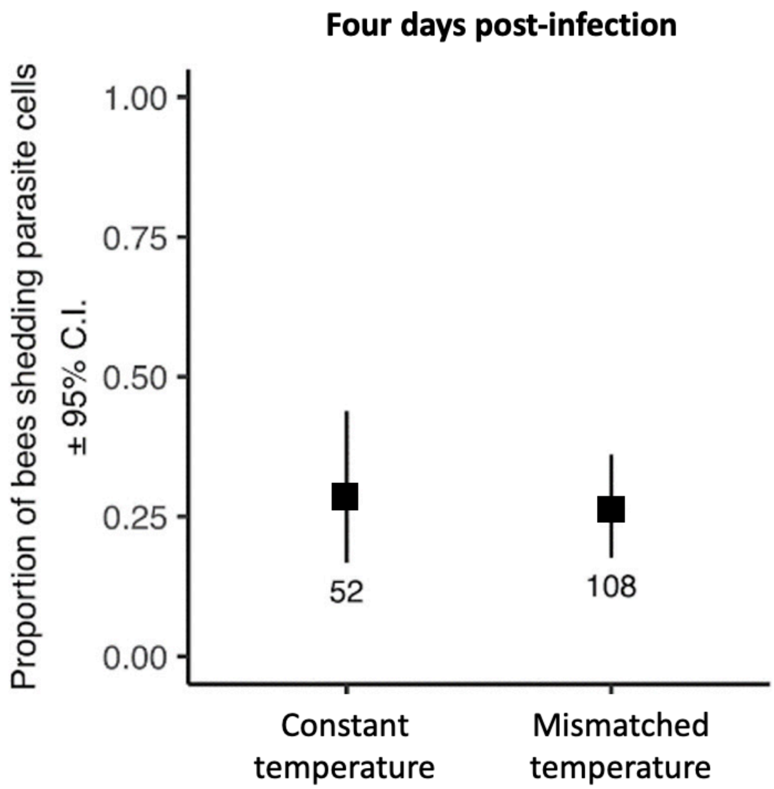

Figure 1. Infected bees 4 days after ***C. bombi*** exposure. The x-axis shows the temperature treatment and the y-axis shows the proportion of bees that became infected. *Adapted from Tobin et al. 2019.*

Figure 2 shows the number of bees that had parasite cells in their feces 6 days after they were infected. On day 6, more bees were infected, but there was still no difference between bees that were kept at **constant** temperature and those that experienced a **mismatched** temperature.

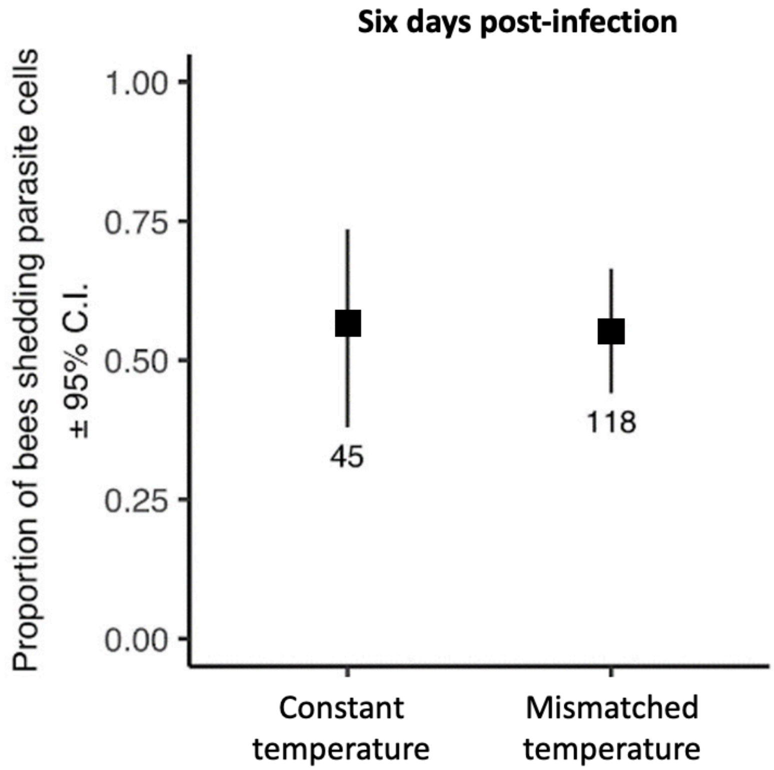

Figure 2. Infected bees 6 days after ***C. bombi*** exposure. The x-axis shows the temperature treatment and the y-axis shows the proportion of bees that became infected. *Adapted from Tobin et al. 2019.*

Figure 3 shows the intensity of the infection 8 days after the bees were infected. There was no difference between bees that were kept at a **constant** temperature and those that experienced a **mismatched** temperature.

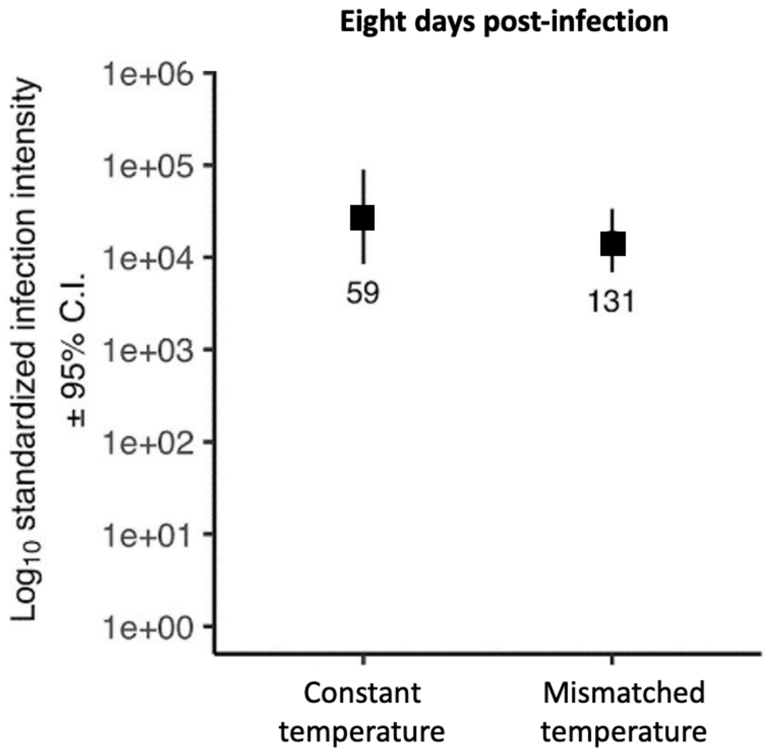

Figure 3.. Intensity of ***C. bombi*** infection 8 days after bees were exposed to the parasite. The x-axis shows the temperature treatment and the y-axis shows a measurement of infection intensity. The data was **log-transformed** to make it easier to interpret. *Adapted from Tobin et al. 2019.*

Taken together, **Figure 1-3** show that temperature did not change whether or not a bee was infected with the parasite or how intense the infection was. This means that we did not find support for the **BAH** in the bumble bee host-parasite system within the range of temperatures that we tested. More research needs to be done to understand the impact of **climate change** on this and other systems.

What My Science Looks Like: The methods that I used in my experiment are presented in **Figure 4**. The boxes on the left show the temperature that a bee experienced during the 7-day **acclimation** period. After this, the bees were exposed to one of two strains of the ***C. bombi*** parasite. After exposure, bees were either returned to their original temperature (long dashed black arrows, **constant**), or they were assigned to a different temperature (short dashed gray arrows, **mismatched**). The boxes on the right side of **Figure 3** show the **performance temperature**. We quantified **transmission** 4 and 6 days after parasite exposure and we quantified the intensity of the ***C. bombi*** infection 8 days after parasite exposure.

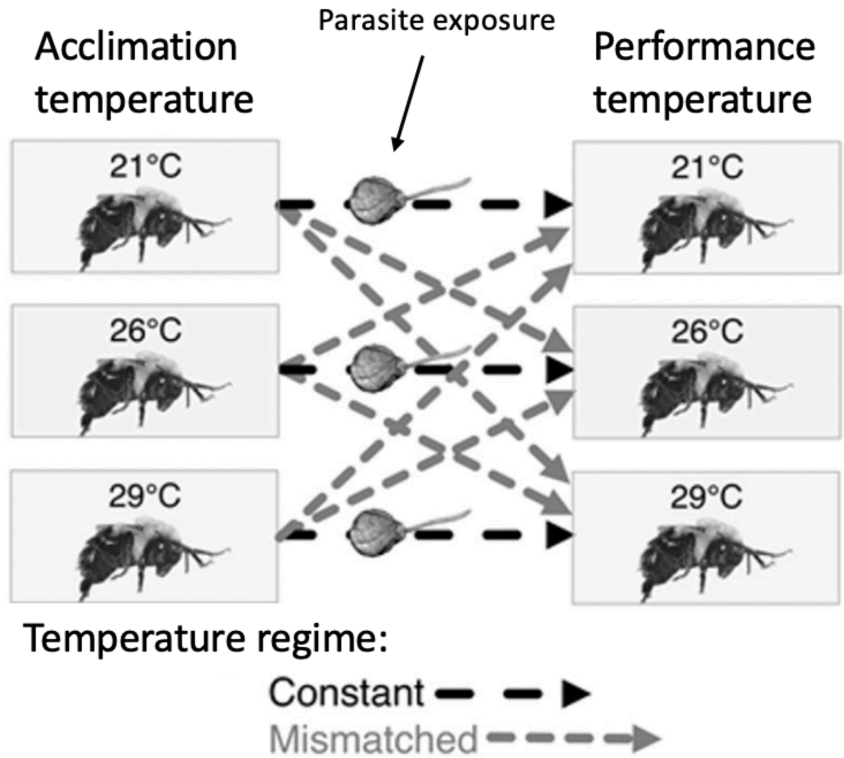

Figure 4. Breakdown of the methods used for the described experiments. Bees started in one temperature (left), were exposed to parasites (center), and were moved to a new temperature before being sampled (right). *Adapted from Tobin et al. 2019.*

The Big Picture: Human-driven **climate change** has many effects on earth, but its full range of impacts are not well understood. This research looked at how one part of **climate change**, thermal variability, will influence a specific host- parasite system. Although we didn't find support for the hypothesis that we tested, other effects of **climate change**, like prolonged exposure to high temperature or heavy rainfall, may impact bumble bees and other pollinators. Humans need pollinators to help create the food that we consume, but we are not the only living things that rely on them. Many ecosystems need pollinator services to help plants thrive and produce the fruits that feed many other animals. Pollinator species are in decline and we cannot help them until we understand why it's happening. Research like mine is important because it helps us to see why pollinators are disappearing. Our work will help to focus conservation efforts.

Decoding the Language:

Acclimation temperature: The temperature that an organism adjusts to over time. In the context of this experiment, this was the temperature that bees had 7 days to get used to before we introduced parasites and tested them.

Beneficial acclimation hypothesis (BAH): The BAH is a hypothesis that suggests that animals that have lived in a particular environment for a long period of time have adapted to that environment. These animals are particularly suited to this environment and will survive better than animals that are from somewhere else.

Bombus impatiens (B. impatiens)**:** The scientific name for the common Eastern Bumble Bee.

Climate change: A change in global or regional climate patterns, often seen as major changes in temperature or precipitation.

Crithidia bombi **(*****C. bombi*****):** The scientific name for the gut parasite that was used to infect bees in this study.

Constant: The bees that started in one temperature and were shifted to the same temperature later in the experiment experienced a constant temperature.

Log-transformed: When data are in a format that is hard to analyze or show graphically, scientists can scale their data set by performing a mathematical operation, like a logarithm, to scale the data.

Mismatched: The bees that started in one temperature, but were shifted to another temperature later in the experiment experienced a mismatched temperature.

Native pollinator: "Pollinator" refers to any animal or insect that helps to carry pollen from flower to flower. A native pollinator is an animal that provides pollination services to flowers and is local to the area. For example, bumble bees are native pollinators because they naturally occur in the United States. The honey bee is not a native pollinator because these bees were imported into the country.

Performance temperature: In the context of this experiment, the performance temperature was the temperature that the bee was experiencing when we tested for the effects of the parasite infection.

Quantitative polymerase chain reaction(qPCR): qPCR is a lab technique where known quantities (or standards) of DNA are amplified at the same time as unknown DNA samples. It is used to estimate the DNA concentration in each unknown sample based on how much the unknown samples were amplified relative to the standards.

Transmission: Transmission refers to whether or not the bee became infected with the parasite.

Learn More:

Pollinator Partnership

U.S. Department of Agriculture pollinator page, Logan, UT (This is where I work!)

Pollinator Conservation Resource Center

The Intergovernmental Panel on Climate Change (IPCC)

Synopsis edited by: Elyse McCormick, M.S. (Anticipated Spring 2022) and Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences, Illinois State University