1-1-2018

Comparing Maximum Critical Temperatures and Lethal Temperatures of Pogonomyrmex californicus and Linepithema humile

Jessica Zhijie Miao
Jillian Michelle Batiuk
Britnie Judith Casillas
Katherine Claire Erickson
Comparing Maximum Critical Temperatures and Lethal Temperatures of *Pogonomyrmex californicus* and *Linepithema humile*

**Introduction**
Climate change has the potential to disrupt current ecosystems and the survival of certain species. To better understand how climate change will affect particular species, we can examine the temperature ranges over which they are able to survive. Ant species have a maximum critical temperature (CT$_{\text{max}}$) at which responsiveness ceases and a lethal temperature (LT) at which they die. These temperatures can serve as a proxy to understanding which species are more likely to survive under periods of climate change. Those species which can survive at more extreme temperatures are also more likely to withstand changes in temperature in their environments.

In addition to understanding how climate change would affect the survival of species, we were interested in comparing the survival of native and non-native species under more extreme temperatures. As non-native species may outcompete native ones already, understanding how the two react to climate change can also give a better understanding of how environments will look in the long-term. For this reason, we chose to test the *Pogonomyrmex californicus*, native to the southwestern United States, and the non-native *Linepithema humile*.

Lutterschmidt and Hutchison reported that behaviors indicating the CT$_{\text{max}}$ were the onset of muscle spasms. We predicted that the CT$_{\text{max}}$ of the *P. californicus* would be higher than that of the *L. humile*, as a 2004 study by Lighton and Turner reported *P. californicus* with a CT$_{\text{max}}$ of 51.78 ± 0.37 °C, while a 1997 study by Lutterschmidt and Hutchison reported *L. humile* with a CT$_{\text{max}}$ between 38 and 40 °C. A 1999 field experiment by Witt and Giliomee found that the upper temperature threshold for *L. humile* was between 40 and 44 °C. We were unable to find previous literature that had determined the CT$_{\text{max}}$ of the *P. californicus*, although we used the higher CT$_{\text{max}}$ data to extrapolate that the *P. californicus* would most likely also have a higher LT. We hypothesized that the *P. californicus* would have both a higher CT$_{\text{max}}$ and LT, due to studies supporting this claim.

**Methods**
We collected 15 ants each of *P. californicus* and *L. humile* from the Bernard Field Station in Claremont, California in 2018. *P. californicus* was found at 34°6'29" N 117°42'26" W at an elevation of 1310 feet, and *L. humile* was found at 34°6'36" N 117°42'33" W at an elevation of 1280 feet. Each ant was placed in an individual vial. To first measure the CT$_{\text{max}}$, we placed all the vials in a water bath at room temperature (20.6 °C), and we increased the temperature at a rate of 2 °C every 5 minutes. At every five-minute interval, each vial was shaken to see if ants were responsive. We continued increasing the temperature until all the ants were unresponsive to determine CT$_{\text{max}}$. We then waited to determine at which temperature the ants died to record the LT. Once the ants died, the vial was removed from the water bath. Data collection occurred in one day, with ants being collected and tested in the same day. A t-test was used to analyze whether there was a significant difference between the CT$_{\text{max}}$ of both species and the LT of the species.
Results

Table 1. The maximum critical temperatures (CT$_{\text{max}}$) and lethal temperatures (LT) (mean ± SE, n=15) of P. californicus and L. humile.

<table>
<thead>
<tr>
<th>Ant species</th>
<th>CT$_{\text{max}}$ (°C)</th>
<th>LT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. californicus</td>
<td>48.6 (0.6)</td>
<td>58.0 (0.3)</td>
</tr>
<tr>
<td>L. humile</td>
<td>51.5 (0.2)</td>
<td>54.2 (0.4)</td>
</tr>
</tbody>
</table>

The average CT$_{\text{max}}$ for P. californicus was 48.6 °C, which was lower than the average CT$_{\text{max}}$ of 51.5 °C for L. humile. This pattern does not support our original hypothesis, as the average P. californicus CT$_{\text{max}}$ was lower than that of L. humile. Of note, however, the average LT for P. californicus was higher than those of L. humile. On average, the LT for P. californicus was 58.0 °C, while that of L. humile was 54.2 °C. A t-test was used to analyze the results and indicated that there was a significant difference between the CT$_{\text{max}}$ of P. californicus and L. humile (t = -4.17, df = 17.68, p<0.05). Another t-test also indicated that there was a significant difference between the LT (t = 7.83, df = 28, p<0.0001).

Discussion

Although the results for CT$_{\text{max}}$ contradict our hypothesis, the results of the LT test may reveal more about P. californicus' survival ability in response to climate change. Our statistical results suggest that P. californicus and L. humile experience significant survival differentials because the p-values for both tests (CT$_{\text{max}}$ and LT) are less than 0.05. Despite a lower critical temperature, their higher lethal temperature may already reveal an ability to withstand higher temperatures or, at the very least, an ability to adapt to rising temperatures.

Importantly, the t-test for the CT$_{\text{max}}$ data revealed a high variance in the results. This is most likely due to experimental error, as different individuals were reporting whether the ants had reached their critical temperatures, and there was some confusion over what defined a critical temperature. While all experimenters were clear that the CT$_{\text{max}}$ was defined by the onset of spasms, what was truly considered a spasm was unclear. Additionally, the size difference between the ants made it more difficult to determine whether ants were spasming. The P. californicus, which was much larger than the L. humile, showed clearer spasms, while it was more difficult to determine whether the L. humile was spasming. These sources of ambiguity most likely led to the variance, and this experiment should be replicated with clearer definitions to determine more accurate CT$_{\text{max}}$ of these species.

In the future, further experimentation could be done comparing native species against each other in order to obtain a clear picture of which native species are most likely to survive in periods of rising temperature and climate change. Ultimately, the data presented here represent a rough comparison of the upper thresholds for the two species and can be used to understand how the two may respond to future climate change.

Literature Cited
