Flume Crabs: Effects of Heat Flux on Body Temperatures in *Pachygrapsus crassipes*

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Abstract

Striped shore crabs, *Pachygrapsus crassipes*, typically live in the rocky intertidal; however, a population can be found in the flume system at Ellen Browning Scripps Memorial Pier. These individuals are significantly lighter in coloration, likely due to a prolonged lack of light exposure. We investigated heat intake over time of *P. crassipes* (n=4) that had been held in the lab under fluorescent light (n=2) and that remained in complete darkness (n=2). All crab temperatures increased after 8 minutes; however, after being exposed to one extreme temperature event, the final body temperatures of *P. crassipes* (n=3) decreased 0.6-1.6°C (p=0.00005, t=-5.698908). This warrants future studies to better understand how exposure to high frequency temperature variability or moderate heat pulses will affect the thermal tolerance of *P. crassipes*.

Introduction

Many organisms exhibit intraspecific color variation and can either respond to environmental changes rapidly, seasonally or over long-term scales (Detto et al., 2008). The striped shore crab, *Pachygrapsus crassipes*, typically inhabits the rocky intertidal ecosystem along the west coast of North America (Cassone et al., 2006). However, a population of these crabs has spent a portion of their lives in darkness within the flume built into the Ellen Browning Scripps Memorial Pier; thus are drastically lighter than those commonly found at the rocky intertidal ecosystem in San Diego, California. Different color intensities can affect thermal budgets and variation in color among populations have often been linked to local adaptation (Detto et al., 2008). Increasing extreme weather events and thermal stress can affect the physiology and behavior of many intertidal organisms and may differ among species and even individuals (Buckley & Hyley, 2016). In a study by Roberts (1957 II), *P. crassipes* was not found on the sand surface in temperatures above 30°C in their natural environment, so this was considered their critical thermal maximum (CTmax). Due to the lighter coloration and decreased sun exposure that the *P. crassipes* flume specimens receive, we explored how this variability might affect their body temperatures when exposed to relatively extreme heat under a 25-watt heat lamp. This could provide valuable insight into the development of *P. crassipes* thermoregulatory abilities and how they will respond in the face of rising global temperatures.

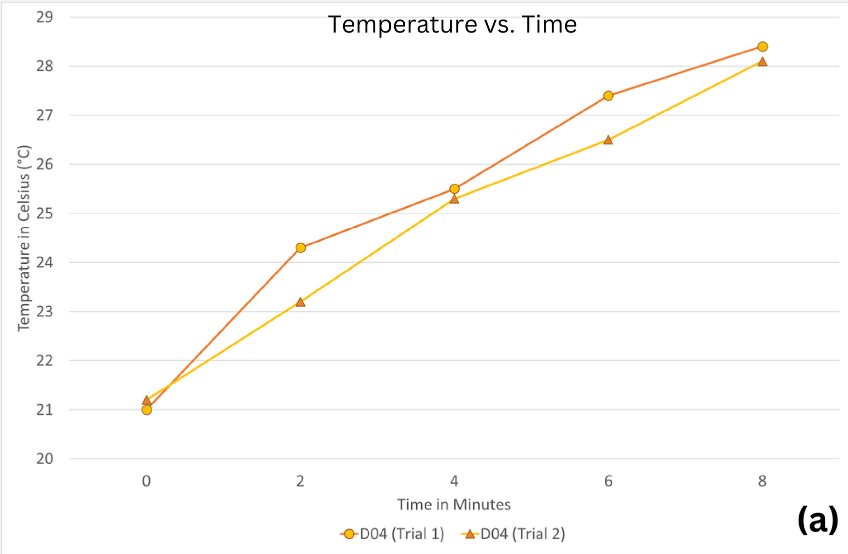
Materials and Methods

- Striped shore crabs (n=7) were collected from the Ellen Browning Scripps Pier Flume (32.86624, -117.2547) and kept at Scripps Institution of Oceanography.
- Specimens of similar size and sex were divided into light and dark treatment groups (n=2) and kept at Scripps Institution of Oceanography.
- Light and dark treatment groups were placed in a cardboard container with a silicone base for 8 minutes under a 25-watt heat lamp.
- The crab's temperature was recorded with a FLIR C5 series camera, initially and then every 2 minutes in the center of the carapace.
- Trials were repeated after 24 hours with female striped shore crabs (n=3).

Figure 1. Collecting *P. crassipes* from the Scripps flume.

Results

- In Trial 1, temperatures of all crabs from t=0 min to t=8 min had a similar positive linear increase over time. The average difference between initial and final temperature was 6.8°C.
- During Trial #1, 66% (n=2) of specimens experienced a spike (>3°C) in body temperature during the first two minutes (Fig. 2a; Fig. 2c), while in Trial #2 only 1 specimen experienced a similar, repeated spike (Fig. 2c).
- During Trial #2, (24 hours after Trial #1), the difference between initial and final temperatures was lower for 2 of the crabs. 66% (n=2) demonstrated a more steady, even, increase in temperature.
- We found a significant difference in the rate of heat flux between the initial and repeated trials (p = .00005, t = -5.698908).



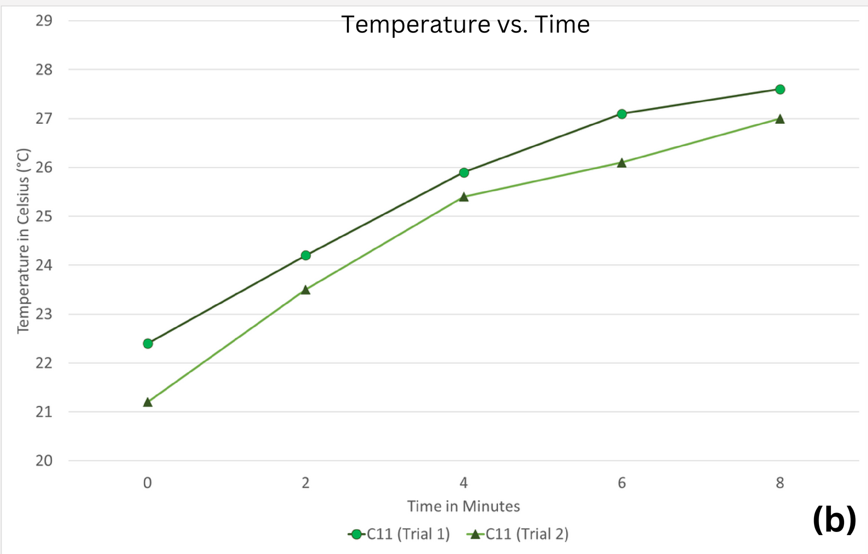
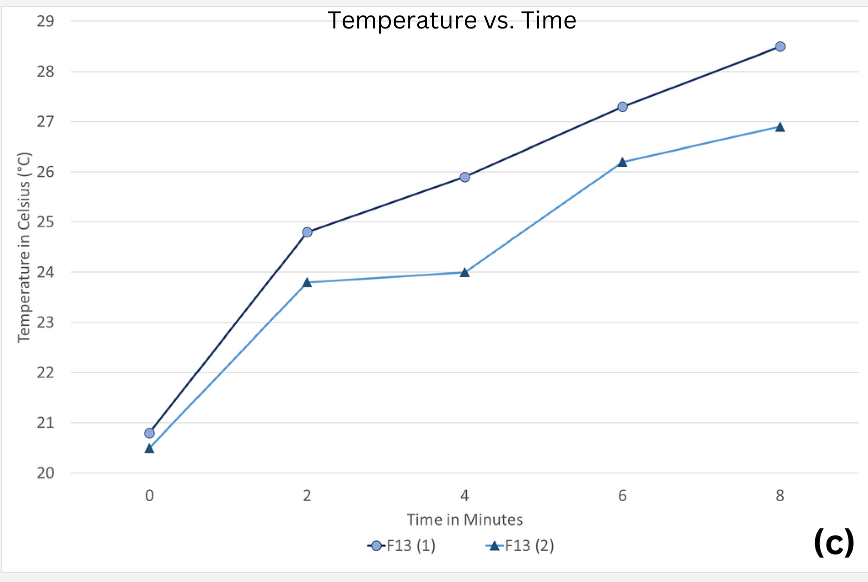


Figure 2. Changes in carapace temperature of *P. crassipes* females under a 25-watt heat lamp during two eight-minute trials. Females C11 and F13 were brooding females, while D04 was not a brooding female.
(a) D04 (4.11g),
(b) C11 (4.12g), and
(c) F13 (3.68g)



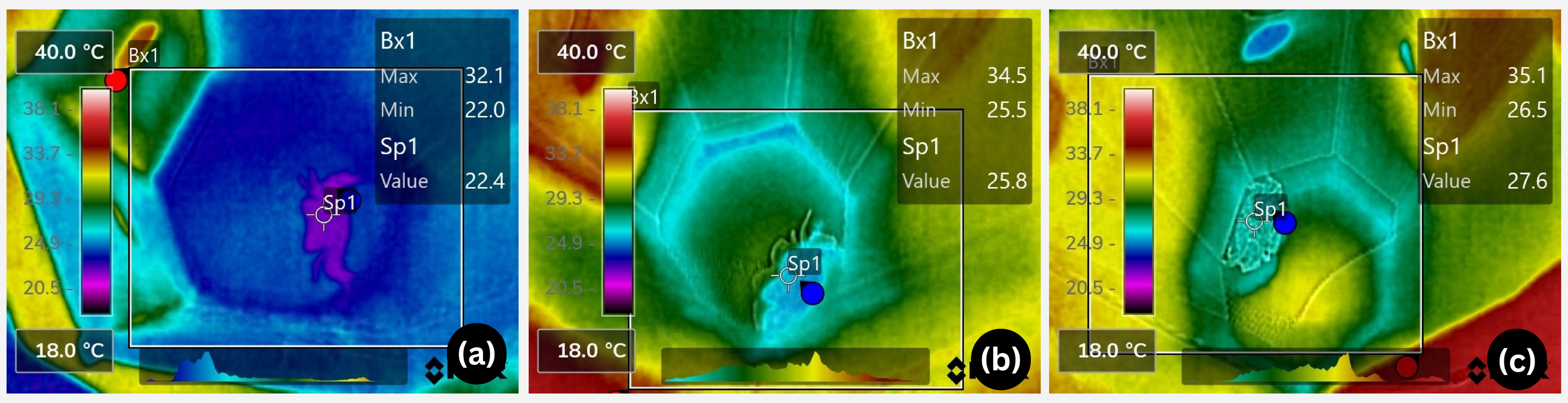


Figure 3. Thermal image of female *P. crassipes* (C11). Trial 1 under a heat lamp at (a) 0 minutes, (b) 4 minutes, (c) 8 minutes. Bx1 shows the max. and min. temperatures within the frame (shown by red and blue markers, respectively). Sp1 shows temperature on the center of the carapace (dorsal view).

Discussion

The drop in temperature between trials suggest a possible relationship between the ability of *P. crassipes* to acclimate to extreme heat events. In Trial 1, *P. crassipes* were most active during the first two minutes, correlating with the observed spike in temperature. However, during Trial 2 the crabs were significantly less active which could suggest a behavioral response to reduce thermal stress.

The lack of noticeable change in carapace coloration and the consistent temperatures between all four crabs suggest that exposure to light in the lab during our experimental trials did not warrant any sort of behavioral or physiological change in the *P. crassipes*. Instead, prior exposure to extreme temperatures may play a more important role in the striped shore crab's ability to maintain a cooler body temperature (Buckley & Hyley, 2016).

The rocky intertidal is a dynamic and complex ecosystem. *Pachygrapsus crassipes*, in their natural habitat, are known to retreat into moist crevices and tide pools for hours at a time (Bovbjerg, 1960). With climate change, it is crucial to understand how increasing temperatures will affect crabs ability to maintain their optimum temperatures.

Figure 4. Brooding female *P. crassipes* (C11) in enclosure exposed to fluorescent light in the lab.

Acknowledgements

Infinite thanks to Sonya Timko, Nicole Yen, Noa Gottlieb, Mel Tomechak, and UC San Diego Extended Studies Pre-College programs for guiding us, Orna Cook, Megan Kennedy, and Jennifer Taylor for lending us their equipment and lab space, Birch Aquarium and Cabrillo National Monument for hosting us, and to Octonauts for inspiring this journey.

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