The Effects on Temperature in *Pagurus samuelis* under Radiation and Convection Sources

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Abstract

Blueband hermit crabs (*Pagurus samuelis*) are commonly found in the rocky intertidal from Canada to Mexico. Despite their abundance, the direct effect of convection and radiation on the body temperatures of the Blueband hermit crabs have yet to be investigated. To explore this, we used a ceramic heat lamp to simulate heat transfer by convection and a halogen lamp that produces a continuous spectrum of light to simulate radiation and convection. After 2 minutes, the hermit crabs exposed to the halogen lamp were on average significantly hotter (27-30°C) compared to the ceramic lamp (21-24°C; p<0.0001). Having a better understanding on how thermal processes affect intertidal organisms will provide more context to the consequences of a warming planet.

Introduction

Pagurus samuelis are nocturnal decapods found in mid to high rocky intertidals from Nootka Sound, British Columbia to Northwest Baja California, Mexico and prefer to inhabit the shells of black turban snails, *Tegula funebralis* (Ball 1968; Billock 2011; Dos Santos 2022; Valère-Rivet et al., 2017). Global air temperatures are continuing to rise which can negatively affect Blueband hermit crab populations by causing stress, slower mobility, and reduced neural activity (De la Haye et al., 2011; Gedan et al., 2011). As ectotherms, hermit crabs rely on their thermal environment to regulate their body temperature and may experience more thermal stress as they get closer to their thermal limits (Gedan et al., 2011).

Climate change involves increasing atmospheric temperatures as a result of all four thermal processes: solar radiation, convection, conduction, and evaporation; therefore, they should be explored both individually and in combination (Marshal et al., 2012; Mount 1978; Befus 2013; Seuront et al., 2018). The goal of this study was to observe the effect of two thermal processes on hermit crabs by imitating conditions where they would be in the sunlight (absorbing heat from both convection and radiation) compared to being in the shade (absorbing heat from just the atmosphere through convection) by using 2 different 100W heat lamps.

Results

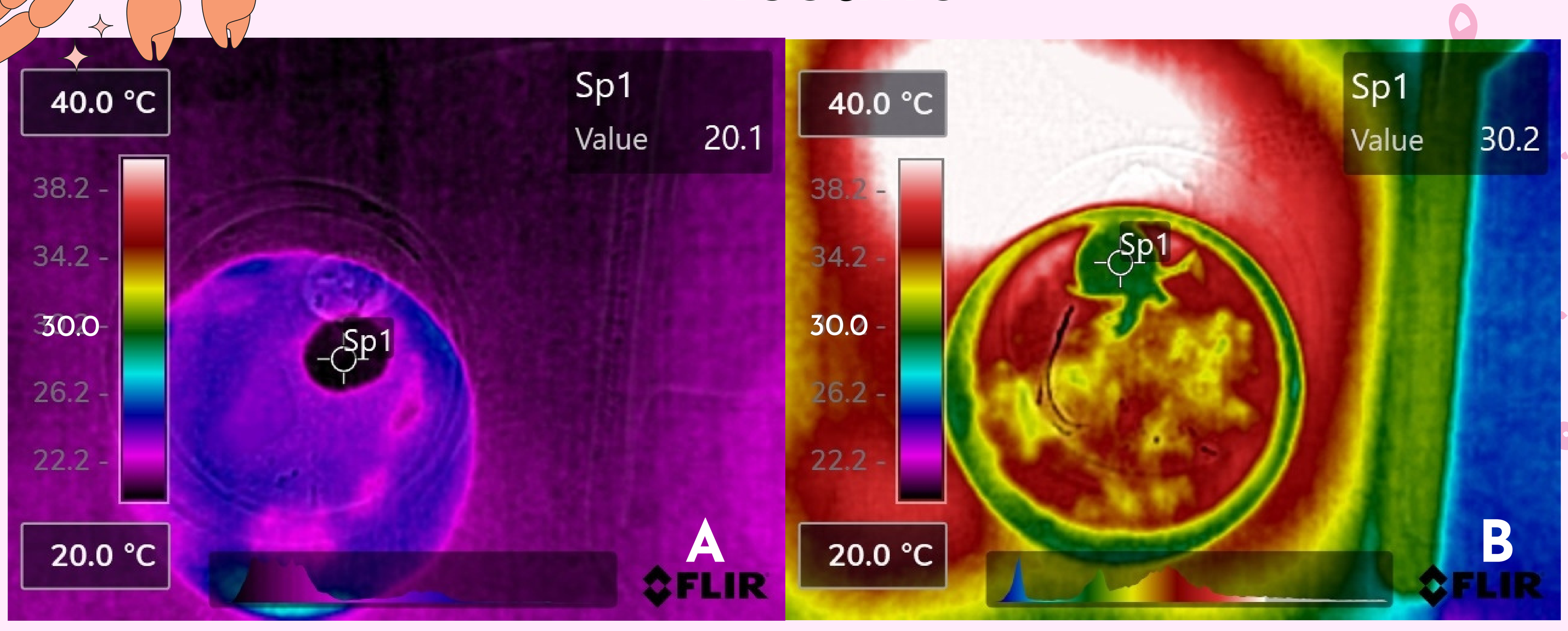

Figure 2. *Pagurus samuelis* under a 100W halogen lamp. A) t=0 min; 20.0°C; B) t=2 min 30.4°C.

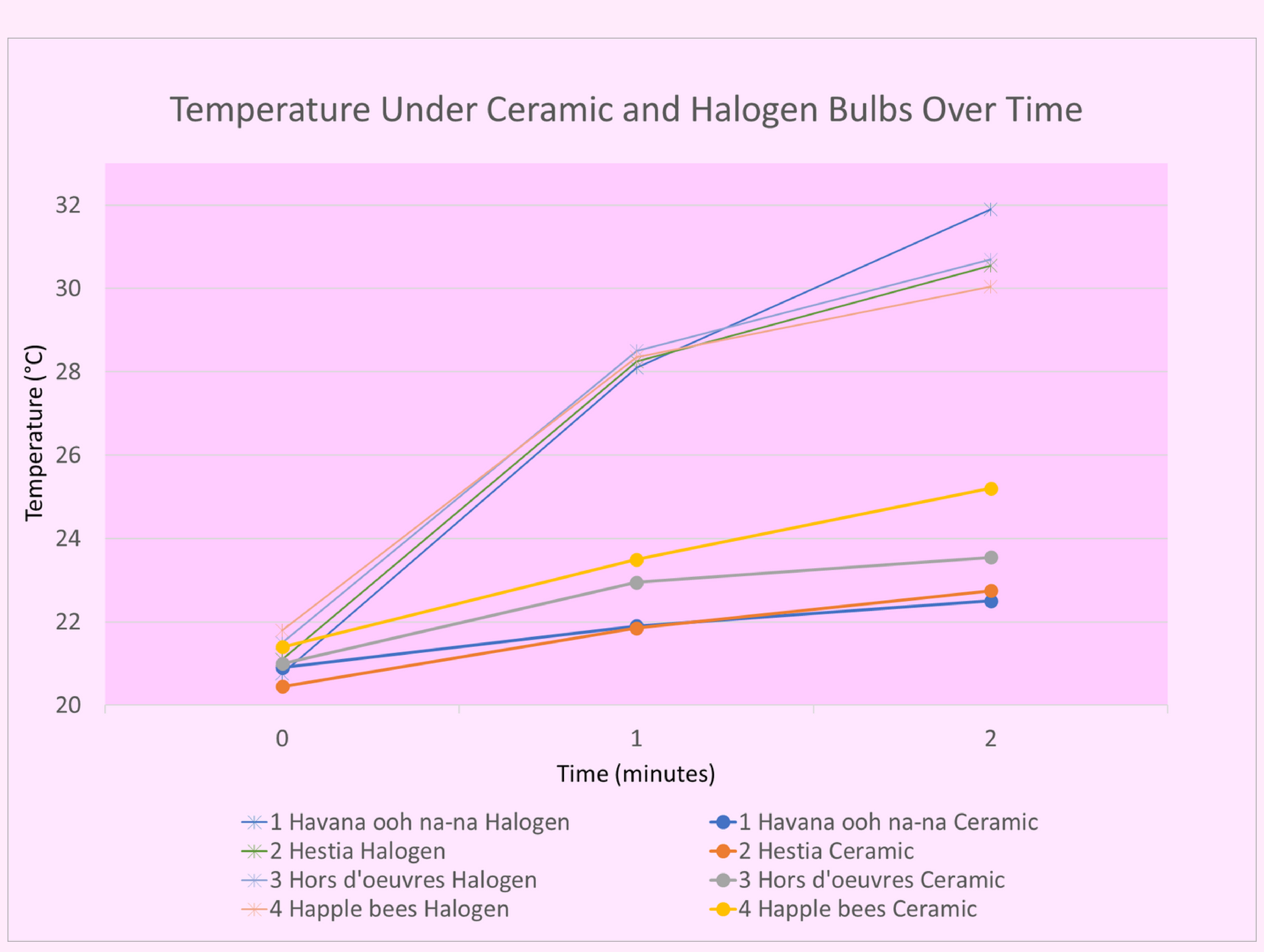

Figure 3. Shell temperatures (°C) of hermit crabs over 2 minutes.

- Colors represent different hermit crabs (n=4; blue, orange, gray, yellow).
- Starred markers indicate halogen heat lamp trials while circle markers indicate ceramic heat lamp trials.

HT1	HT2	HT	CT1	CT2	CT
6.9°C	2.5°C	9.5°C	1.7°C	0.9°C	2.6°C

HT1: Mean ΔT°C Halogen - 0-1 min
HT2: Mean ΔT°C Halogen - 1-2 min
HT: Mean ΔT°C Halogen - 0-2 min
CT1: Mean ΔT°C Ceramic - 0-1 min
CT2: Mean ΔT°C Ceramic - 1-2 min
CT: Mean ΔT°C Ceramic - 0-2 min

Paired t-test:
HT1/CT1 = Extremely statistically significant (p<0.0001)
HT2/CT2 = Very statistically significant (p=0.0098)
HT/CT = Extremely statistically significant (p<0.0001)

The most common behavioral responses to the extreme heat included shell lifting, retreating into its shell, and attempting to escape the petri dish.

Materials and Methods

1. Juvenile Blueband hermit crabs were collected at Marine Street Beach (32.8369919, -117.2814266) and kept at Scripps Institution of Oceanography.
2. Hermit crabs (n=4; mass=0.79-1.41g) were blotted dry with paper towels and left to air dry for 5 minutes before each trial to control for evaporative cooling.
3. Hermit crabs were placed in a plastic petri dish directly under a 100W heat lamp for a duration of 2 minutes.
4. Temperature measurements were recorded of each hermit crab's initial temperature, and once every minute using a C5 FLIR Camera.
5. Steps 1-4 were repeated for all other hermit crabs (n=3).
6. Steps 1-5 were repeated with both the halogen and ceramic 100W bulbs (n=4) over a period of 2 days.

Figure 1. *Pagurus samuelis* (Hors d'œuvres)

Discussion

Significance

- Heat from radiation and convection significantly increases the hermit crab temperatures at a mean ΔT° of 6.9°C more than heat from convection alone which suggests that radiation has a significant impact on the shell temperature.
- For both lamps but especially the halogen one that included radiation, there was greater rate of change during 0 and 1 minute than between 1 and 2 minutes. This shows that radiation plays a significant role in heat uptake by the *Tegula* shells that the hermit crabs inhabit.
- There was no distinct variability between results for each crab since they were of similar color and size.
- We also observed some physical responses such as shell lifting or retreating to the shell. This could allow them to withstand higher levels of heat without significant consequences to their fitness (Leung et al., 2023). Although this was not the focus of our experiment, these behaviors are worth exploring as adaptations to increasing atmospheric temperatures.

Future Directions

- We could place heat sensors inside the shell or on the body of the hermit crab to compare to the external, dorsal side of the shell.
- We could manipulate more variables such as wattage of the heat lamp, and different types of heat lamps in order to find more trends within the data.
- We could explore other thermal processes such as conduction and evaporative cooling.
- We could imitate various elements of their natural environment such as water temperature or wind speed, pH (as a result of ocean acidification), salinity, or substrates.

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Acknowledgements

Sonya Timko, Nicole Yen, Noa Gottlieb, Mel Tomechak,
Orna Cook, Megan Kennedy, Jennifer Taylor,
UCSD Extended Studies Pre-College Programs, Birch Aquarium, Cabrillo National Monument,
Happlebees, Havana Ooh Na-Na, Hestia, Hors D'oeuvres, Hamahoa, Hartholomew, Hathaniel, Hermione