Temperature Differences in Clustered versus Solitary Common Periwinkle Snails (*Littorina littorea*)

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Abstract

As the frequency of extreme temperature events increase, the thermal aspects of intertidal organisms that inhabit the supralittoral zone will likely be impacted. Common periwinkle snails (*Littorina littorea*) experience some of the greatest physical stresses associated with long periods of emersion. We investigated how grouping techniques used by *L. littorea* can affect heat flux, both in the lab, when exposed to a 50W heat lamp and in the field when exposed to natural thermal process at Dike Rock tide pools in La Jolla, California. Clustered periwinkle snails, on average, were significantly warmer (p=.00028; t=5.226709) than solitary snails both in the lab (22.5°C; 21.9°C) and in the field (30.6°C; 24.2°C). Exploring the thermal effects of aggregating behaviors is crucial to understanding how intertidal organisms will respond to thermally extreme conditions.

Introduction

The rocky intertidal zone is home to a wide variety of marine organisms that must endure the stress of one of the world's harshest biomes (McNeil, 2010). Its abundance of biodiversity and tidal variations provides the advantage of a "natural laboratory" (Tomanek & Helmuth, 2002). With a heat tolerance minimum of 6°C and a maximum of 41°C (McDaniel, 1969), snails in the mollusc family Littorina are among the most heat-tolerant eukaryotes found at the rocky intertidal (Chen et al., 2021). Periwinkle snails are known for their ability to resist high temperatures and desiccation in very harsh conditions adjusting their physiology and/or behavior when exposed to thermally extreme conditions (Sokolova, 2000; Munoz et al., 2005). *Littorina littorea*, or common periwinkle snails are often found clustered or stacked on top of each other across rocks and crevices in the supratidal zone of the rocky intertidal area in San Diego. Intertidal snails, *Cerithium moniliferum,* were observed clustering at outgoing tides and during mid-afternoon cycles (Rohde & Sandland,1975), while terrestrial snails showed that individuals at the bottom of a cluster were 4.4°C cooler than those at the top or solitary individuals (McQuaid et al., 1979). We used thermal imaging technology to investigate the heat flux of clustered *L. littorea* compared to solitary individuals in the field at Dike Rock and in a laboratory setting.

Results

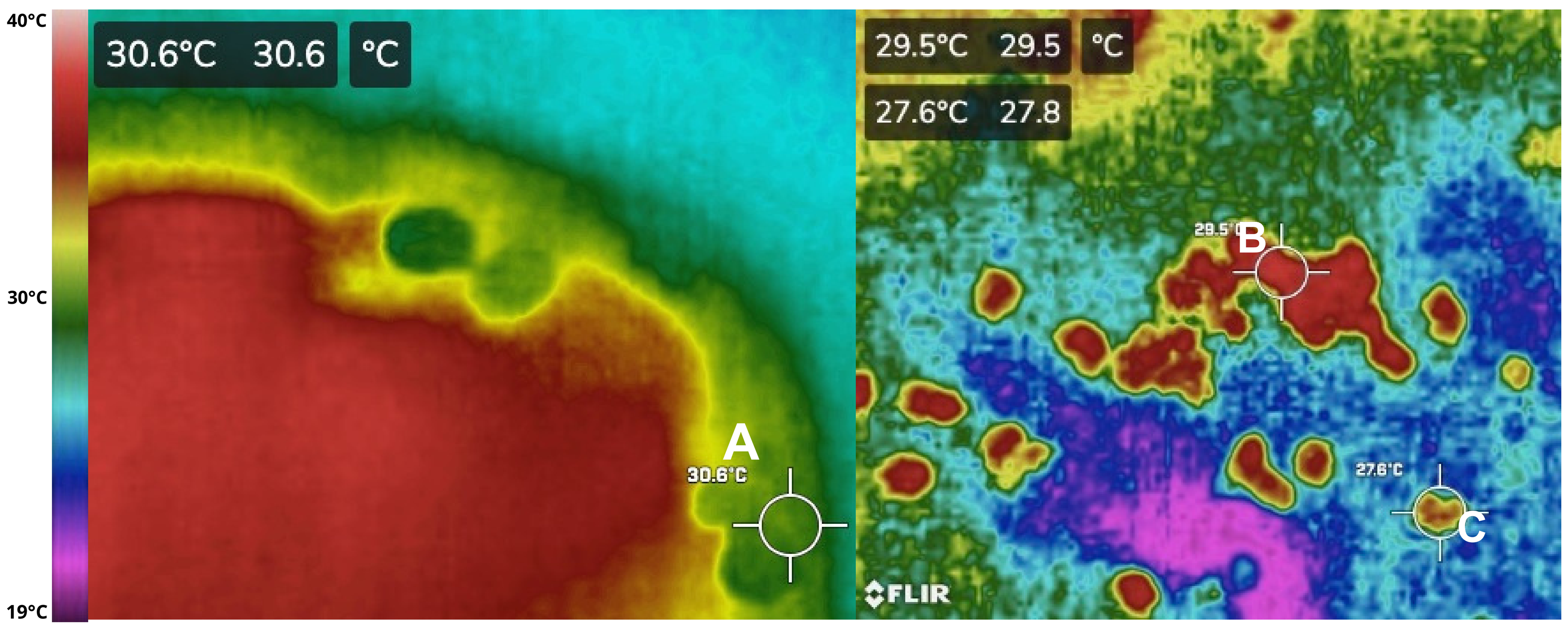

Figure 2. Thermal images of periwinkle snail clusters in the lab and in the field. **A)** 30.6°C (n=2; t=6 min; lab); **B)** 29.5°C (field cluster); **C)** 27.6°C (field solitary).

Paired T-Test (p=.00028; t=5.226709) from lab data was statistically significant between shell temperatures prior to heat lamp exposure and after 8 minutes of heat lamp exposure.

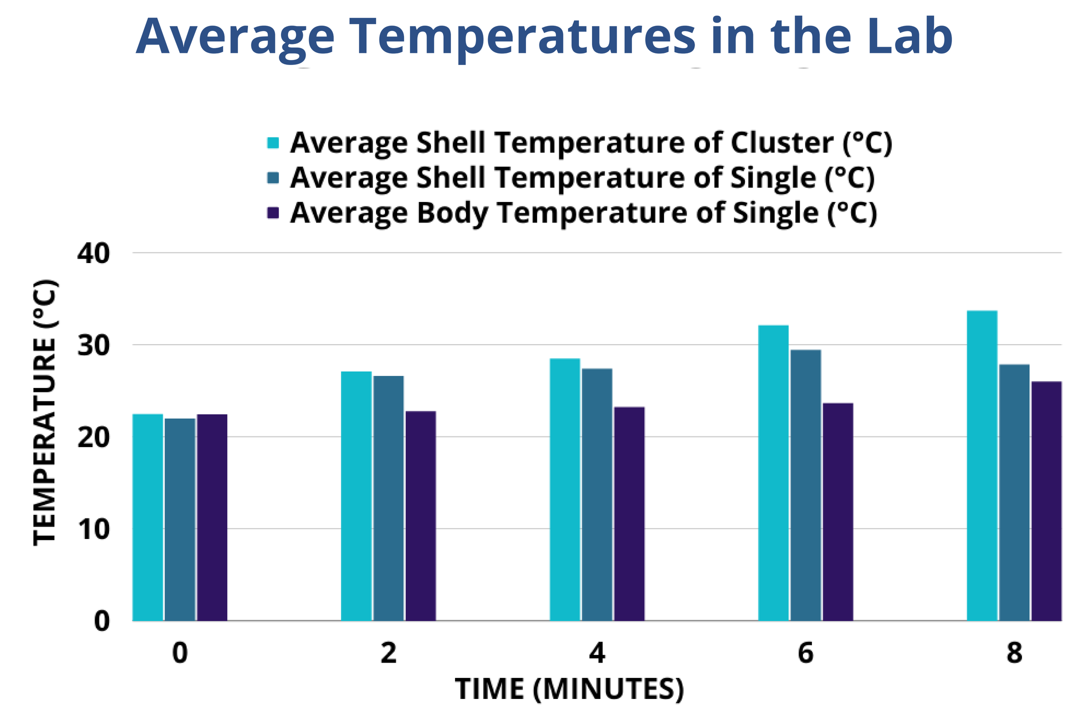

Figure 3. Bar graph with shell average temperature of clustered *L. littorea*; shell temperature and body temperature of solitary *L. littorea* underneath a 50W heat lamp (t=8min).

Shell temperature of clusters (n= 2-5) were significantly warmer than the solitary *L. littorea* (5.82°C). The average body temperature of solitary was cooler than the average shell temperature of the solitary (6.1°C).

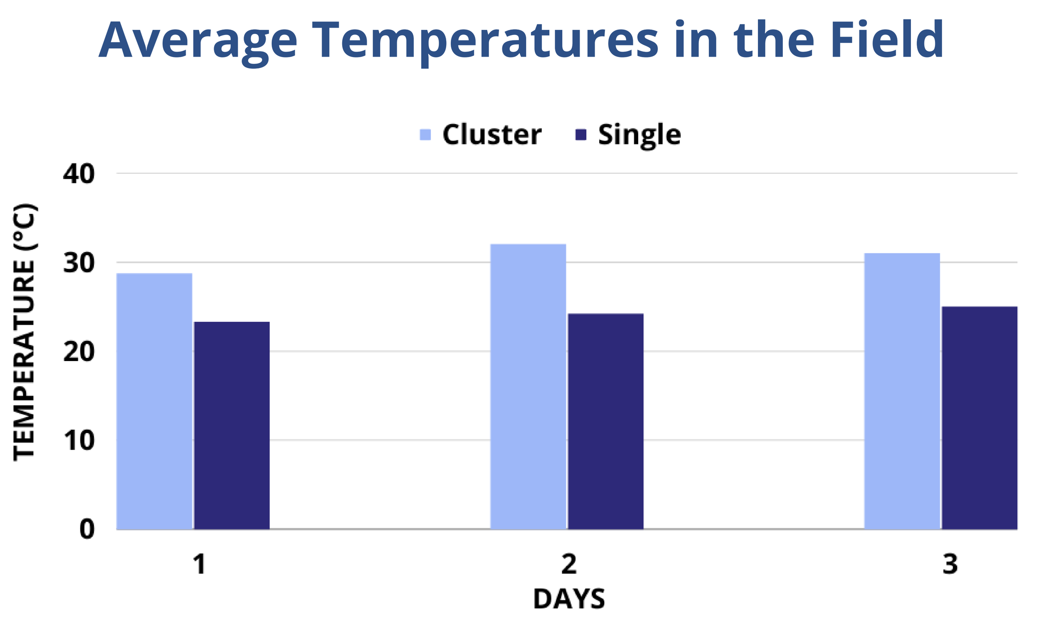

Figure 4. Bar graph with average shell temperature of clustered and a solitary *L. littorea* at Dike Rock.

Clusters of 2 or more *L. littorea* were significantly warmer than the solitary *L. littorea* (6.37°C).

Materials and Methods

LAB

- *Littorina littorea* collected from Marine Street Beach (32.8369919, -117.2814266) and kept at Scripps Institution of Oceanography.
- Clustered snails (n=5) were stacked using tweezers in plastic container (15.24cm x 15.24cm) while a solitary snail (n=1) was placed in a petri dish.
- Snails were dry-blotted and placed under a 50W heat lamp for a total of 8 minutes.
- Body temperature and shell temperature were measured at initial time and at intervals of two minutes using a FLIR C5 camera, FLIR tools, and thermometer.
- Trials were repeated two more times for a total of three trials.
- Temperatures in clusters were recorded in by taking the average of five points in the cluster.

FIELD

- North-facing clustered and solitary snails were observed at Dike Rock (32.8714703, -117.2531979) between 9:00 and 10:00am PST.
- Temperatures were measured and recorded using FLIR C5 cameras and FLIR tools in a cluster by selecting five points and averaging them out.
- Measurements were repeated two more times to get an average temperature, for a total of three trips to the field
- The air temp was 20.5°C on day one, 22°C on day two, and 21°C on day three
- The tide measured -0.1ft on day one, -0.2ft on day two, and -0.3ft on day three
- Temperatures in clusters were recorded in by taking the average of five points in the cluster.

Figure 1. *Littorina littorea* cluster at Dike Rock.

Discussion

Since the periwinkle snails did display clustering behaviors albeit an increase in body temperatures, this may indicate that the snails cluster for increased ability to survive extreme changes in their environment Small increases in some organisms' body temperature due to clustering may enhance individual performance, fitness, and could also increase the adaptive ability to abrupt environmental changes (Chapperon & Seuront, 2012). Clustering behavior in *L. littorea* may play more of a role in preventing desiccation than in thermoregulatory aspects since snails are found usually stacking 2-3 high in the field. Their thermoregulation may have more to do with the substrate the snails choose to inhabit (Muñoz et al., 2005.) Postural behaviors such as elevating shells to create more shade may also contribute to their thermoregulation (Chapperon et al., 2017).

Limitations

- We only observed snails at Dike Rock that were stacked two at the most, so findings may have been different if we found more snails per stack.
- Other variables affecting field research results such as rock crevices, air temperature, water temperature, time of day, and tides may have been present.
- Our lab snails often moved from their whole cluster, so some data was taken when they were in clusters of two or three.

Future studies

- Future research could include research on larger stacks of periwinkle snails and how that affects their temperatures.
- Increase the sample size of common periwinkle snails.
- Conduct more lab trials.

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