

Heat Stress and Behavioral Responses in *Phyllaplysia taylori*

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Marine heatwaves have caused thermal stress on many aquatic organisms of the Pacific Northwest. In 2013, the infamous “Blob” increased water temperatures by 2 to 4°C, resulting in mass die offs of marine mammals, fish, intertidal invertebrates, as well as many others (Cavole 2016). This also led to the increase of algal blooms, which reduced productivity, especially for eelgrass *Zostera marina* (Bond, 2015). *Z. marina*, apart from being a nursery to many marine mammals, as well as a carbon sequestration tool, is home to sea hare *Phyllaplysia taylori*. This heterobranch is an intertidal species with a range from the NE Pacific all the way to Baja, California (Tanner, 2018). It feeds on the epiphytes residing on *Z. marina*, usually diatoms and various forms of algae. This interaction results in a mutually beneficial relationship between these organisms, as *P. taylori* essentially “cleans” the epiphytes off the eelgrass, resulting in increased productivity due to a decrease in shading on the blades (Tanner, 2018). They are also poikilotherms, meaning their body temperature is determined by the external environment and fluctuates with it. Little is known about how *P. taylori* specifically, responds to changes in temperature. Most studies have focused on feeding or grazing behavior over long periods of time, or the more popular Aplysidae sea hare, *A. californica*. Righting time however, can be helpful for understanding short-term thermal stress, as it is a behavioral response that can integrate neuromuscular and metabolic changes.

This study explores *P. taylori*'s behavioral response when subjected to higher water temperatures. The alternative hypothesis is that when subjected to water of higher than normal temperatures (19°C and 24°C) *P. taylori* will exhibit longer righting times. The null hypothesis deems that higher temperatures will have no effect on *P. taylori*'s righting time.

Three trials were conducted over the course of three days. Four replicates were used originally. Three were borrowed from the FHL eelgrass tank, while the fourth was collected at False Bay, Friday Harbor. Two separate heating and cooling treatments were done every trial. Righting time was taken at a control temperature of 14°C, then the organisms were subjected to thermal stress, at 19°C, then at 24°C for the last trial. After 2 hours, righting was measured every hour for the duration of the trial, to allow for acclimation. The heating setup consisted of one main tank, with a water heater and 4 smaller separate tanks for each replicate. The control tank was the same, but was kept at 14°C. Every separate replicate was supplied with new pieces of *Z. marina* every trial day. To determine righting time, a sea hare was picked up and placed on their

dorsal side in their respective tank. After floating to the bottom, a timer was started until the replicate had their full ventral foot on the bottom of the tank.

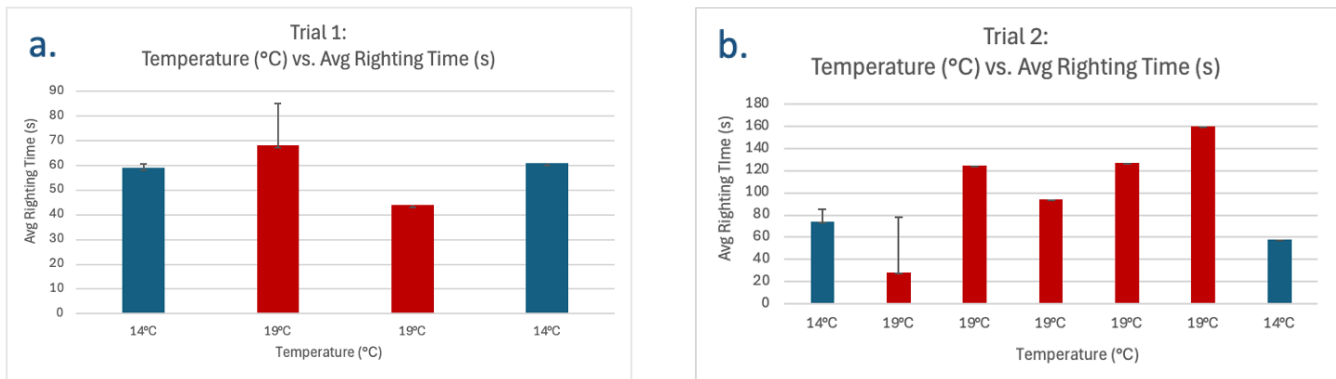


Figure 1: Bar charts showing the average righting time at each temperature for *P. taylori*. The first righting time data at 19°C was taken ~ 2 hours after exposure to allow for acclimation. (a) Day 1: average of 4 replicates. Righting time increased at 19°C, then decreased and increased again at 14°C. (b) Day 2: average of 3 replicates (#4 was non-responsive). Righting time decreased at 19°C, then increased until 14°C, where it returned to a similar start time.

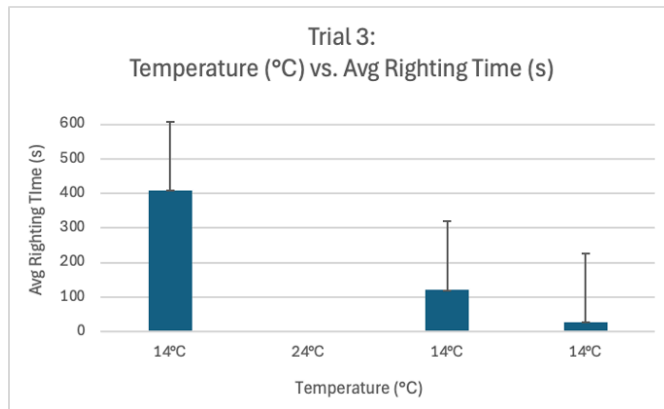


Figure 2: Bar chart showing the average righting time at each temperature for *P. taylori*. The first righting time data at 24°C was taken ~ 2 hours after exposure to allow for acclimation. Day 3: Replicates decreased (n=1-2) due to mortality/unresponsive. At 24°C, all replicates were unresponsive for > 10 minutes, so no data were taken. At 14°C, replicate #2 became responsive and righted. At the next righting time, replicates #2 and #3's righting time decreased significantly.

The initial increase in righting time at the 19°C temperature, as seen in Figure 1: a, may be due to an increase in metabolic rate. This could have sped up neuromuscular function, which decreased righting time. The sequential increase after this could be due to the prolonged exposure resulting in overbearing thermal stress, increasing righting time. When returned to 14°C, righting time decreased significantly. This return to baseline temperature could have

relieved thermal pressure and subsequently increased their behavioral response. This was also apparent in Figure 2, even after losing replicates.


In the face of increasing climate change and global heatwaves, knowing how these events will affect important species and relationships, as is the case with *Z. marina* and *P. taylori*, is necessary from a prevention and conservation standpoint. With further research, awareness, and protection plans, as well as in-depth knowledge of intertidal species and their habitat. These lesser-studied species will be able to flourish even more.

Sources:

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Heat Stress and Behavioral Response in *Phyllaplysia taylori*

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FHL 432: Marine Invertebrate Zoology

Introduction & Background

Phyllaplysia taylori

- Intertidal species – NE Pacific to California
- Lives on eelgrass beds (*Zostera marina*)
 - Feeds on epiphytes (diatoms, algae) that live on *Z. marina*
 - Increases light access, increased photosynthesis
- Poikilotherm
 - Body temperature is determined by external environment and fluctuates



Question & Hypothesis

Research Question:

What is *Phyllaplysia taylori*'s behavioral response to increased temperature conditions?

Alternative Hypothesis:

When subjected to water of higher than normal temperatures (19°C and 24°C), *P. taylori* will exhibit longer righting times.

Null Hypothesis:

Higher water temperature (19°C and 24°C), will have no effect on *P. taylori*'s righting time.

Gap in Knowledge:

Little is known about how *P. taylori* responds to changes in temperature

- Most studies focus on feeding/grazing behavior over long periods of time
 - Focus on other sea hares of the Aplysiidae family (*A. californica*)
- Righting time can be helpful with understanding short-term thermal stress
 - Behavioral response that can integrate neuromuscular and metabolic changes
- How increasing anthropogenic and climate change will affect *P. taylori*, *Z. marina*, and similar species

Significance

The “Blob”

- Marine heatwave in NE Pacific from 2013-2016
- Resulted in +2-4°C increase in temperature
- Mass die-offs
- Algal blooms
 - Reduced productivity
- Projected to increase in the future

Intertidal Animals

- Increasing temperatures may be too high for acclimation
- Chances of detrimental effects on both *P. taylori* and *Z. marina*

Experimental Design

14°C

- 4 replicates
- 3 days, 3 trials total

19°C

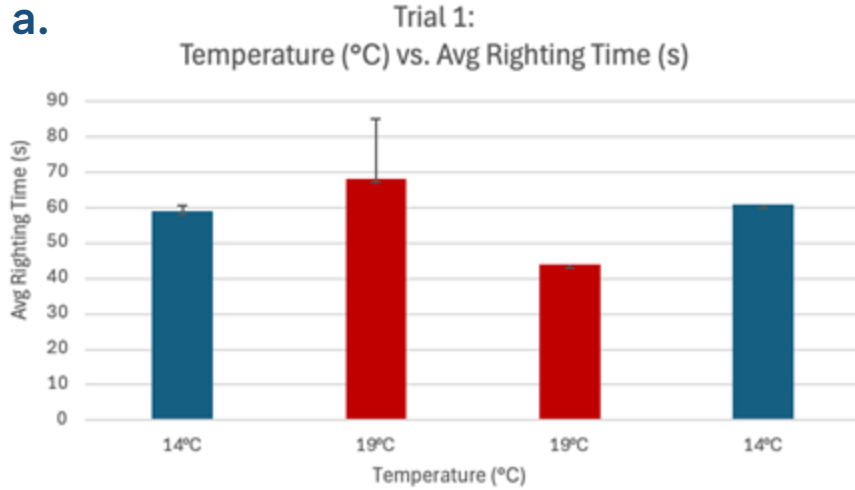
- Righting time was taken before *P. taylori* was placed in either heat treatment
- After 2 hours, righting was measured every hour for the duration of the trial

24°C



Results:

a.



b.

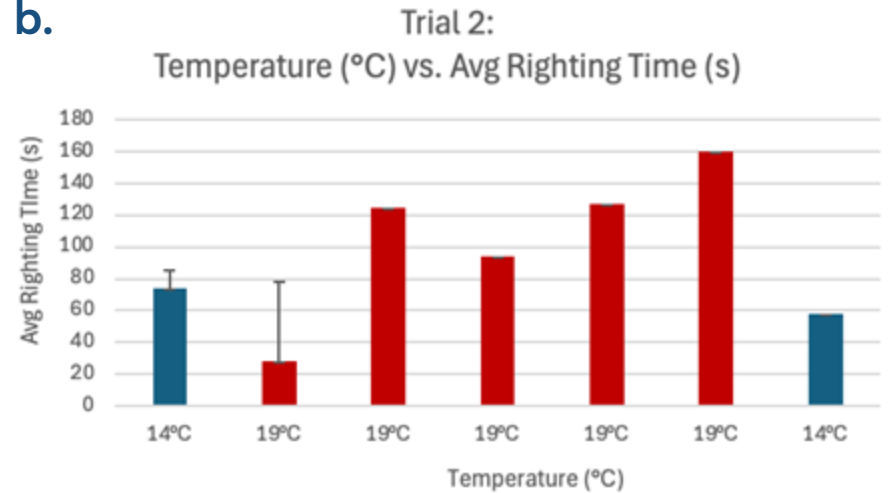


Figure 1: Bar charts showing the average righting time at each temperature for *P. taylori*. The first righting time data at 19°C was taken ~ 2 hours after exposure to allow for acclimation. (a) Day 1: average of 4 replicates. Righting time increased in 19°C, then decreased and increased again at 14°C. (b) Day 2: average of 3 replicates (#4 was non-responsive). Righting time decreased in 19°C, then increased until 14°C, where it returned to a similar start time

Results:

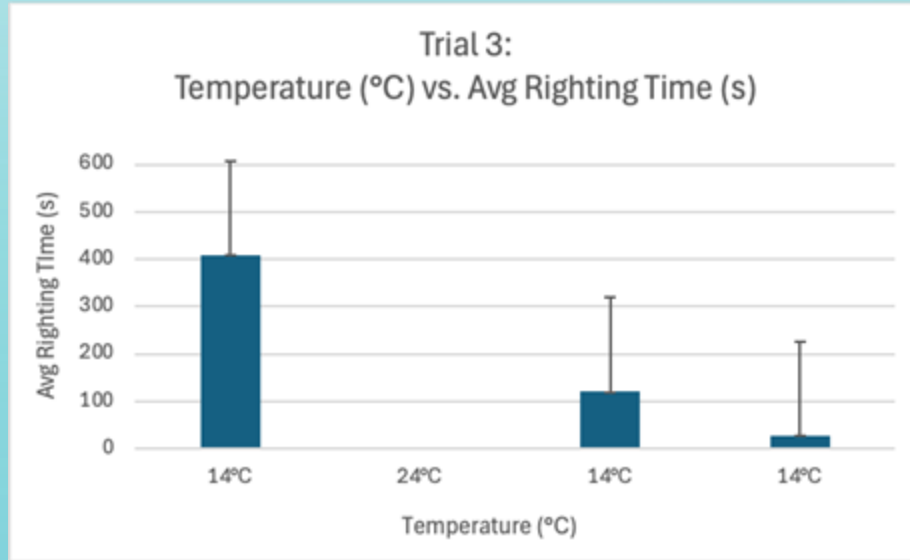


Figure 2: Bar charts showing the average righting time at each temperature for *P. taylori*. The first righting time data at 24°C was taken ~ 2 hours after exposure to allow for acclimation. Day 3: Replicates decreased (n=1-2) due to mortality/unresponsive. At 24°C, all replicates were unresponsive for > 10 minutes, so no data was taken. At 14°C, replicate #2 became responsive and righted. At the next righting time, replicates #2 and #3's righting time decreased significantly.

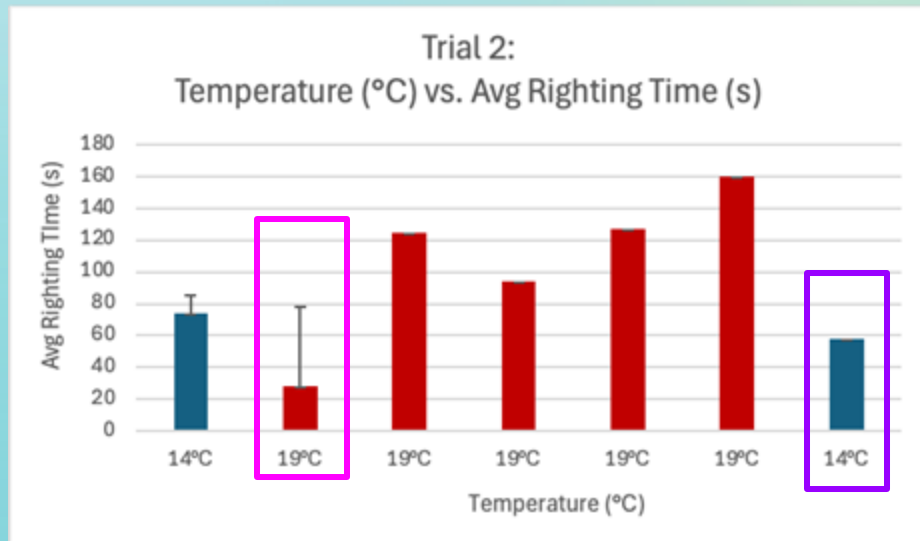
Discussion

19°C

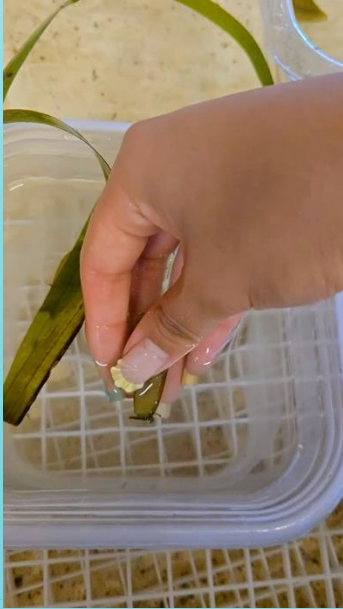
- Increase in metabolic rate, could have sped up neuromuscular function
 - Decreased righting time initially
 - Prolonged exposure resulted in thermal stress – increased righting time

14°C

- Baseline temperature could have reduced stress
 - Relieved thermal pressure and increased behavioral response



Behavior



Thanks!

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