The following article is by one of our 2019 Scholarship Recipients, Lily McIntire, of Humboldt State University and FHL.

Can't take the heat? get out of the tidepools: evaluating the grazing performance and thermoregulation efficiency of gumboot chitons

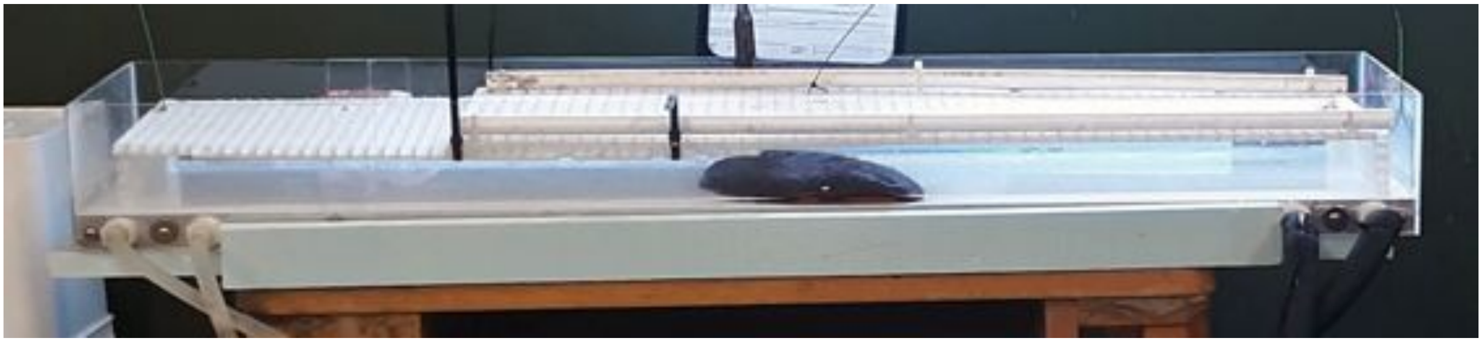
By Lily McIntire

Rocky intertidal zones are very thermally stressful environments, where ectotherms like molluscs deal with fluctuations in air and water temperatures during low tide that can exceed thermal performance limits. However, there is a mosaic of stress experienced by intertidal organisms that is cause by the timing of the tides. Ectotherms in northern regions of the Pacific Northwest, like Washington, experience more thermal stress because summertime low tides occur during midday. However, in more southern regions like northern California, ectotherms are buffered from thermal stress by cooler pre-dawn low tides. The gumboot chiton (**Fig. 1**; *Cryptochiton stelleri*), also known as the giant Pacific chiton or the wandering meatloaf, is the world's largest chiton. They are a thermally sensitive intertidal grazer that reaches their upper thermal limit for respiration at only 18 ℃ in water and 20 ℃ in air (Petersen and Johansen 1973). Additionally, they range from southern California (CA) to Alaska, and are therefore exposed to the mosaic of thermal stress due to the timing of the tides (Yates 1989, Mislan et al. 2009). To understand phow gumboots will be affected by elevated temperatures like those caused by climate change, I did a laboratory experiment quantifying how both air and water temperatures affect their grazing rates and I measured their thermoregulation efficiency in the field. I compared the thermoregulation efficiency of gumboots from a thermally-benign part of their range in northern California with those from thermally-stressful part of their range on San Juan Island (SJI), Washington. I used three components to calculate their thermoregulation efficiency: 1) biomimetic thermal models, (**Fig. 2**; aka "roboboots") deployed intertidally at three sites each in CA and SJI; 2) gumboot body temperatures in the field; and 3) gumboot thermal preference in a laboratory-based thermal gradient. I combined these three elements to calculate how well gumboots are selecting for habitat in the field.

I found that gumboot grazing was reduced at 18℃ in water and reached their grazing performance limit at 20℃ in air, confirming previous work documenting thermal performance limits on gumboot chiton respiration. I also found that preferred temperatures of gumboots in the laboratory were close to their thermal performance limits, but that they rarely achieved body temperatures that would maximize their performance in the field. This suggests that gumboots are thermoregulating inefficiently with respect to maximizing performance, but instead may be

Fig. 1: A gumboot chiton in the intertidal

Fig. 2: A live gumboot (left) next to a roboboot (right). Roboboots were an iButton temperature loggers embedded in a carwash sponge and covered by a football skin and attached to the rocks in the intertidal with a vexar mesh and bolts. Roboboots also matched live chitons within 1℃.



A gumboot on my laboratory based thermal gradient. This thermal gradient was an aluminum block covered by PVC sticker and less than 0.5cm of sea water. Gradient was heated to 25℃ on the warm side and cooled to 11℃ on the other end.

minimizing exposure to detrimental thermal extremes. This has been documented in other slow-moving intertidal invertebrates, like the sea star *Pisaster ochraceus*. This sea star will rarely achieve its maximum temperatures in the field, but instead will select habitat to avoid overheating during low tide (Monaco 2016). My data suggests that these slow-moving grazers are not going to be able to vacate the premises when temperatures are too warm. Therefore, they are not going to be able to survive in the intertidal, where temperatures are going to become too hot, so they must get out of the tidepools and into the subtidal.

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