The Boiled Crab: The Effect of Temperature on Food Consumption in Rock Crabs

Alex Alvarez, Audrey Angulo, Arjun Bharat

UC San Diego, Extended Studies, Scripps Institution of Oceanography

UC San Diego EXTENDED STUDIES

Abstract

In recent years, the danger of global warming has been more potent than ever; a constant reminder of how privileged we are to be living in such a beautiful and diverse world. Rising temperatures are a large threat to marine ecosystems and invertebrates in particular, who are cold-blooded and do not possess the ability to regulate their body temperature. Instead, their body heat fluctuates, mirroring their surroundings, making them extremely vulnerable to the effects of global warming. Additionally, physiological elements could be altered, such as metabolism and ability to ingest food. Changes in temperature could be potentially detrimental to their food intake, and their lives. We measured the amount of frozen Branzino, Dicentrarchus labrax consumed by Yellow Rock Crabs, Metacarcinus anthonyi, at different temperatures within the thermal tolerance of the species. Infrared Thermography (IRT) was used to record the temperature of the crabs. M. anthonyi was found to consume more fish at higher temperatures within their thermal preference, reported to be under 25.4 C. Higher temperatures were shown to expedite the feeding in the crab, as the warmed crab was more active and had an increased appetite. However, large shifts in temperature proved to be deadly, as the specimen heated to 26.7 C (80 F) died after three days due to various stresses, both past and present, including heat and malnutrition. In conclusion, understanding the effects of increased temperature is crucial in predicting the effects of global warming on marine organisms.

Introduction

Climate change poses a serious threat to marine ecosystems, impacting species like Yellow Rock Crabs (*Metacarcinus anthonyi*) along the Eastern Pacific Coast of North America (Coates and Briley, 2020) . These crabs, being poikilotherms, rely on environmental warmth since they cannot regulate their own body temperature (Lewis and Ayers, 2014). They play pivotal roles as both predators and prey in intertidal ecosystems and are economically important as a substantial component of the commercial crab catch (Jones, 2018). Their diet primarily consists of gastropods and mollusks, though they occasionally consume small fish (Bruner, 2022).

Yellow Rock Crabs typically inhabit sandy bottoms rather than rocky substrates and are found from the lower intertidal zone to depths of about 100 meters (Bruner, 2022). Given their ecological importance, understanding how these crabs adapt to changing temperatures is crucial amidst ongoing climate change. This study investigates their response to varying temperatures, focusing on daily food consumption as a metric of environmental stress and aims to advance our knowledge of adaptive mechanisms in intertidal organisms facing environmental challenges, thereby contributing to informed conservation strategies.

Materials and Methods

Three Yellow Rock Crabs (*M. anthonyi:* 383.47-465.93 g; 2 females, 1 male) were individually housed in 5.5-gallon tanks at 3 different temperatures: ambient (18.5±1.0C), warm (22.1±0.5C), and hot (27.7±0.6C). Each crab received 10 g of Frozen Branzino twice daily, with daily water changes post-feeding. Temperature measurements were taken post-feeding using a FLIR C5 infrared camera, correlating water temperature with crab body temperature due to their poikilothermic nature. Excel was used for data input, analysis, and graphical representation. Normality was tested using Shapiro-Wilk, and a Pearson's R correlation analysis explored heat exchange dynamics between crabs and water over time. FLIR cameras facilitated comprehensive data collection within single images, capturing ranges and specific temperatures critical for understanding thermal dynamics in this study.

Fig. 1. *M. anthoyi* **(465.93 g) observed in the experimental container (control)**

Results

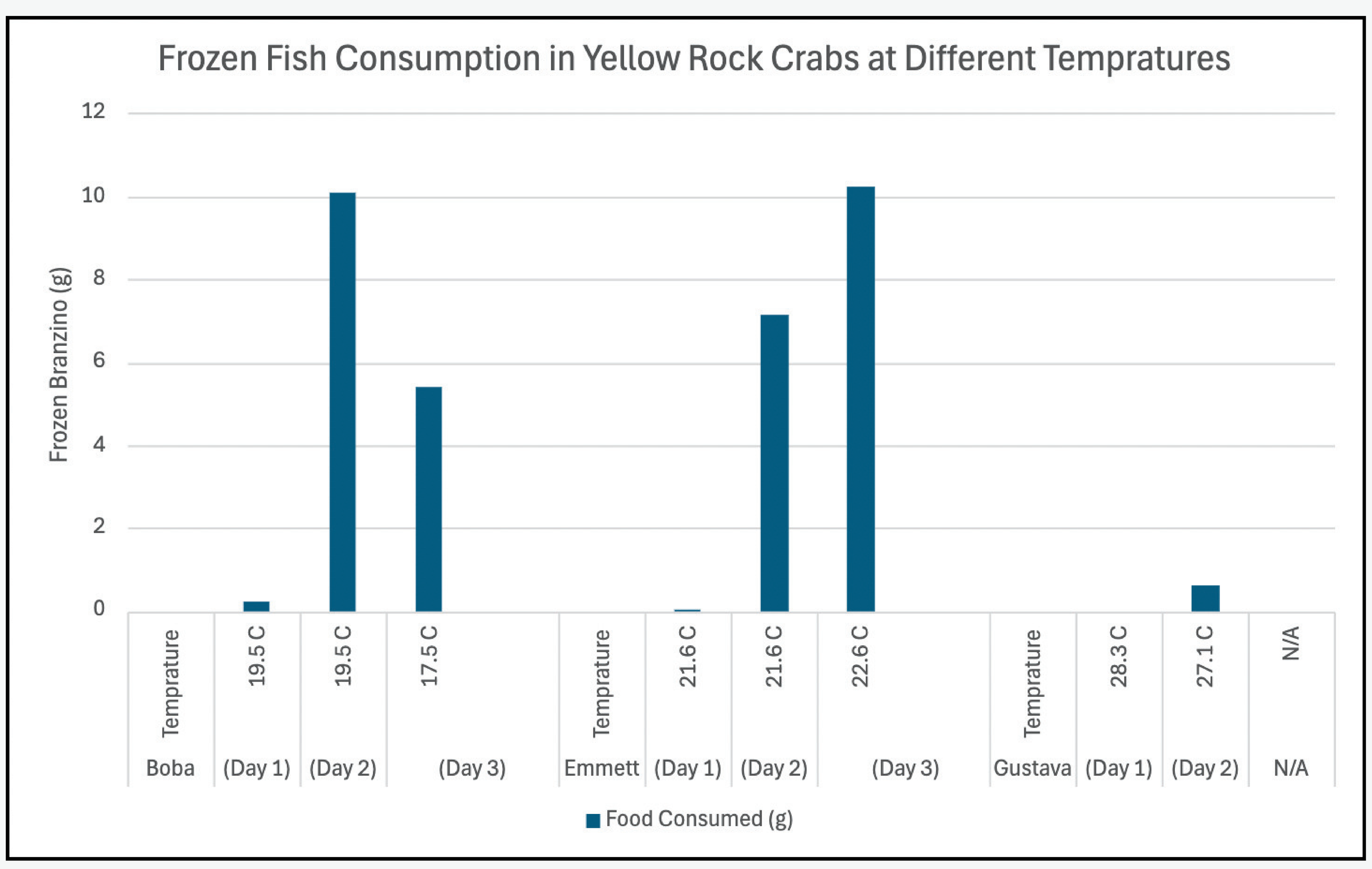

Fig 2. The amount of food consumed by *M. anthonyi* over 3 days at different temperature ranges: ambient (18.5±1.0C), warm (22.1±0.5C), and hot (27.7±0.6C)

Overall, the data showed a slightly negative correlation (R=-0.3275) between temperature and food consumption in Yellow Rock Crabs. Generally, the crabs would eat more fish as the temperature increased. Emmett (warm) remained in warm water over the three days, its appetite increased from eating 71% fish on the Day 2, to 100% fish on Day 3 (Fig. 2). In contrast, the Boba (control) ate 100% fish on Day 2, but only ate 52% during a lower ambient temperature on Day 3. The crabs were given a negligible amount of frozen fish to test if they would consume on Day 1, and despite an increase in food provided on the Day 2, Gustava (hot) ate very little (Fig. 3), and died on Day 3, affecting the minimum and variance (Fig. 4).

	Warm	Hot	Control
Day 1	0.003	0	0.21
Day 2	7.13	0.6	10.1
Day 3	10.25	0	5.38
Mean	5.7943333	0.2	5.23
Median	7.13	0	5.38
Variance	27.588256	0.12	24.4699
Range	10.247	0.6	9.89
SD	5.2524524	0.34641	4.946706
SE	3.0325048	0.2	2.855982

Table 1: The amount of frozen branzino consumed by *M. anthonyi* at different temperature ranges, with statistical summaries. Shapiro-Wilk showed normal distribution (W(5) = .9, p = .519).

Discussion

The data gathered concluded that Emmitt (warm) consumed most of the fish. Day 1 and Day 2 were almost the same in terms of feeding rates between Boba (control) and Emmett (warm). On Day 3, the ambient temperature of the control tank dropped to 17.5 C, causing Boba (control) to have slower movements and a decreased appetite, similar to the experienced symptoms of Gustava (hot) who died on Day 3. However, previous conditions before Gustava was obtained cannot be dismissed and may play some part in her death. With the data observed, is seems that *M. anthonyi* is less likely to survive extreme temperatures due to heat-related stress. This can be further proved by earlier experiments in which crabs have died in extremely high temperatures (Siikavuopio and James, 2013). Through analyzing the data observed, *M. anthonyi* may be severely weakened when stressed by extreme temperatures. The experiment performed can hopefully shed light on *M. anthonyi's* metabolism and behavior in their natural envireonment.

Experimental Limitations & Errors:

- Crabs were identified by morphology and name sold under, so may not be accurate
- Crabs measured different mass and lengths, and unknown medical history & previous stressors
- Small pieces of food were left in the tank, creating oil and producing CO2

Future Study:

- Comparing more crabs at different temperatures to eliminate outliers
- Sample different species, sizes, sexes, or ages
- Decrease temperature from control, test thermal limits (CTMin, CTMax)
- Vary food type (snails, clams, other fish, etc.)

Fig 3: Close up of *M. anthonyi,* known for its large black pincers.

Acknowledgments

On behalf of all of our research and achievements, our appreciation goes to Sonya Timko, Nicole Yen and Jordan Renee Chalmers, whose tireless work ethic, empathy, and guidance made our experimental process possible. To Orna Cook, Megan Kennedy and Phil Zerofski at Hubbs Hall, we're grateful for facilitating our research and allowing us to grow through this unique opportunity. Finally, to all staff at Cabrillo National Monument, Tijuana Estuary, and Pre-College at UCSD, we thank you for aiding and accommodating us.

References

1. Lewis, Lara, and Joseph Ayers. "Temperature Preference and Acclimation in the Jonah Crab, Cancer Borealis." Journal of Experimental Marine Biology and Ecology, vol. 455, June 2014, pp. 7–13. ScienceDirect, https://doi.org/10.1016/j.jembe.2014.02.013.
2. *Rock Crab | California Sea Grant*. https://caseagrant.ucsd.edu/seafood-profiles/rock-crab. Accessed 17 July 2024.
3. *CA Marine Species Portal*. https://marinespecies.wildlife.ca.gov/red,-yellow,-and-brown-rock-crab/the-species/. Accessed 17 July 2024.
4. "Yellow Rock Crab (Metacarcinus Anthonyi)." *iNaturalist Canada*, https://inaturalist.ca/taxa/204580-Metacarcinus-anthonyi. Accessed 17 July 2024
5. "Yellow Crab Aka Yellow Rock Crab." *Pier Fishing in California*, 5 Nov. 2018, https://www.pierfishing.com/yellow-crab-or-yellow-rock-crab/.
6. Siikavuopio, S. I., & James, P. (2015). Effects of temperature on feed intake, growth and oxygen consumption in adult male king crab Paralithodes camtschaticus held in captivity and fed manufactured diets. Aquaculture Research, 46(3), 602-608. Accessed 23 July 2024