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Determination of temperature preference and the role of the enlarged cheliped in thermoregulation in male sand fiddler crabs, *Uca pugilator*

A. Windsor, M. Crowe*, J. Bishop

Department of Biology, Coastal Carolina University, P.O. Box 261954, Conway, SC 29528, USA

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Abstract

1. Male *Uca pugilator* whose major cheliped was immersed in 3 °C water bath experienced a significant drop in T_b. Thus, the enlarged claw of male *Uca pugilator* may have an unexplored function: thermoregulation.
2. Crabs prefer warmer substrates (19–24 and 28–30 °C) over cooler (15–17 °C).
3. Mean selected temperature (MST) may not be an accurate reflection of T_b. Crabs in a thermal chamber preferred temperatures between 25 and 30 °C but their average T_b was 23.2 °C.

Keywords: Thermal preference; Crabs; Ocypode; *Uca*; Fiddler crab; Dimorphism

1. Introduction

Over the past 50 years many studies have investigated the thermoregulatory behavior of ectothermic animals. These animals use a combination of behavioral and physiological mechanisms to maintain their body temperatures within a narrow range, even under varied environmental conditions and microhabitats (see reviews by Casey and Hegel, 1981; Avery, 1982; Hutchinson and Dupre, 1992). One group of ectotherms whose thermoregulatory behavior is less well studied is that of intertidal salt marsh invertebrates. The behavior and physiology of thermoregulation of these invertebrates is likely more complex than their terrestrial counterparts because they experience substantial changes in temperature, salinity and moisture content of the substrate as the tide floods and ebbs. While submerged, the temperatures of these invertebrates is likely to approximate that of the water; then, during aerial exposure, air temperature, wind speed, solar radiation and relative humidity will all influence their temperatures (Helmuth, 1998).

Many physiological processes are temperature dependent, so effective thermoregulation is essential for an ectotherm's growth and development (Angilletta, 2001). Because of the cyclic nature of tides, it is critical that intertidal invertebrates reach their preferred body temperature (PBT) temperature quickly and remain there for as long as possible until the tide returns. In this study we examined several aspects of thermoregulatory behavior in the sand fiddler crab, *Uca pugilator*, which is found in the intertidal zone of salt marshes on the Atlantic and Gulf of Mexico coasts of the United

*Corresponding author. Center for Undergraduate Research, Xavier University of Louisiana, 1 Drexel Drive, P.O. Box 34, New Orleans, LA 70125, USA. Tel.: +1-504-520-5751; fax: +1-504-520-7889.

E-mail address: mcrowe@xula.edu (M. Crowe).

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States (Crane, 1975). Individuals of this species encounter a large range of temperatures in a single day, over a given season, and on an annual basis. Fiddler crabs retreat into burrows, change color, move into the shade and change orientation to the sun as a means of coping with high temperatures, suggesting that crabs behaviorally thermoregulate (Wilkens and Fingerman, 1965; Smith and Miller, 1973; Powers and Cole, 1976; Thurman, 1998). In addition, a variety of fiddler crab behaviors are sensitive to temperature including burrowing, claw waving, molting, movement and sound production (Salmon, 1965; Miller and Vernberg, 1968; Powers and Cole, 1976; Doherty, 1982; Wolfrath, 1992; Weinstein, 1998).

Fiddler crabs exhibit one of the most widely known sexual dimorphisms of any group of organisms (Crane, 1975). Males have one enlarged claw and one smaller feeding claw while females have two equal sized feeding claws (Crane, 1975). Males use their enlarged claw in male-male combat and as a signaler to attract females (Christy and Salmon, 1984; Pope, 2000). The enlarged cheliped of an adult male can comprise up to 48% of its body mass (Christy and Salmon, 1984). The extreme sexual dimorphism exhibited by these crabs may have implications on the thermal ecology of the crabs. Given the large surface area of the enlarged claw, males might use it to thermoregulate in the same manner in which other ectotherms use body orientation and posture to control their body temperatures (Casey and Hegel, 1981; May, 1979; Kingsolver, 1985; Angilletta, 2001; Blouin-Demers and Weatherhead, 2001). Scientists have remarked anecdotally upon the curious behavior of male fiddler crabs emerging from their burrows early in the morning and facing the sun with their large chela outstretched (Crane, 1943; Smith and Miller, 1973).

Our objectives were to determine whether male *U. pugilator* crabs used their enlarged claw to influence body temperature, whether they have a PBT and whether their mean selected temperature (MST) is an accurate reflection of the crab's body temperature.

2. Materials and methods

During 2001 and 2002 male sand fiddler crabs were collected from a salt marsh at Waites Island, (33°50′43″N and 78°35′12″W) in northeastern South Carolina and brought to the laboratory. Laboratory temperatures ranged between 16–20 °C and the light regimen followed a natural light/dark cycle. Crabs were kept in moist marsh sediment and allowed to feed ad libitum. We constructed copper-constanan thermocouples and calibrated them with either ice or boiling water. We equipped crabs with thermocouples by removing the posterior leg farthest from the major claw and inserting a thermocouple into the body cavity of the crab (sensu Edney, 1961; Smith and Miller, 1973). Crabs with thermocouples remained alive through the observation period and beyond.

2.1. Heat transfer between claw and body

For both the control and experimental groups, we restrained individual crabs on a metal rod using plastic tie downs. After a 5 min acclimation period, we monitored the temperatures over a 35 min trial by recording the crab's body temperature (T_b) every 10 s and averaging it over a 60 s period using a Campbell 10 × datalogger. For the treatment group, 5 min into the trial we immersed the crab's major claw in an ice bath of 3 °C (Fig. 1) for 20 min at which point the ice was removed and we continued monitoring T_b for an additional 10 min ($N = 20$). For the control group, we only recorded the temperature of the crab for a 35 min period ($N = 10$).

To determine if immersing the claw in ice influenced T_b, for both the control and treatment groups, we use paired *t*-tests to compare the crab's T_b at minute 5 with the crab's T_b at minute 24. For the treatment group, this represented the minute before the claw was immersed in ice and the last minute the claw was in the ice.

3. Laboratory determination of PBT

3.1. General temperature preference

We covered the bottom of a 10-gal aquarium with approximately 2.5 cm of moist marsh sediment. One hour before trials, we placed a heating pad under one-third of the tank and an ice bath under the opposite third of the tank (between trials we randomly changed which end of the tank was hot or cold). We placed a thermocouple about 1 cm into the marsh sediment in each one-third section of the tank during the experiment. The temperature of the substrate located above

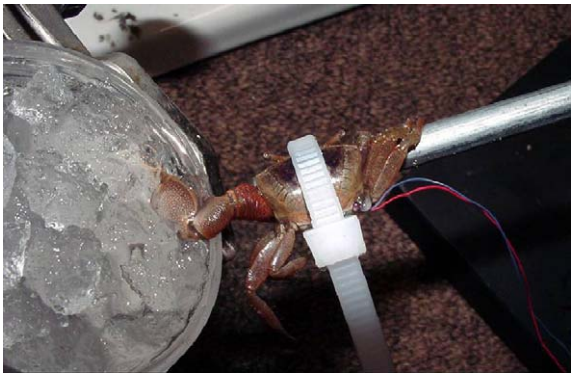

Fig. 1. Male crab with major claw immersed in ice bath.