Thermal acclimation dynamics in fiddler crabs

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Introduction

The Ambeua mangrove on Kaledupa, Indonesia boasts the highest alpha-diversity of fiddler crabs in the world (Barnes 2010), and exhibits spatial zonation of species. With global warming causing mangrove environments to become dryer and warmer, little is known about how populations of fiddler crabs will react. My project hopes to understand how these crabs thermal tolerance will be affected by their species specific habitat within the mangroves. This study will be relevant to the wider context of the effects of global warming on mangrove ecosystems, due to the crab's role as a key bioengineering organism (Andreeta et al 2014).

Fig 1, from left to right, Uca crassipes, Uca vocans and Uca triangularis

Aims

1) *To quantify the spatial distribution of different species of fiddler crabs within the Ambeua mangrove, Indonesia, with regards to temperature.*
2) *To test how thermal tolerance changes over time spent in acclimation at a higher temperature, for each species*
3) *To test whether prior exposure to sub-lethal temperatures increases thermal tolerance and for how long, a phenomenon known as heat hardening.*

CTmax = 'critical thermal maximum', a sub-lethal endpoint to thermal stress

Methods

Field data

- *Water, air, sediment and burrow temperatures recorded with a thermometer*
- *Salinity recorded using a refractometer*
- *Crab abundance measured using a randomly placed 1x1m²*

Acclimation

- *Crabs held in separate containers per species with a layer of mangrove sediment*
- *Heated by a water bath to a mean temperature of 33°C ± 0.12 °C*
- *CTmax tested on randomly selected individuals on days 1, 3, 5, 7 and 10 for each species (n=3)*
- *CTmax tested by placing individual in an elevated container above a water bath, heated at a mean rate of 0.34°C ± 0.06 °C*
- *End point quantified by the temperature at which the crab cannot right itself when flipped over, signalling 'ecological death'.*

Heat hardening

- *CTmax of individuals were tested at 0 hours, 24 hours and 72 hours for each species (n= 8)*
- *CTmax tested by placing individual in an elevated container above a water bath, heated at a mean rate of 0.34°C ± 0.06 °C*
- *End point quantified by the temperature at which the crab cannot right itself when flipped over, signalling 'ecological death'.*

Results

Field data results

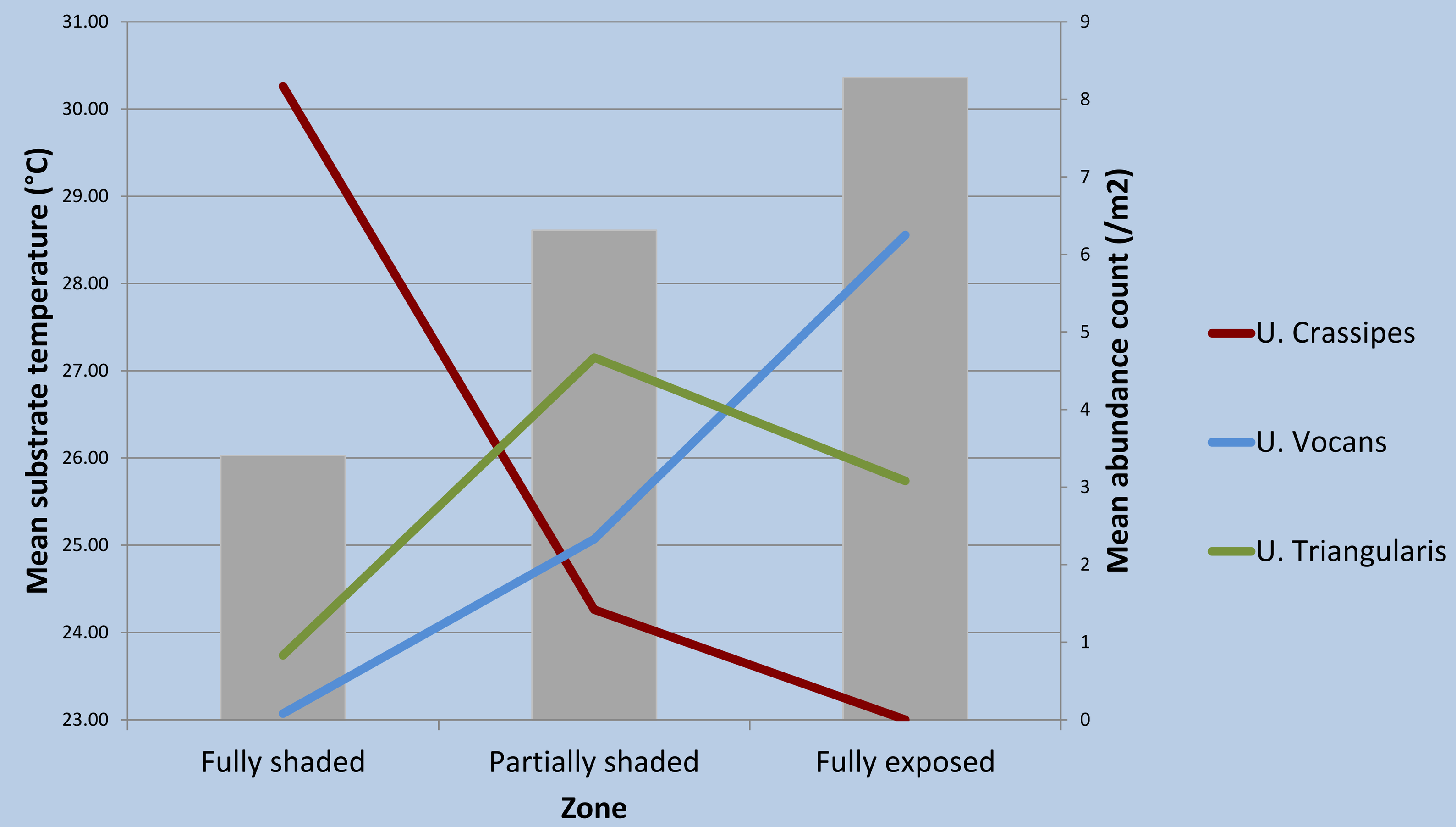

Fig 2. Mean substrate temperature and mean abundance count per m²of three species of fiddler crab

As demonstrated in figure two, there is a clear correlation between temperature and distribution of each of the three species. U. crassipes was most abundant in the fully shaded region which experienced the lowest temperatures. U. triangularis was the most abundant in the partially shaded zone which experienced a median temperature. U. vocans was the most abundant in the fully exposed region, which corresponded with the highest temperature.

Acclimation results

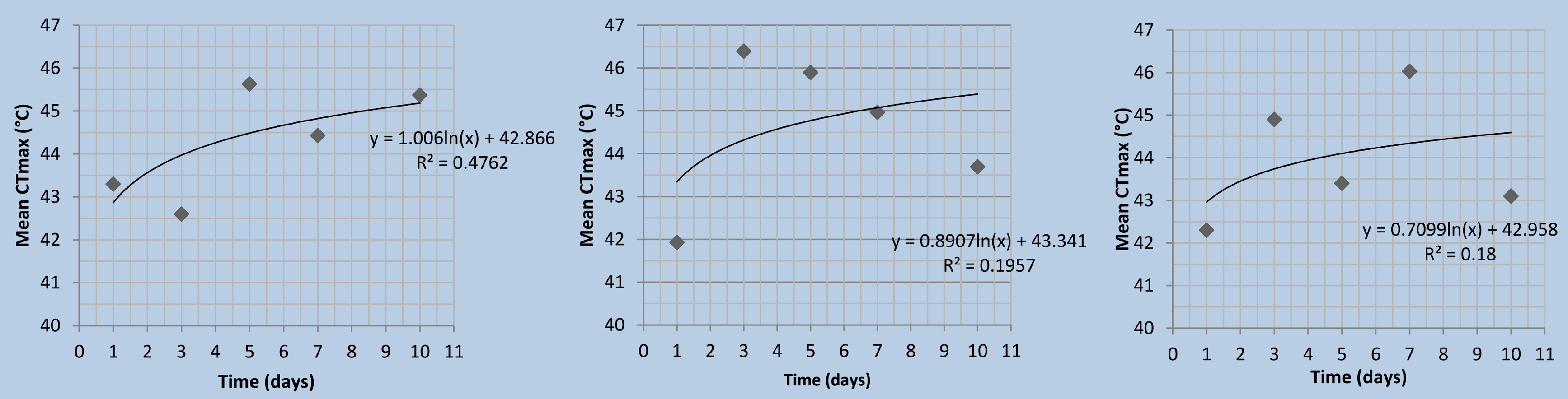

Fig 3. Second order logarithms regression of (from left to right) U. vocans, U. crassipes and U. triangularis mean critical thermal maximum over a period often days acclimated at 33°C

The regression allows me to generate a predictive model for the time taken for each species to acclimate to 33°C . As shown from figure three, after around five days CTmax starts to 'level out' indicating that from preliminary observation, 5 days is roughly the required time period for 100% acclimation. Further statistical analysis is required.

Heat hardening results

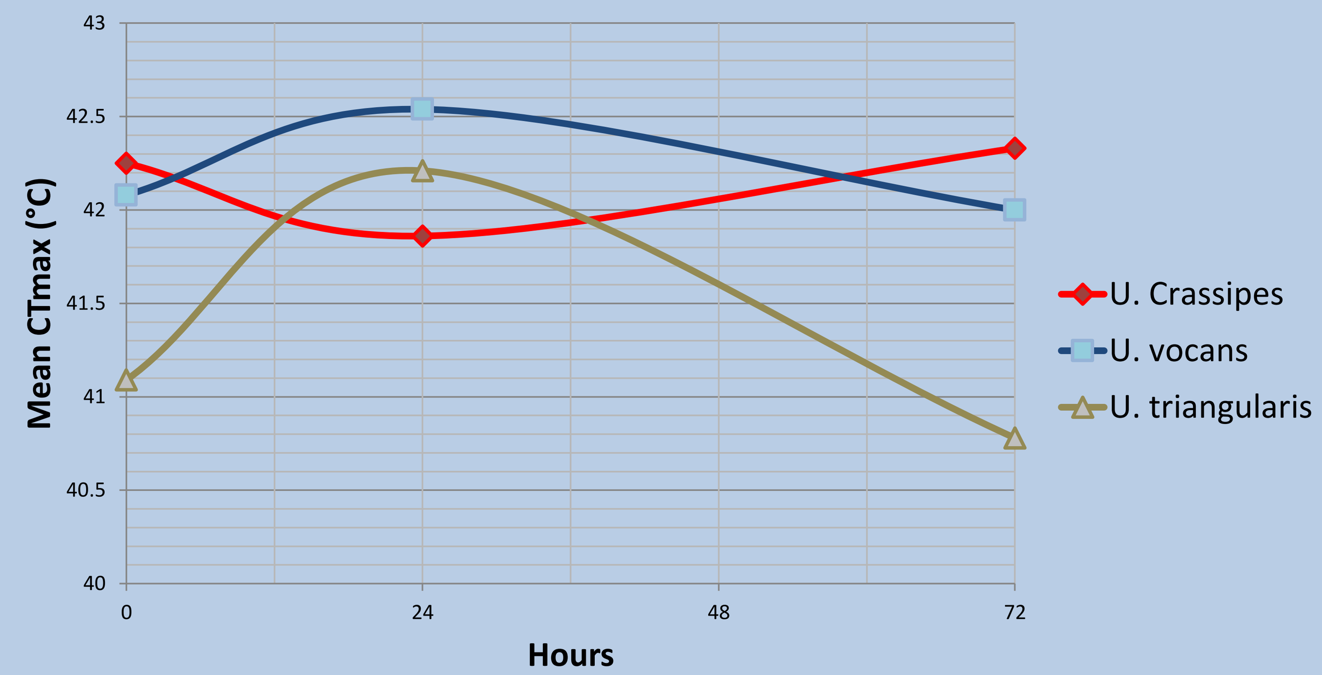

Fig. 4: Mean CTmax of three species of fiddler crab in repeat tests over 72 hours

- *U. triangularis exhibited the most dramatic increase in thermal tolerance*
- *U. vocans also demonstrated an increase in mean CTmax after 24 hours before decreasing at 72 hours.*
- *Contrastingly, U. crassipes actually exhibited a decrease in temperature after 24 hours then increased 72 hours after initial exposure*

Discussion

- *Uca triangularis had the lowest initial thermal tolerance, quantified by CTmax, but had the strongest heat hardening response. This may be because in an environment where they have a low thermal tolerance compared to other resident species, they compensate by having a strong 'hard and fast' heat hardening response.*
- *Uca crassipes had the lowest mean CTmax, possibly due to living in an environment with a relatively steady low temperature; living in the fully shaded zone, minimum thermal plasticity is required.*
- *Uca vocans had the highest initial mean CTmax due possibly due experiencing to daily temperature fluctuations in the fully exposed zone of the mangroves*
- *Both U. triangularis and U. vocans exhibited the effects of heat hardening. U. crassipes did not, possibly due to living in a stable environment where a dramatic increase in temperature is not a likely stressor*
- *Another point to consider is the behavioural adaptations such as burrowing and physiological adaptations such as a hard carapace to come with thermal stress in their natural environment*

References: Andreetta, A., Fusi, M., Cameldi, I., Cimò, F., Carnicelli, S., and Cannicci, S. (2014); Mangrove carbon sink. Do burrowing crabs contribute to sediment carbon storage? Evidence from a Kenyan mangrove system. *Journal of Sea Research*. Vol.85, pp. 524-533.

Barnes. R. (2010); A remarkable case of fiddler crab, Uca spp., alpha diversity in Wallacea. *Hydrobiologia*. Vol. 637, pp.249-253

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