Thermal Adaptation of Streamside Salamanders (*Ambystoma barbouri*) across a Latitudinal Gradient

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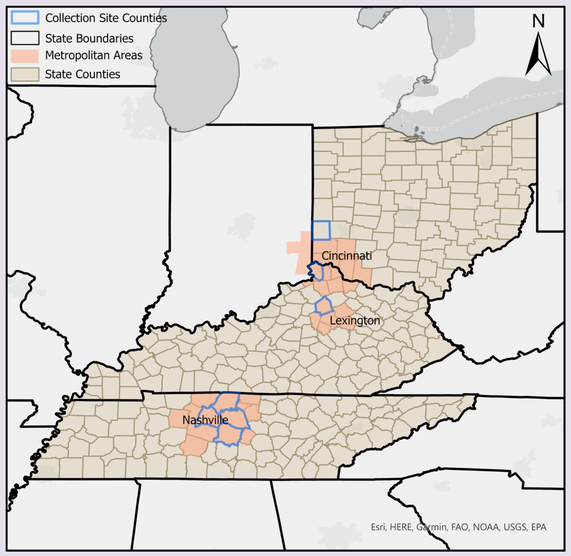
Background

- Temperature change across latitude has been used as a proxy for climate change, but little is known about how salamander embryos respond to thermal variation[1]
- The Streamside Salamander, a Tennessee state endangered species, has a broad latitudinal range (Fig 1)
- Streamside Salamanders utilize ephemeral streams for breeding which exhibit large thermal variation, allowing for thermal adaptation of development[2] (Fig 2)

Research Questions

- What is the thermal environment for Streamside Salamander embryos across latitudes and habitats?
- How do individuals and populations respond to developmental temperature?

Figure 1. Map of counties from which eggs were collected and adjacent metropolitan areas.



Methods

- Collected eggs from across the latitudinal range of *A. barbouri* (Fig 1)
- Placed temperature loggers (HOBO TidbiT) at sites throughout range recording hourly nest temperatures
- Incubated eggs at 5, 10, 20, 22, and 25°C
- Monitored egg survival and developmental rates (i.e. Harrison stage) (Fig 3)[3]
- Used imageJ to measure morphology from photos

Citations: [1]Massey, M. D., & Hutchings, J. A. 2021. Thermal variability during ectotherm egg incubation: a synthesis and framework. Journal of Experimental Zoology Part A: Ecological and Integrative Physiology, 335: 59-71. [2]Brooks, R.T. 2004. Weather-related effects on woodland vernal pool hydrology and hydroperiod. Wetlands 24: 104-114. [3]Duellman, W.E., & Trueb, L. 1994. Biology of Amphibians. Johns Hopkins University Press, Baltimore, Maryland, USA. Salamander silhouette: Matt Reinbold (modified by T. Michael Keesey), https://creativecommons.org/licenses/by-sa/3.0/

Figure 2. Study species *Ambystoma barbouri*. (A) Nest (B) Adult (C) Disturbed site (D) Undisturbed site.

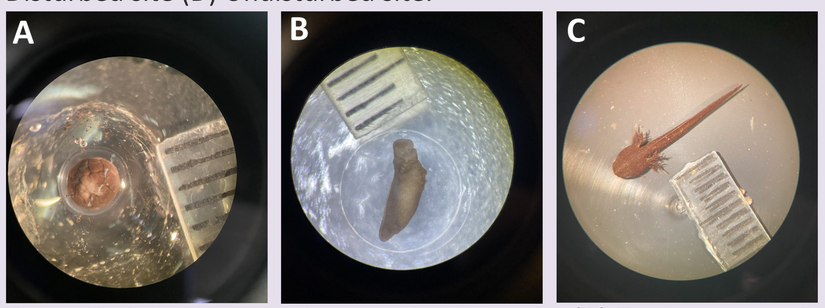


Figure 3. *A. barbouri* embryonic development. (A) Harrison stage 6 (B) Harrison stage 36 (C) hatchling Harrison stage 43.

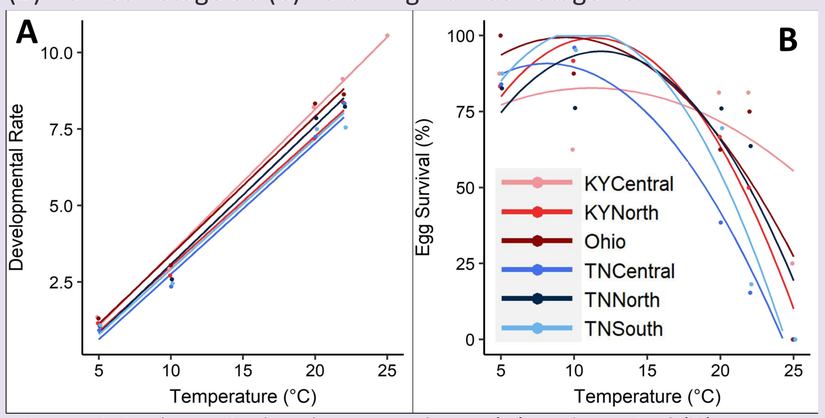


Figure 4. Embryonic developmental rate (A) and survival (B) exhibited population by temperature interactions (p=0.0003, p = 0.0014, respectively)

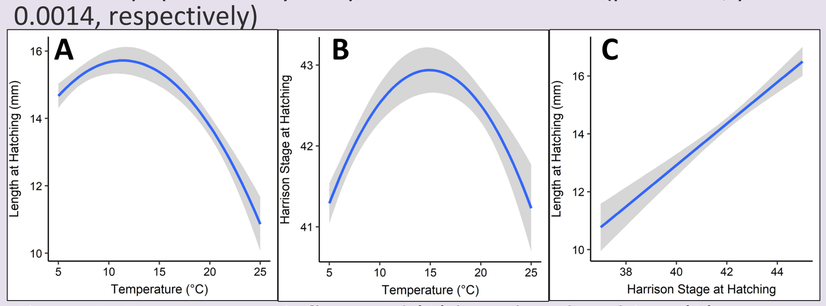
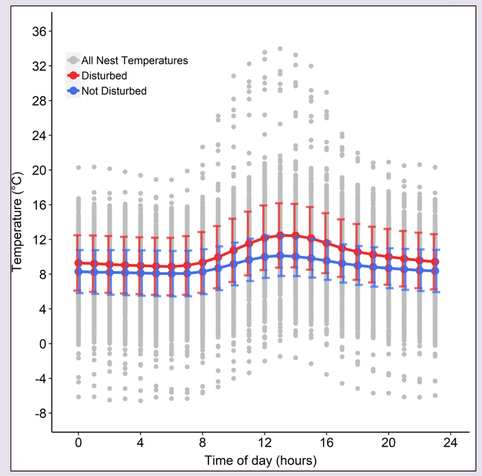


Figure 5. Temperature influenced (A) length at hatching, (B) stage at hatching, (C) earlier stage hatchlings were shorter in length. p < 0.0001. No population by temperature interaction was observed.

Results

- Observed population-specific effects of temperature on developmental rate and embryo survival (Fig 4)
- Length at hatching and Harrison stage at hatching only responded to temperature (Fig 5)
- Nest temperatures were 4°C warmer at disturbed sites than undisturbed sites (Fig 6)

Figure 6. Water temperatures were significantly different between disturbed sites (n=4) and undisturbed sites (n=5). p = 3.025e-13



Conclusions

- Embryos appear adapted to environmental temperature as fitness-relevant phenotypes are optimized at nest temperatures.
- Embryo survival and physiology exhibit population specific responses to temperature, indicating potential population-specific responses to global change
- Nest temperatures at disturbed and open canopy sites are warmer; therefore, future global change may detrimentally increase nest temperatures.
- TN populations exhibit lower survival and slower development at warm temperatures; this may increase their vulnerability to future climate warming

Acknowledgements

Funding for this project was provided by faculty start-up funds awarded to Dr. Joshua Hall from TTU, a Tennessee Herpetological Society grant awarded to Julia Thulander, and the TTU Water Center through providing equipment and assistantship funding. Thank you to all the students that assisted with animal husbandry, Kaitlyn Darnell, Alec Gordon, Aileen Granados, Maggie Lee, Haley Oakley, Lydia Dudley and Chelsy Bartley.