Thermal Performance Curves of Streamside Salamanders (*Ambystoma barbouri)*

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Background

- Urbanization increases environmental temperatures across the globe.[1]
- Ectotherms are particularly sensitive to these temperature changes because environmental temperature directly affects their body temperature and physiology, impacting fitness.
- For amphibians, swimming performance is influenced by temperature and provides insight into the efficiency of whole-organism physiology.[2]
- Streamside Salamanders (*Ambystoma barbouri)* are a Tennessee state endangered species found within and around the Nashville metro area which is undergoing a high rate of urbanization.[3]
- We wanted to understand the effects increased stream temperatures (Fig. 1) on physiology, so we measured *A. barbouri* swimming speed across temperature.

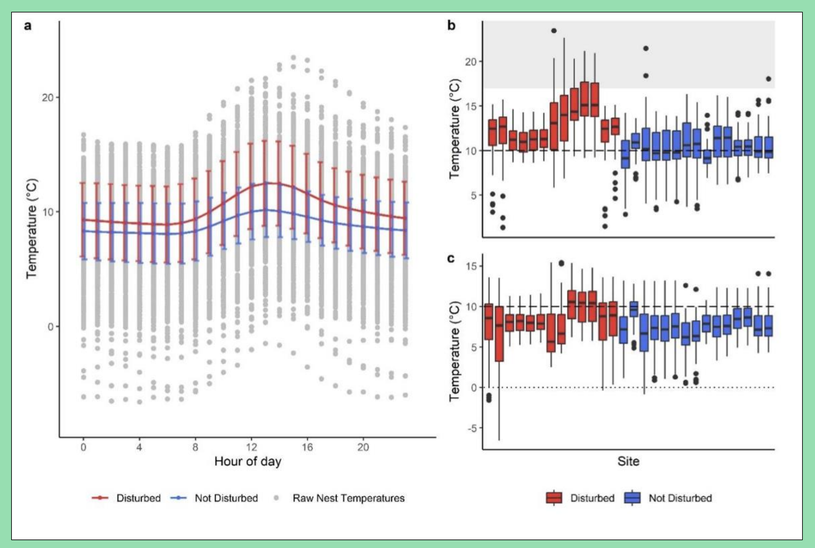


Figure 1: Average hourly stream temperatures between disturbed and undisturbed sites used by *A. barbouri* for breeding.[3]

Methods

Fasted and incubated adult salamanders for 48 hours before testing at each temperature: (4, 15, 20, or 25°C)

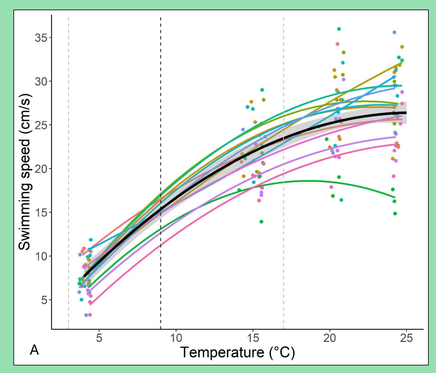
Salamanders were massed then swam three times in a track divided into three 30-centimeter segments.

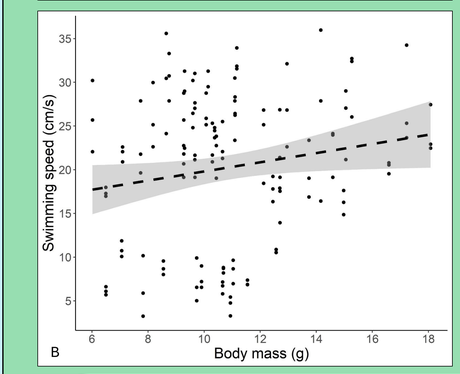
Adobe Premiere Pro was used to determine the 9 total speed estimates (3 runs x 3 sections) for each salamander.

Calculated speed using the formula S=d/t, where S equals speed, d equals distance, and t equals time.

Analyzed the fastest speed for each trial using linear mixed models with body mass and temperature (as a quadratic) as fixed effects and individual ID as a random effect.

Created thermal performance curves to visualize how temperature affects speed.





	log(Speed)		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1.48	1.22 – 1.74	**<0.001**
Mass	-0.01	-0.04 – 0.01	0.352
MeanTemp [1st degree]	0.17	0.15 – 0.19	**<0.001**
MeanTemp [2nd degree]	0	-0.00 – -0.00	**<0.001**
Random Effects			
σ^2	0.04		
$\tau_{00\ ID}$	0.02		
ICC	0.35		
$N_{\ ID}$	12		
Observations	144		
Marginal R^2 / Conditional R^2	0.832 / 0.891		

Table 1: Statistical values the determine speed significance (*p*=<0.001), mass significance (*p*=0.352), and how well the model explains speed's effect on swimming performance (Marginal R^2 =0.832/0.891

Figure 2: Effect of water temperature (A) and body mass (B) on swimming speed. In panel A, each line is an individual salamander. Vertical dashed lines are the coolest and warmest means of stream temperature[1].

Results

- Swimming speed increased linearly from 4 to 15 ° C but plateaued at warmer temperatures (Fig. 2 A; Table 1).
- Larger salamanders had slightly faster swimming speed, but this was not statistically significant(Fig. 2 B; Table 1).

Conclusion

- Swimming speed plateaus around 15°C, indicating that warmer temperatures inhibit neuromuscular or cardiovascular function and may be stressful.
- Stream temperatures exceed 15°C more often in urbanized systems (Fig. 1), indicating the potential for increased physiological stress in urban areas.
- Such stress may come with costs to reproduction, growth, and survival.
- Our next step is to analyze the data using non-linear regression to better estimate the performance curve.

1. McKinney, M. L. (2008). Effects of urbanization on species richness: a review of plants and animals. *Urban ecosystems*, *11*(2), 161-176.
2. Cano, J. M., & Nicieza, A. G. (2006). Temperature, metabolic rate, and constraints on locomotor performance in ectotherm vertebrates. *Functional Ecology*, 464-470.
3. Thulander, J. (2024). *Embryonic Temperature Has Carry-Over Effects on Body Size, Development Time, and Larval Survival in the Streamside Salamander (Ambystoma barbouri)*(Master's thesis, Tennessee Technological University).

Acknowledgements
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