Tradeoffs between Developmental Rate and Swimming Performance in Wood Frog (*Rana sylvatica*) Larvae

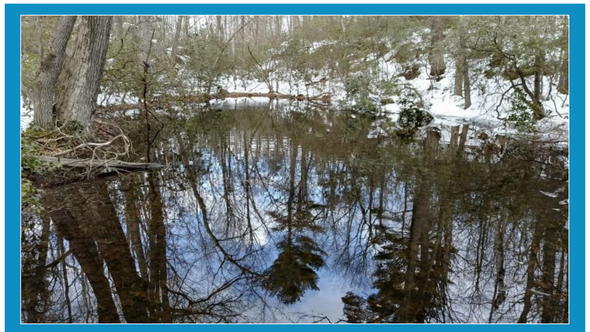
Kaija Gahm[1], Andis Arietta[2], & David Skelly[2]

[1]Department of Ecology & Evolutionary Biology, [2]School of Forestry & Environmental Sciences

Yale

Introduction

- The wood frog (*Rana sylvatica*) is widely distributed across the northern U.S. and Canada. It breeds in **ephemeral wetlands**, which dry up in the summer.
- Wood frogs start breeding as soon as pond ice melts in the spring. Their **aquatic larvae** (tadpoles) must develop rapidly enough to transform into **terrestrial adults** before their ponds dry up in the summer.
- **Climate change** is putting pressure on wood frog development:
  - Delayed spring ice melt means that breeding starts later.
  - Increased summer temperatures speed pond drying.
  - As a result, tadpoles are under pressure to **develop more rapidly.**



An ephemeral pond in Yale Myers Forest. Wood frog development is constrained on one end by spring ice melt. Photo from the Skelly Lab.

- Why wouldn't it be **good** to develop quickly and get a head start?
- Organisms that grow and develop quickly may have to **compromise** other traits.
  - Silverside fish: **reduced** swimming performance and metabolic capacity (Arnott *et al.* 2006).
  - Toad tadpoles: **slower** burst swimming (Arendt 2003).
- A pilot study in the Skelly lab last year suggests that wood frogs might also display this **trade-off**.
- Trade-offs at the **genetic** level, or as a result of **phenotypic plasticity**?
  - Tested tadpoles from a variety of ponds of different temperatures to find effects of **intrinsic** growth rate.
  - Lab-reared tadpoles under two different temperature regimes to test **plasticity.**

Hypothesis: If there is a tradeoff between developmental rate and swimming performance, then slower-developing tadpoles should have faster **burst speeds** than those with more rapid development.

Significance:

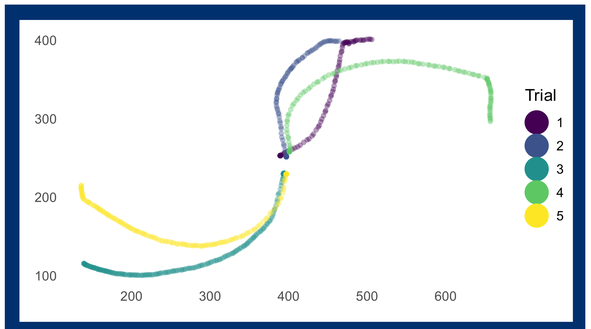
- Will faster development push wood frogs to their physiological limits?
- Studying wood frogs can help us understand how **amphibians**, more generally, might evolve in response to new and continuing pressures.

Methodology

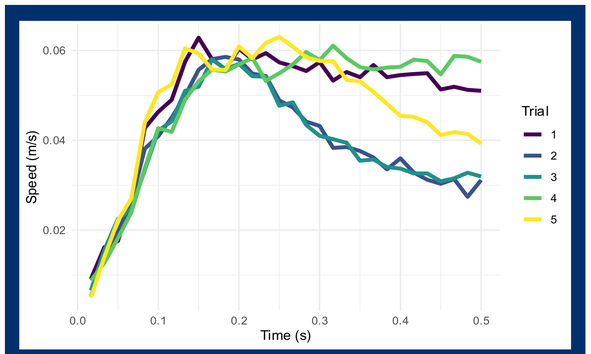
1 Eggs were collected from several ponds in Yale Myers Forest and reared at high and low temperature treatments. For comparison, wild-raised tadpoles from the same ponds were also tested.

2 A probe startled each tadpole into swimming, simulating a predator attack. Trials were video recorded from above.

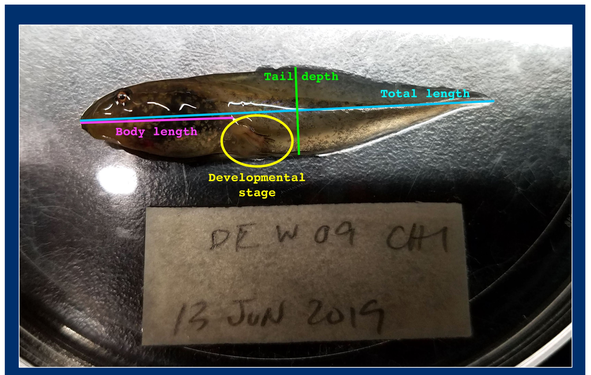
3 A custom-built MATLAB algorithm tracked the tadpole's position in each frame of the video.



4 Frame-by-frame coordinates were combined to visualize the tadpole's path in each of several trials.

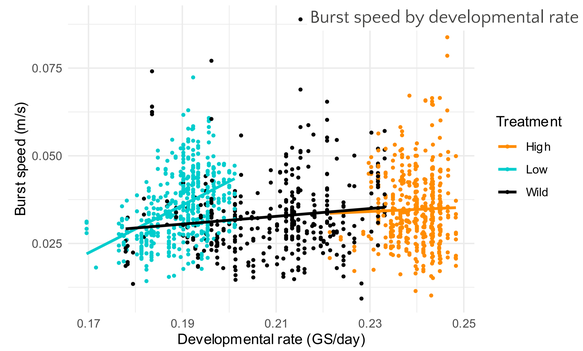


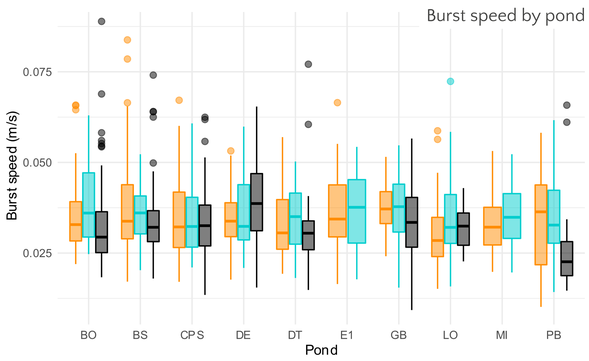
5 Speeds were calculated for each burst and visualized as a function of time during the first half second of the burst. To reduce noise, a moving average function was applied to the speed data.



6 Following the burst trials, each tadpole was measured and staged.

Preliminary Results





- Developmental rate had a different relationship to burst speed for each temperature treatment
- No evidence that rapid development correlates with slower swimming. In fact, the **low** temperature group showed the opposite trend.
- No clear differences across ponds

Next steps:

- Mixed models to incorporate nested random effects
- Incorporate morphological data: what *does* explain variation in burst speeds?
- Other metrics: trajectory characteristics, max. instead of average speed
- Relationship of burst speed to metabolism?

References:

Arendt, J.D. 2003. Reduced burst speed is a cost of rapid growth in anuran tadpoles: Problems of autocorrelation and inferences about growth rates. *Functional Ecology* 17 (3): 328–34.

Arnott, S. A., S. Chiba, and D.O. Conover. 2006. Evolution of intrinsic growth rate: Metabolic costs drive trade-offs between growth and swimming performance in *Menidia menidia*. *Evolution* 60 (6): 1269–78.

Thanks:
Adriana Rubinstein
Simon Stump
Kirby Broderick

Funding:
Yale College Dean's Research Fellowship
Kohlberg-Donohoe Research Fellowship
Pierson College Richter Summer Fellowship