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TEMPERATURE AND SWIMMING SPEED OF THE SPOTTED SALAMANDER (*AMBYSTOMA MACULATUM*)

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ABSTRACT

We tested whether water and air temperatures affect the aquatic locomotor speed of Northern Spotted Salamanders. We hypothesized that the salamanders would swim faster in warmer water, thus enabling them to escape predation better. Our results showed, however, that water temperature does not significantly affect the swimming speed of salamanders, while air temperature may play a role in their speed. Therefore, salamanders would fare better if they waited to emerge later in the year, when temperatures are warmer. Whether they chose cooler or warmer vernal ponds to breed in, however, would not affect their swimming speed

Keywords: Ambystoma maculatum*, locomotion, predation avoidance, salamander, temperature effect, water speed*

INTRODUCTION

The Northern Spotted Salamander, *Ambystoma maulatum*, is commonly found in vernal ponds in Pennsylvania. These mole salamanders spend the winter buried in mud and emerge in spring to breed (Erelli, 2002). Since these animals do not overwinter in ponds they travel some distance to breed. Thus faster salamanders may have an advantage in better avoiding predation during these risky overland treks. Once in the water, they must still be able to avoid predators living in or near the water. Therefore, speed may be important in water, as well as land. Since vernal ponds form in the spring when temperature fluctuates, we wanted to see if the temperature of the water they were breeding in, or the air they were raised in, affected their swimming speed. We hypothesized that both males and females should swim significantly faster in warm water than in cold water. We developed our hypothesis based on our belief that higher temperatures should facilitate increased activity. Thus water temperatures may importantly affect susceptibility of salamanders to predation and thus their population success.

FIELD SITE

Salamanders were collected from the area surrounding Petersburg Spring in Petersburg, Pennsylvania.

METHODS AND MATERIALS

Forty salamanders, twenty male and twenty female, were collected for the experiment. Ten males and ten females were placed in separate 10-gallon terrariums at room temperature (20° C). The remaining males and females were placed in separate 10-gallon terrariums in a refrigerated room (10° C). The bottoms of the terrariums were covered with damp leaves and peat 2-3 inches deep. Large pieces of bark were added for the salamanders to hide under, because they like dark conditions. The salamanders were kept under fluorescent lighting for 12 hours a day and in dark for 12 hours a day. The terrariums were misted daily to maintain moist conditions. The salamanders were fed redworms, waxworms, and earthworms 2-3 times a week.

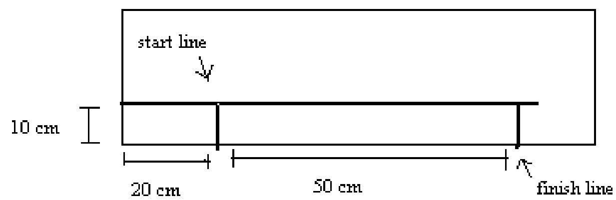

Figure 1. Aquarium setup for testing swimming speed of spotted salamanders in 5 cm of water.

To estimate the swimming velocities of the salamanders, we set up a 50-gallon aquarium, with a lane created by a divider. The lane was 10 cm wide and 70 cm long. We hung string above the water to mark the start and finish points, with the start line 20 cm from the end of the aquarium, making the salamanders swim a total of 50 cm (Figure 1). We began the experiment by testing their swimming speed in about 5 cm of water at room temperature (20 °C). Each of the 40 salamanders was timed from when its nose crossed the start line to when its nose crossed the finish line. The runs were repeated three times for each salamander to obtain an average speed, calculated in m/sec. We recorded the speed, sex, and velocities for each specimen. We repeated these procedures in the refrigerated room, replacing the warm water with cool water (10° C).

We employed two-way and one-way ANOVAs to test for differences in speed between males and females and between cold and warm water salamanders. The air temperature at which the animals were pre-conditioned was labeled as the treatment; and the water in which they swam was labeled as the block.

RESULTS

The results below use abbreviated names for the groups of preconditioned salamanders and the water temperatures in which they were swimming during an experimental run (Table 1). The “ww” represents warm water, approximately 20°C, and “cw” represents cool water, approximately 10°C. The symbols, “wf”, “wm”, “cm”, and “cf”, represent the temperature at which the salamanders were pre-conditioned. These are “wf” meaning warm female and “cm” meaning cold male, etc.

The initial two-way ANOVA revealed no significant difference in salamander swimming speed for either water temperature at which the salamanders swam (F = 0.00, P = 0.984, df = 1) or air temperature at which the salamanders were pre-conditioned (F = 2.40, P = 0.075, df = 3), but the effect of air temperature was closer to being statistically significant (Table 1). To test whether the pre-conditioned salamanders differed in swimming speed, we ran two separate one-way ANOVAs on both the cool and warm water treatments. These tests also showed no significant differences for either the cool water (F = 2.09, P = 0.119, df = 3) or warm water treatments (F = 0.81, P = 0.495, df = 3) (Tables 3 & 4). The cool water ANOVA though, was closer to the accepted 5% error.

Table 1. Average (± SD) swimming speeds of spotted salamanders in different treatment groups (see text).

Group	Total Average (secs/50cm)	Standard Deviation
ww-wm	3.68	3.13
ww-wf	3.40	1.59
ww-cm	3.31	2.28
ww-cf	4.95	3.31
cw-wm	3.25	1.18
cw-wf	3.00	1.69
cw-cm	3.89	2.62
cw-cf	5.16	2.59

Table 2. Two-way ANOVA testing for differences in swimming speeds of spotted salamanders at different air (pre-conditioned) and water (experimental) temperatures. Shows a possible difference between treatments (air temperature), but not between blocks (water temperature).

Two-way ANOVA: seconds versus Treatment, Block

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Analysis of Variance for seconds
Source         DF        SS        MS        F        P
Treatment       3     41.72     13.91     2.40    0.075
Block           1      0.00      0.00     0.00    0.984
Interaction     3      3.62      1.21     0.21    0.890
Error          72    416.67      5.79
Total          79    462.01
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Tables 3 & 4. One-way ANOVA tests comparing effects of preconditioning air temperature on swimming speed of spotted salamanders placed in warm versus cool water. No significant differences were observed.

One-way ANOVA: seconds (warmwater) versus Treatment

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Analysis of Variance for secs (warmwater)
Source     DF        SS        MS        F        P
Treament    3     17.34      5.78     0.81    0.495
Error      36    255.99      7.11
Total      39    273.32
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One-way ANOVA: seconds (coolwater) versus Treatment

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Analysis of Variance for secs (coldwater)
Source     DF        SS        MS        F        P
Treatment   3     28.01      9.34     2.09    0.119
Error      36    160.68      4.46
Total      39    188.69
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DISCUSSION

Temperature appeared to have no effect on swimming speed of spotted salamanders (Table 1). However, preconditioning air temperature nearly had a significant effect. The two-way ANOVA results showed that although there was no correlation between swimming speed and water temperature, there was only a 7.5% chance that the speed differences between salamanders kept at different air temperatures was due to error (Table 2). While slightly above the widely accepted 5% error rate, this result merits further attention.

One-way ANOVAs were run separately for both the cool water (10°C) and warm water (20°C) blocks (Tables 3 & 4). No significant differences were observed between preconditioning air temperatures, though there might have been a difference in swimming speed between the warm and cool preconditioned salamanders run in cool water (P value was only 12%).

Therefore, our original hypothesis appears to be incorrect. Preconditioning air temperature seemed to have more of an effect on salamander swimming speed than the water temperature in which speed was measured. The greatest difference appeared to be between the speeds of the preconditioned cool and warm females in the cool water (Table 1). This difference may be important to females traveling in nature. Females emerging in the cooler temperatures of early spring would probably be more susceptible to predation and less likely to have offspring. Perhaps, females emerging later in the warmer air temperatures would be able to move more quickly, regardless of the water temperature.

ACKNOWLEDGEMENTS

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