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SWIMMING SPEED IN RELATION TO BODY SIZE IN THE SPOTTED SALAMANDER (*AMBYSTOMA MACULATUM*)

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ABSTRACT

In this study swimming speed was examined in the salamander *Ambystoma maculatum*. It was hypothesized that the larger the salamander the faster it would be able to swim. We also hypothesized that tail length would have a greater effect on speed than snout to vent length. However, contrary to these hypotheses, swimming speed was negatively correlated with three measures of body length (snout to tail, snout to vent, and vent to tail), though not significantly. The smaller salamanders tended to swim faster than the larger ones.

Keywords: Ambystoma maculatum*, body size, spotted salamander, swimming speed, vernal pond*

INTRODUCTION

The spotted salamander, *Ambystoma maculatum*, is generally black with two rows of large yellow to yellowish orange spots on their heads, backs, and tails (Metts, 2003) (Fig. 1). Spotted salamanders are generally five to seven inches in length but can grow to be as long as nine inches. They can live up to thirty years and continue to go back to the same pond every spring to breed (Metts, 2003). Spotted salamanders are common in bottomland forests near floodplains, but also occur in upland forests and in mountainous regions (Metts, 2003). Like other closely related species of mole salamanders, spotted salamanders spend most of their lives on land and migrate to ponds for breeding (Metts, 2003). Females lay their eggs in the water, in clumps or masses, and may deposit over 300 eggs in one mass (Metts, 2003).

Spotted salamanders survive best in ponds that do not contain larvae-eating fish (Metts, 2003). Adults are most abundant in deciduous and mixed forests. They feed primarily on invertebrates, such as earthworms, insects, and mollusks (Metts, 2003). During the breeding season, the forest provides vernal pools and ditches necessary for reproduction (Metts, 2003). The salamanders select temporary water bodies with slightly acidic pH for breeding (Metts, 2003). Immigrating females weigh more than the males when reaching the breeding pool (Stout, 2003). During breeding the females undergo a three-fold reduction in mass (Stout, 2003). This loss is equal to the mass of the gametes (Figure 2) (Stout, 2003). This loss leaves females weak and susceptible to death, which contributes to the smaller number of females relative to males (Stout, 2003).

Figure 1. The spotted salamander, Ambystoma maculatum *(picture courtesy of http://www.uga.edu/srel/spotted_salamander.htm)*

Figure 2. An egg mass of Ambystoma maculatum *observed at Petersburg Ponds.*

We hypothesized that larger animals should swim faster than smaller animals. We reasoned that larger animals would have longer and more powerful legs and tails, thus increasing propulsion.

FIELD SITE

The salamanders were found at local vernal ponds where they are abundant during the spring breeding season. These ponds are located near Petersburg Pike Road in Huntingdon County, Pennsylvania, USA (Fig. 3).

Figure 3. A vernal pond near Petersburg Pike Road, Huntingdon, PA.

MATERIALS AND METHODS

Salamander collection and care

We collected 11 *Ambystoma maculatum*, over a period of three weeks, from Petersburg Pike Ponds at night, usually between 10pm and 2am, using dip nets, a seine, and hand collection. The salamanders were stored in a five-gallon bucket for transportation from the pond to the lab. Males and gravid females were placed in separate ten-gallon tanks, where they were fed meal worms and earthworms. The tanks were filled with rocks, leaf litter, and approximately three centimeters of deionized water to maintain as natural an environment as possible. Upon completion of the trials, the salamanders were immediately returned to the wild. The salamanders were held in captivity for no longer than 48 hours.

Speed trials

Before each trial, the snout to vent length, tail length, and total length (Fig. 4) were measured (± 1 cm) for each salamander. The trials took place in a 50-gallon tank in which two 1-m sticks were placed in 5 cm of water on their edge with 10cm between them to create a "lane" (Fig. 5). Leaf litter was placed at the end of a 50 cm distance because this "shelter" stimulates salamanders to swim toward it, thus acting

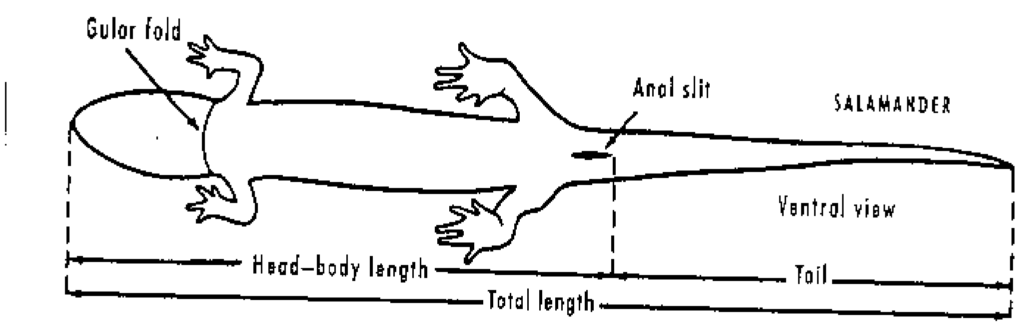


Figure 4. A pictorial depiction of the different length measurements used (picture courtesy of Peterson's Field Guide to Reptiles and Amphibians).

like a "finish line." Each salamander was placed individually in the tank before the start line and released. A standard stopwatch was used to time how long it took for a salamander to swim 1 m from start to finish. The mean swimming speed of each salamander was calculated from ten trials.

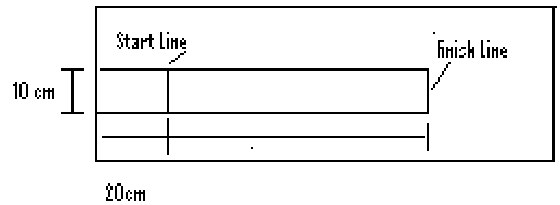


Figure 5. Aquarium setup for testing swimming speed of spotted salamanders in 5 cm of water.

RESULTS

The average speed of the salamanders was 17.32 cm sec^{-1}. The mean swimming speed of each salamander in relation to three measures of body length is given in Table 1. Swimming speed was a negative function of all three measures of body length (Fig. 6). The following relationships were determined using linear regression analysis:

Swimming rate = 134 – 15.3 (Snout to vent length) [r^2 = 0.281, F = 3.52, P = 0.093]

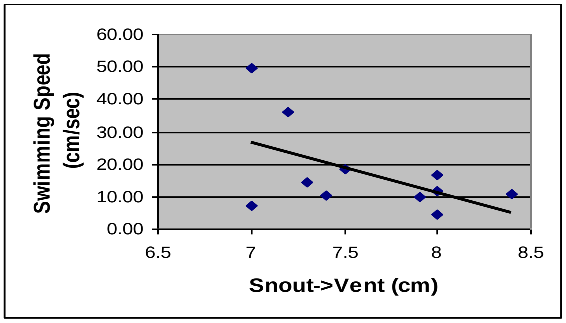
Swimming rate = 69.8 – 6.58 (Vent to tail length) [r^2 = 0.210, F = 2.39, P = 0.156]

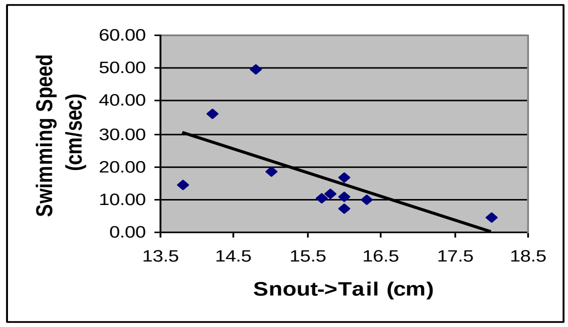
Swimming rate = 129 – 7.19 (Snout to tail length) [r^2 = 0361, F = 5.09, P = 0.051]

As can be seen, none of these relationships are significant, but the negative relationship between swimming speed and total (snout to tail) length is marginally significant.

Table 1. Mean swimming speed of spotted salamanders in relation to three measures of body size.

Salamander #	Snout->Vent (cm)	Snout->Tail (cm)	Vent->Tail (cm)	Average Time (sec)	Swimming Rate (cm/sec)
1	8	18	10	23.16	4.32
2	7	16	9	13.77	7.26
3	7.5	15	7.5	5.41	18.48
4	8	16	8	5.96	16.79
5	8	15.8	7.8	8.66	11.55
6	7.3	13.8	6.5	6.83	14.65
7	8.4	16	7.6	9.39	10.65
8	7.4	15.7	8.3	9.57	10.44
9	7.9	16.3	8.4	10.29	9.72
10	7.2	14.2	7	2.77	36.11
11	7	14.8	7.8	2.02	49.58





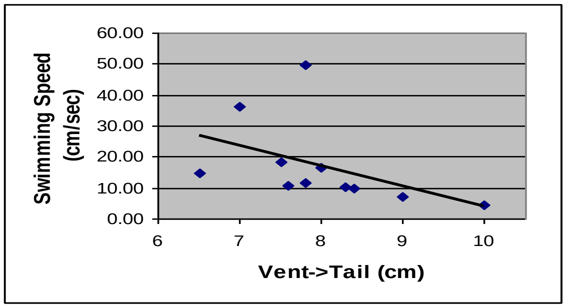


Figure 6. Allometric comparisons of swimming speed of 11 individual spotted salamanders in relation to three measures of body size.

DISCUSSION

The present results suggest that the swimming speed of spotted salamanders is negatively correlated with body length (Table 1, Fig. 6). Although the data are not statistically significant (P >.05), they show a trend: in general, the smaller the overall body length of a salamander, the faster its swimming speed, with the exception of one outlier. Larger salamanders ($\geq$ 16cm) tended to be slower than smaller salamanders (< 16 cm). These observations contradicted our original hypothesis.

Perhaps longer salamanders are heavier and this causes them to be slower. Further research should examine the effect of body mass on swimming speed. Insufficient sample size (due to difficulty of collecting salamanders during inclement weather conditions) prevented us from testing the effects of body size separately in males, gravid females, and nongravid females. Heavy egg masses may slow down gravid females, as compared to males and nongravid females.

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