Baby Got Bite? A Determination of Venom Delivery in Cottonmouths

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Introduction

The morphology of an organism has a great influence on its performance[1].

- These effects on performance can also play a vital role in the organism's fitness.

An animal's body size has an impact on many aspects of their life-history[2].

- Younger animals are often at a disadvantage compared to older individuals when competing for food or when confronted with a predator, simply because of their difference in size[3].
- Measures of body size are common predictors of performance capabilities[4].

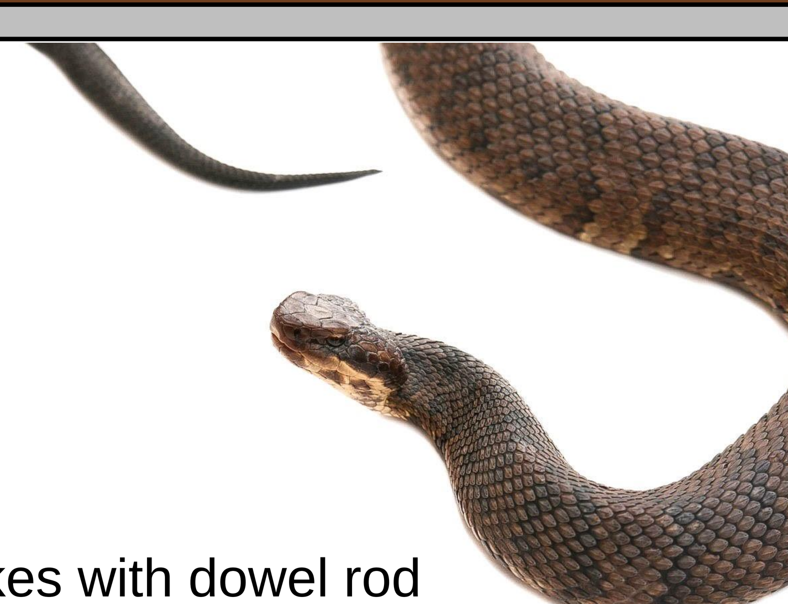
Cottonmouth vipers are a prime research subject, as post-strike defensive mechanisms have been rarely studied.

- Venom is a useful tool, but is metabolically expensive, so it seems wise for each snake to limit venom expenditure as much as possible[5].

Here, we measured the defensive performance of cottonmouth vipers using high-speed video cameras and a high-accuracy mass scale for venom delivery determination.

Data Collection

Sample size and demographics



- 42 Cottonmouth vipers
- (Body mass = 26.8–862 g; SVL = 270–845 mm). All individuals were kept in the Snake Ecology Lab at MSU.

Methods:

- Presented simulated threat to snakes with dowel rod
  - Attempted to elicit 3 defensive strikes from each individual
  - Simulated threats consisted of a latex glove filled with polyester, controlled for size
  - Recorded mass of venom injected into the simulated threat
- Filmed strikes with 2 Edgertronics SC1 cameras (1000 frames per second)
  - Calculated 3-dimensional strike parameters (Vicon Motus software)
    - Strike distance (meters)
    - Strike duration (seconds)
    - Average and maximum strike velocity (m/s)
    - Average and maximum strike acceleration (m/s^2)

Analysis:

- We used correlations and regressions to explore the relationships between body size and striking performance/venom delivery.

Results

Cottonmouths expended various amounts of venom

- One individual never delivered venom, five delivered two dry bites, and 11 delivered one dry bite
- Maximum venom yield (range = 1–280 mg) from each snake was highly variable but positively and significantly related to body mass and length
- There was no significant difference in venom delivered across repeated encounters for individuals that injected venom across all 3 strikes

Body size is an accurate predictor venom delivery

- There was a significant and positive relationship between mass of venom delivered and SVL (Yield=2.9*SVL-6.26, $r^2=0.38$, $p<0.0001$)

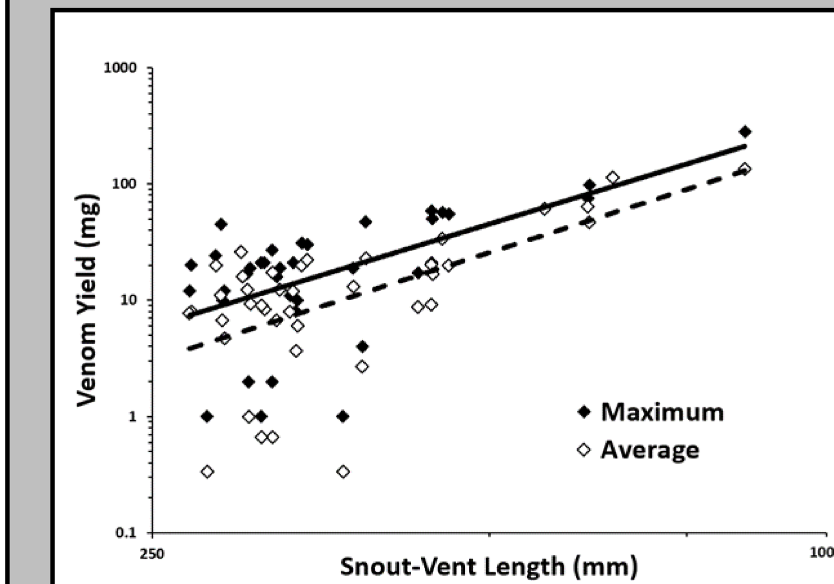


Figure 1. Maximum (black diamonds) and average venom yield (open diamonds) regressed against snout-vent length (mm).

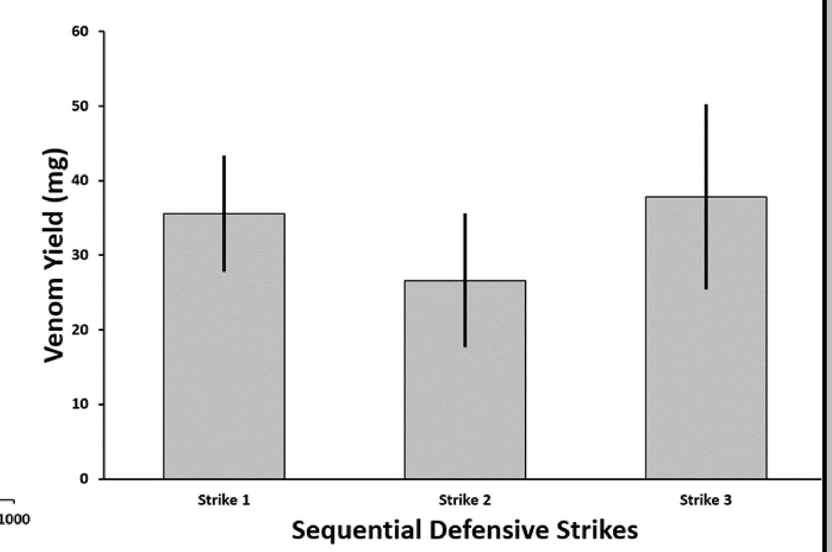


Figure 2. Average (± standard error) venom yield (mg) from each of 23 *A. piscivorus* that delivered venom during all three sequential defensive strikes.

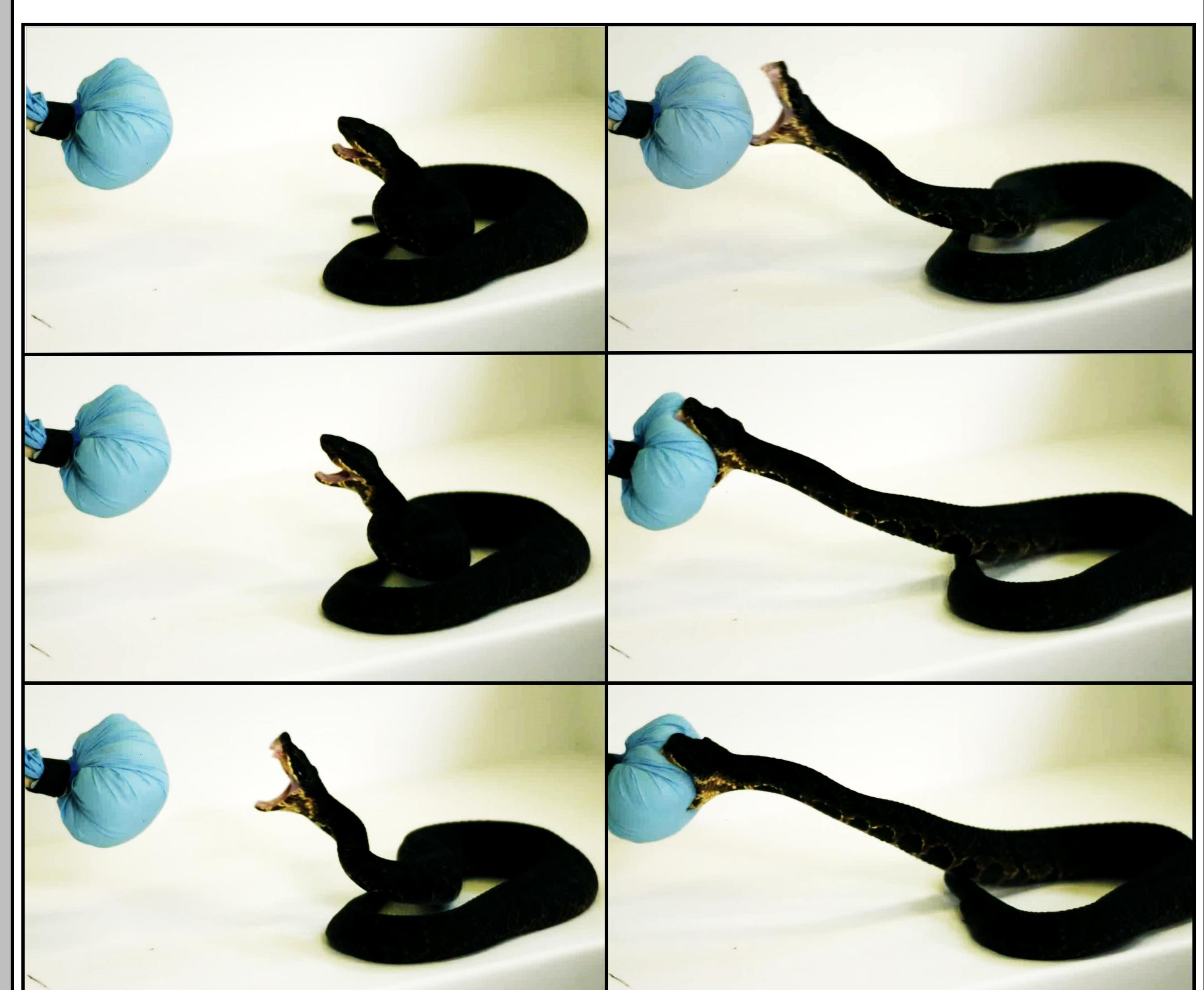


Figure 3. Still images of a typical strike sequence filmed at 1000 fps. Numbers denote elapsed time in milliseconds from the first frame of initial movement towards the target (ms).

With the exception of strike duration, all measures of strike performance show a positive and significant correlation with Snout-Vent Length (for all, P<0.05).

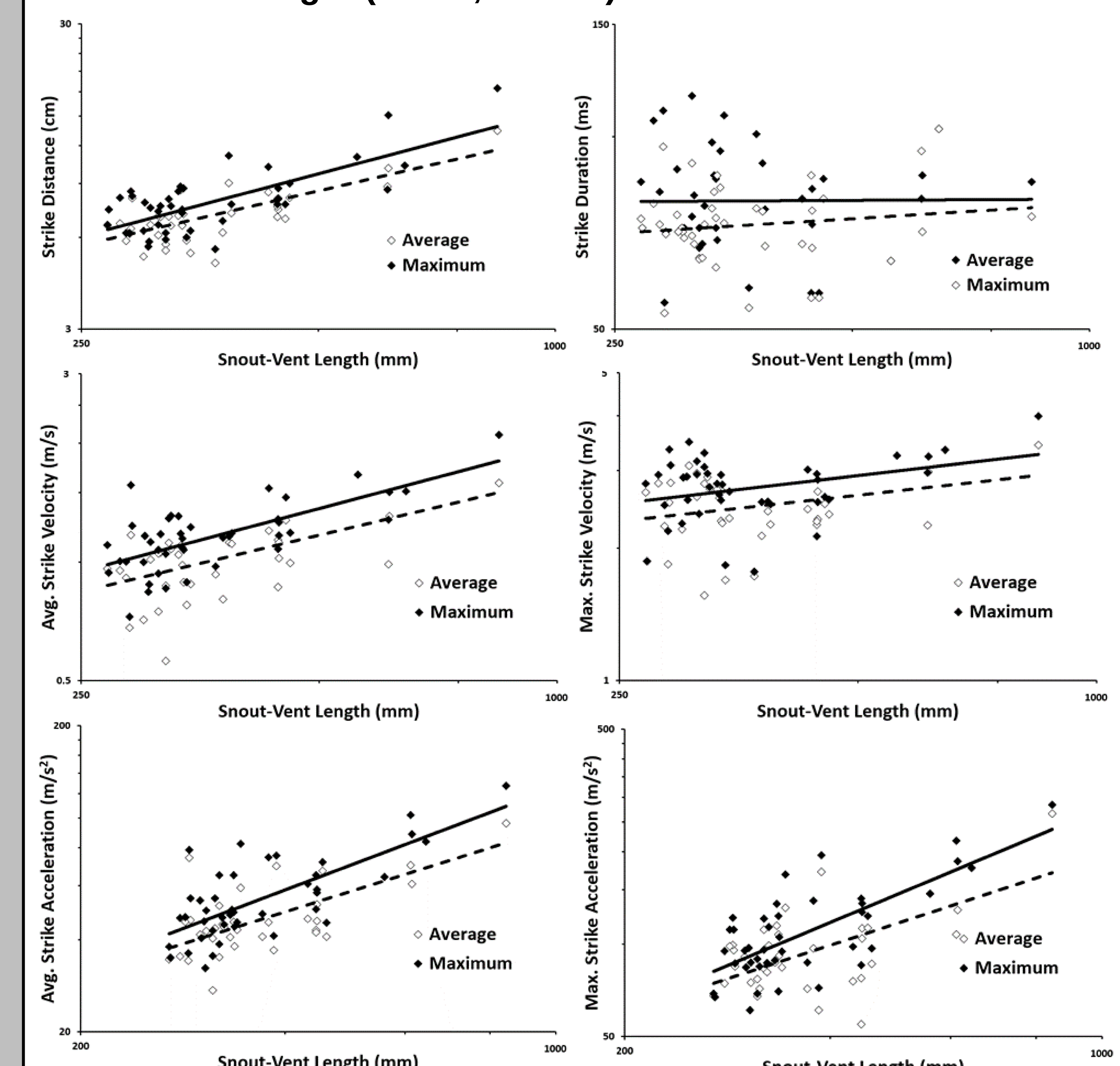


Figure 4. Strike kinematics regressed against snout-vent length (cm). Lines represent OLS models (black = maximum, dashed = average). Closed diamonds represent maximum performance (single best performance from each snake). Open diamonds represent average performance (average of all performances from each snake).

Discussion

While there was higher variation in venom yield among smaller snakes, yield positively and significantly increased with body size.

- Venom yield did not increase with repeated threats to the snakes

Larger snakes strike over greater distances, with higher velocities and accelerations

- Strike duration remained constant across body size

Interestingly, in a more complex analysis, the two main predictors of venom yield are body mass and strike acceleration suggesting some aspects of strike performance may be impacting venom yield.

References and Acknowledgments

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