Seeing Red : Quantifying the diversity of constriction pressures generated by snakes

Jillian Hackney & David A. Penning PhD
Department of Biology & Environmental Health; Missouri Southern State University

@thePenninglab

Introduction

Across the animal kingdom, predation is an essential mechanism for survival.

- For snakes, two of the most commonly used mechanisms are constriction and striking.

There are several hypotheses about how high constriction pressures impact prey during constriction.

- Those hypotheses include suffocation[1], cardiac trauma and arrest[2, 3, 4], blunt force trauma[5], and neural damage[6, 7].

The Red-out Hypothesis

- Suggests that when snakes constrict their prey, they are able to drive blood and bodily fluids towards the head of their prey, quickly incapacitating them.
- This would then lead to the shut down of the nervous system.

The Red-out Hypothesis has been investigated in one species.

- We quantified intercranial and chest pressures of prey to find evidence for this hypothesis across a greater range of constricting snakes.

We measured multiple boa and python species to further explore and quantify the pressures experienced by prey.

- These measurements were then compared to the existing data from the Penning Lab testing this Red-out hypothesis in kingsnakes.

Materials and Methods

Carpet Pythons (*Morelia spilota*), Borneo Pythons (*Python breitensteini*), and Red Tail Boas (*Boa constrictor)*

- Body mass = 248 - 2006 grams (n=14 in total)
- Prey mass was held ~constant

Prior Kingsnake (*Lampropeltis getula*) data

- Body mass = 214 - 608 grams (n = 18)

We measured the constriction strengths using two Harvard Apparatus Blood Pressure Transducers

- A 2.0 mL fluid-filled latex bulb served as the pressure sensor, linking the mouse to the transducer (traditional method of recording pressure)
- **A custom intercranial pressure cap was attached directly to the skull to record intracranial pressures (see Figure 1).**
- The intercranial pressure sensor was secured using a combination of glues that connected the catheter system to the cranium.

Statistical Analyses

We are interested in the relationship between intercranial and thoracic pressures during constriction.

- We are also interested in differences between snake groups

We used regression and correlation models to explore the patterns found in the performance data.

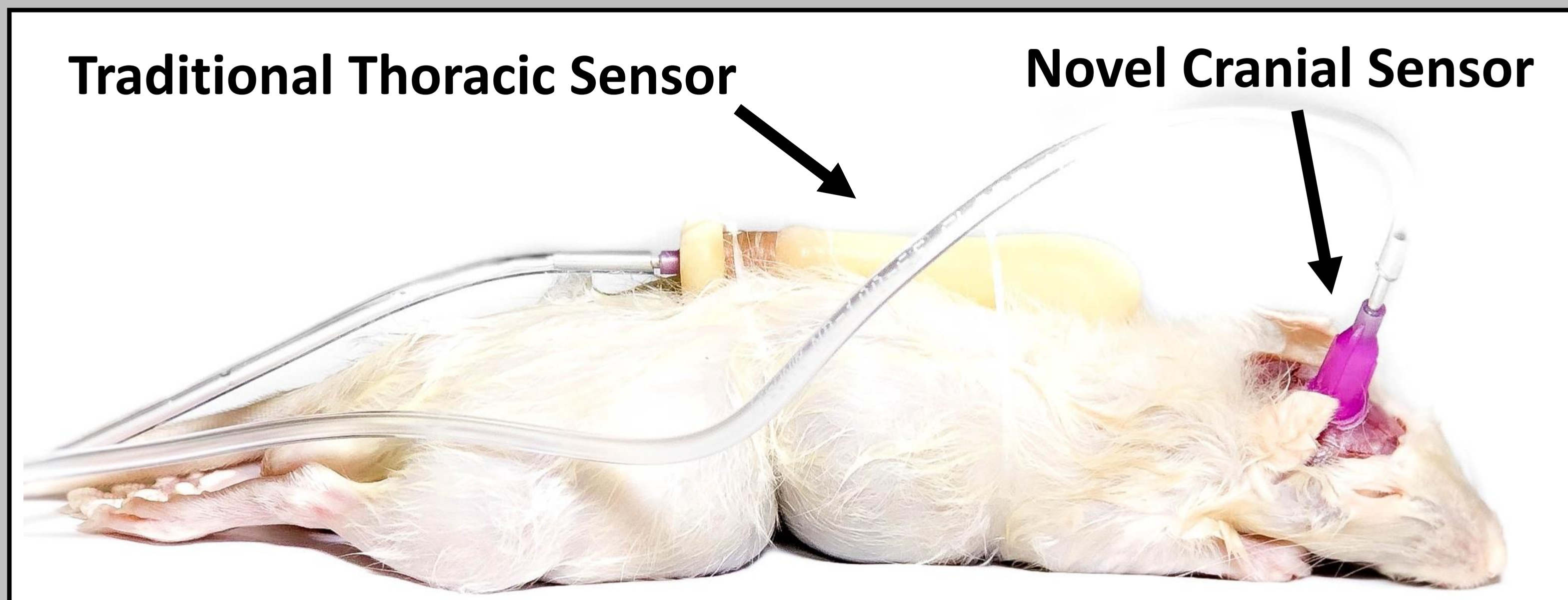

Figure 1. Cadaveric juvenile rat connected to traditional (thoracic) and novel (cranial) pressures systems. Both catheter systems hook up to separate pressure transducers to record simultaneous values.

Results

On multiple occasions, the rapid contact with the prey immediately dislodged the cranial sensor leading to many failed attempts at measuring cranial pressure.

- Record dual pressures at least once from each snake (Figure 3)

New Performance Results:

M. spilota: cranial pressures (7-32 mm Hg)
P. breitensteini: cranial pressures (13-14 mm Hg)
B. constrictor: cranial pressures (18-32 mm Hg)

Prior Kingsnake Results:

L. getula: cranial pressures (8-50 mm Hg)

Cranial pressures were quite high but not different between the boa/pythons and kingsnakes (t_{30}=1.56, *p*>0.13).

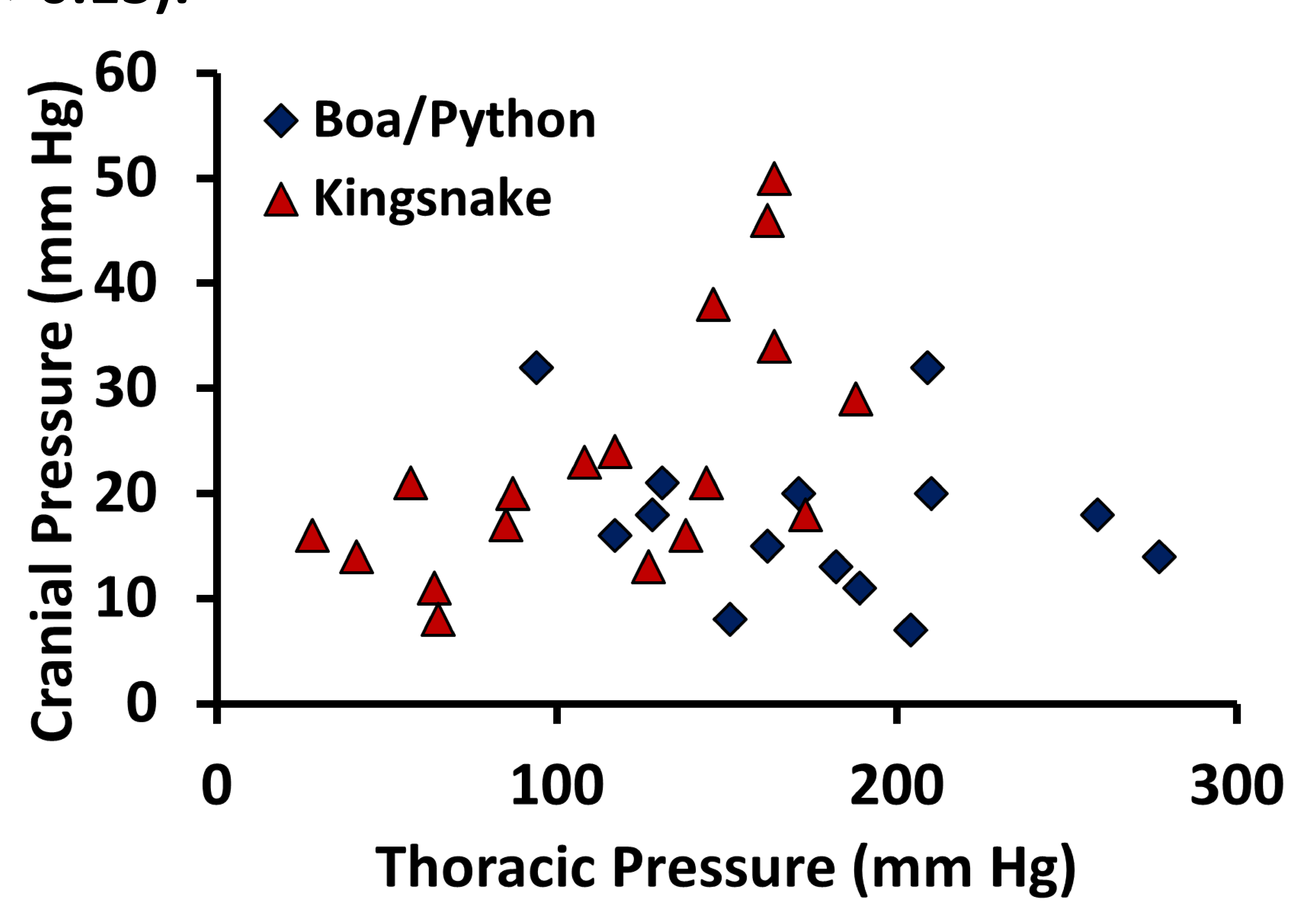

Figure 2. Scatterplot of cranial pressure regressed against thoracic pressure for all measured snakes. There is no significant correlation between pressures.

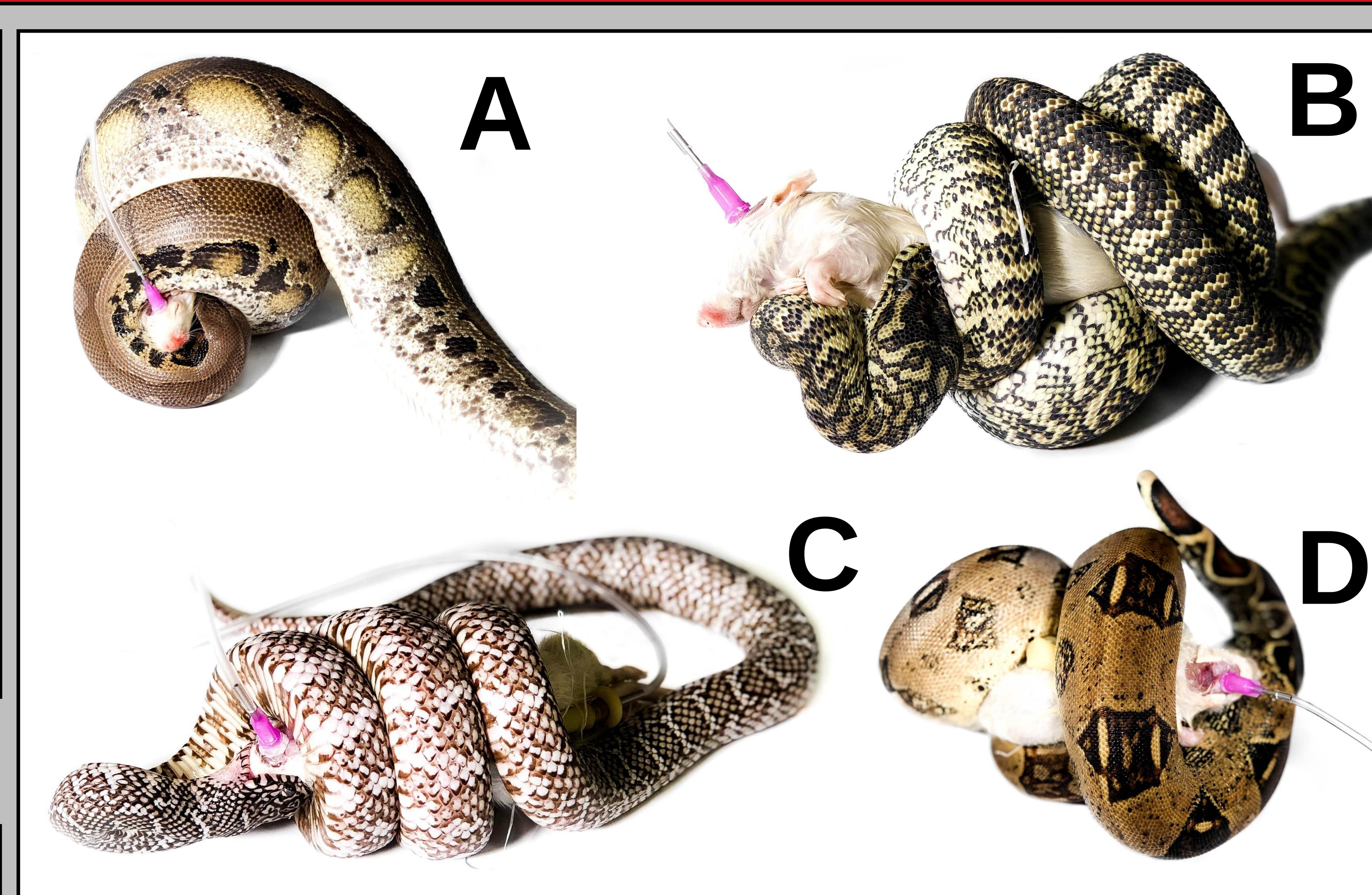

Figure 3. Images of the varying constriction postures used by *P. breitensteini* (A), *M. spilota* (B), *L. getula* (C), and *B. constrictor* (D).

While cranial pressures were not different between snake types, thoracic pressures were higher in the boas/pythons (177±52 mm Hg) compared to kingsnakes (114±49 mm Hg t_{30}=3.5, *p*<0.002).

- This results in no correlation between thoracic pressure and cranial pressure (Spearman's RS=0.07, p>0.7).
- Why this pattern exists is yet to be determined but may be partially explained by tissue compliance at higher pressures.

Discussion

The relationship between cranial pressure buildup and thoracic pressure becomes more complex with the addition of more snakes.

- **While there is no relationship, cranial pressures from all snakes were considerably high!**
  - **The average cranial pressure from our snakes (21 mm Hg) is the same pressure threshold that trauma surgeons typically decide to remove a portion of a human's skull to relieve pressure![8]**

Lastly, worth noting is the continued confirmation that blunt force trauma is a known mechanism of death during constriction. This rodent ↑ was folded in half. The top of his head is currently touching his lower back![9]

References and Acknowledgments

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