Individual snakes can exhibit a diversity of antipredator responses including crypsis, flight, and a variety of stereotyped behavioral reactions to predators at close range. Among these responses are behavioral differences in the movement (e.g., waving or wigglng) of a conspicuous tail by an otherwise cryptically colored snake. Defensive tail displays may disorient a predator, divert attack to the tail, act as a warning signal, or serve no function at all. The use of tail displays in snakes may also depend on current physiological investment into color production and body size, which can affect locomotor ability to escape predators. The purpose of this study was to determine if variation in tail color is related to the defensive tail behavior exhibited in Common Garter Snakes (Thamnophis sirtalis) when subject to a sudden tactile stimulus. We also analyzed potential relationships between tail coloration, mass, and circulating concentrations of testosterone, to determine if conspicuous tail morphology is condition-dependent. Here, relative tail orange coverage is significantly related to defensive tail behavior and also yields significant negative correlations with mass and testosterone concentrations. This suggests conspicuous tail displays in T. sirtalis to be a size-dependent response to predation, as mediated by testosterone. The prevalence of this defensive behavior in relatively smaller snakes may function as a diversion of attack to the tail while larger snakes instead exhibit greater locomotor capacity to escape predation.

**Objective**

To determine if variation in tail color is related to the defensive tail behavior exhibited in Common Garter Snakes (Thamnophis sirtalis) when subject to a sudden tactile stimulus. We also analyzed potential relationships between tail coloration, mass, and circulating concentrations of testosterone, to determine if conspicuous tail morphology is condition-dependent. Here, relative tail orange coverage is significantly related to defensive tail behavior and also yields significant negative correlations with mass and testosterone concentrations. This suggests conspicuous tail displays in T. sirtalis to be a size-dependent response to predation, as mediated by testosterone. The prevalence of this defensive behavior in relatively smaller snakes may function as a diversion of attack to the tail while larger snakes instead exhibit greater locomotor capacity to escape predation.

**Methods & Materials**

**Field Capture and Measurements**

- During Spring 2014, 39 adult male garter snakes were caught at two locales in Logan, UT, USA.
- Body mass was measured using a digital scale, and snout-vent length was measured using a standard metric ruler.
- Blood samples were collected for analysis in the lab.

**Blood Analysis**

- Testosterone (Radioimmunoassay)

**Behavior Analysis**

- Snakes were tactile stimulated on a 2-meter track to determine flight or defensive behavior.

**Tail Coloration Measurements**

- Individual tails photographed with metric ruler.
- Relative tail color coverage calculated in ImageJ.

**Results**

- Relative color coverage significantly predicts about 75% of defensive tail behaviors (Fig. 4; p = 0.011, AUC = 0.752).
- For every 1% (B = 0.189) increase in color coverage, snakes are about 1.2 (Exp(B) = 1.21) times more likely to exhibit a defensive tail display, with about 20% of variation in the behavior explained by variation in orange coloration (Cox & Snell $r^2$ = 0.199).
- Color coverage is significantly, negatively related to body mass (Fig. 5; p = 0.018, $r^2$ = 0.124) and significantly, negatively related to circulating testosterone (Fig. 6; p = 0.0049, $r^2$ = 0.192).

**Discussion**

- Our hypothesis that defensive tail display behavior in male Common Garter Snakes is condition-dependent was supported.
- Defensive tail behavior is significantly related to relative tail color coverage of snake tails. Moreover, variation in color coverage is negatively related to body mass and circulating levels of testosterone.
- Based on these findings, we suggest that snakes of smaller body size invest more in orange tail coloration to compliment the function of defensive tail behavior.
- The prevalence of tail defensive behavior and conspicuous coloration may function as a diversion of attack to the tail in the prospects of escaping predation are limited by locomotor capacity. This would lead the head free to gain a mechanical advantage and escape.
- Size-dependent variation in defensive responses have also been found in Cottonmouths (Agkistrodon piscivorus). Here, increasing body size leads to declines in anti-predator behaviors.
- Differences in defensive behavior, color expression, and body size may be mediated by testosterone levels as this hormone is known to regulate development and maintenance of these traits.
- Increases in testosterone levels have also been positively correlated with frequency of defensive behaviors in Common Garter Snakes (Thamnophis sirtalis).

**Literature Cited**


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