Interactions of Diet and Behavior in Death-feigning Snakes (*Heterodon*)

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Abstract

The three species of hog-nosed snakes (*Heterodon*) are well-known for their defensive behaviors, including escape, intimidation, and death-feigning. That this last behavior discourages vertebrate predators has been called into question, and several authors proposed that it is a physiological side-effect of eating toads. We are testing this hypothesis in nature by comparing individuals of *H. platirhinos* and *H. nasicus* with differing frequencies of toads in their diet, and by using stable isotope analysis to determine the contribution of toads to the diets of each snake species. We hypothesize that those individuals with lower proportions of toads in their diet will exhibit either longer latency to death-feigning or shorter death-feints, or both. Additionally, we propose that the more generalist species, *H. nasicus*, will exhibit these same trends in behavioral performance when compared with *H. platirhinos*. Differences between sexes might also exist in both species, based on the observation that the adrenal glands of male *Heterodon* are larger than those of females (one probable indicator of detoxification ability). In addition to presenting comparative morphometrics for the two species collected at our study sites, we present preliminary stable isotope data that will attempt to validate decades of fecal and stomach-content analyses. Furthermore, we discuss the differences observed in ethograms generated for each species based on initial encounters and simulated predatory threats. All three species of *Heterodon* are threatened in parts of their range, so further study of this unusual genus will augment its conservation.

Figure 1: *Heterodon nasicus* defensive behaviors: a) hood-spreading, b) burrowing, c) death-feigning

Introduction

- Habituation in captivity causing loss of the death-feigning behavior has made it difficult to study the circumstances under which hognose snakes death-feign (2,3).
- Human presence has been used as a proxy for predator threat in other studies of snake behavior (12).
- Sexual dimorphism in adrenal gland size (8) suggests that stress response and defensive behavior may also differ between the sexes.
- We compared behavior of wild *Heterodon* between sexes and across the body size gradient. This study represents the first field analysis of patterns in hognose snake death-feigning behavior.

Methodology

- We recorded 2 min of defensive behaviors of 40 *H. nasicus* (17 ♂, 23 ♀) while sampling along a 1.8 km transect at Thomson-Fulton Sand Prairie (Fig. 2) in Carroll County, IL, between 17 May and 27 June, 2010.
- No snakes had initiated death-feigning behavior upon detection.
- Because eye contact is known to increase the duration of death-feigning (1; Fig. 3), we used the video camera to shield the observer's face during all encounters.
- Recordings were coded to quantify the latency to body inversion, and subsequent reversal.
- We collected morphometrics and tissue samples from all specimens.

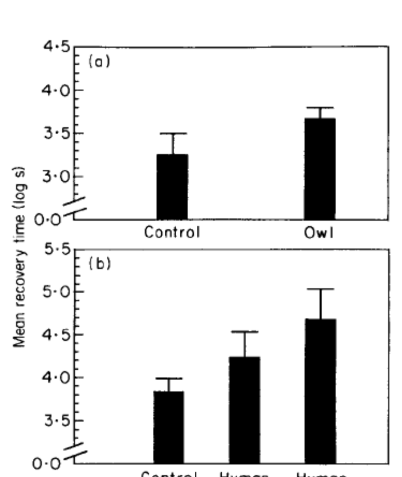


Figure 3: Latency times from quiescent phase to moving away in hognose snakes to (a) the presence or absence of a stuffed owl or (b) the presence of a human observer directly gazing at the snake, the same person with the same head position but with eyes averted, or the absence of a human.
from Burghardt & Greene 1988 (1)

Results

- Snakes captured later in the morning exhibited shorter latency to inversion ($F_{1,18} = 4.74$, $p = 0.04$, $R^2 = 0.31$).
- Male snakes death-feigned less readily than females (mean latency to 1st inversion for males and females = 41.6 and 30.6 sec, respectively; $F_{1,18} = 5.51$, $p = 0.03$). The mean duration of inversion (*i.e.*, latency to reversal) for males (54.2 sec) was greater than that for females (45.7 sec; $F_{1,16} = 3.33$, $p = 0.09$, $R^2 = 0.63$; Fig. 4).
- Overall, heavier snakes death-feigned for a shorter duration than lighter ones ($F_{1,16} = 15.01$, $p = 0.001$) but we observed a mass-by-sex interaction indicating that large female snakes death-feigned for longer than small females ($F_{1,16} = 13.41$, $p = 0.002$; Fig. 5), with an opposite weaker trend for males.
- There were no differences in snout-vent length or mass between sexes.
- Preliminary analysis indicates that our detection probability was 26.4 ± 0.07 %.

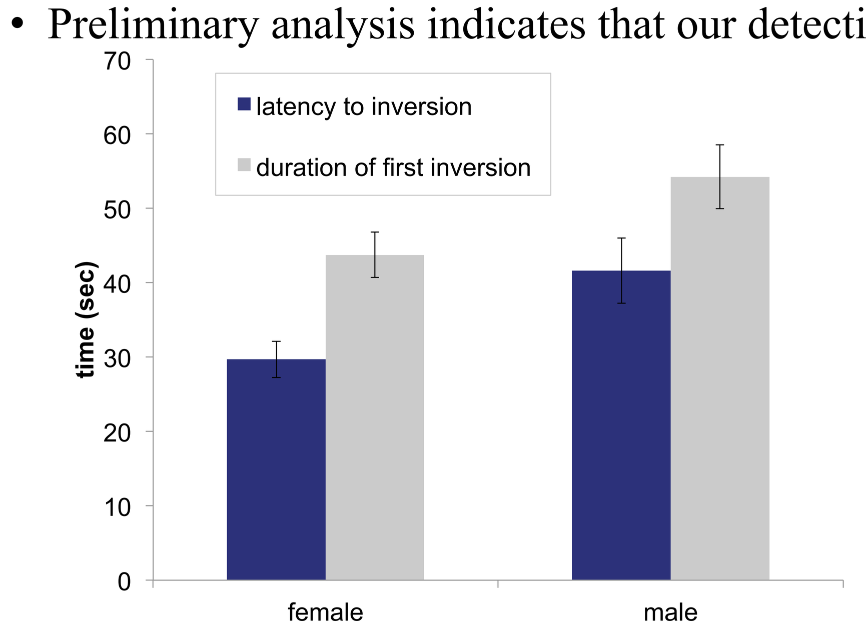


Figure 4: Differences between sexes in latency to inversion (dark bars) and duration of first inversion (light bars). Bars represent means ±1 SE.

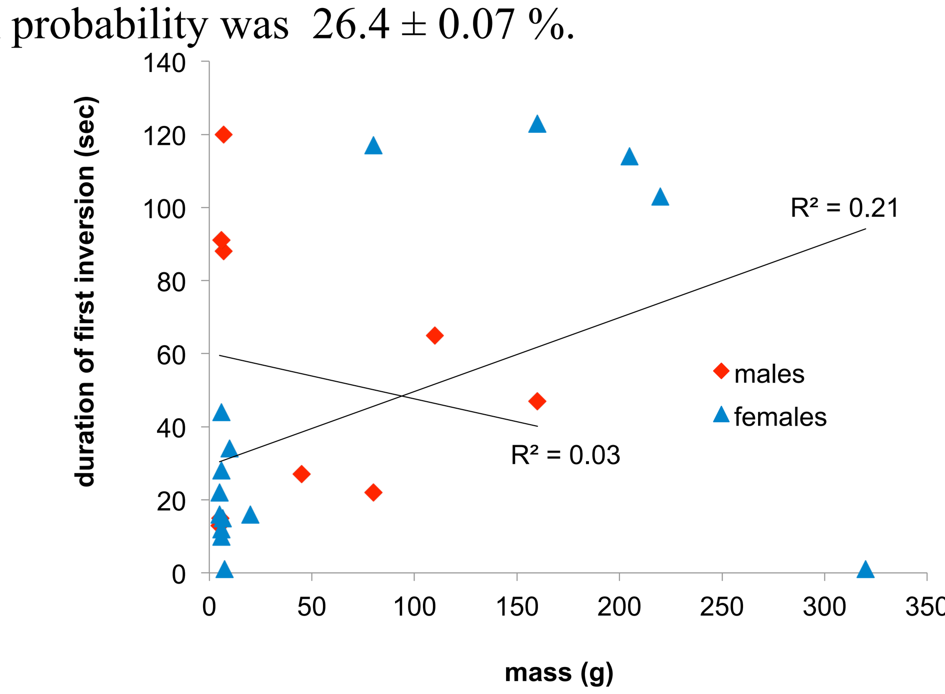
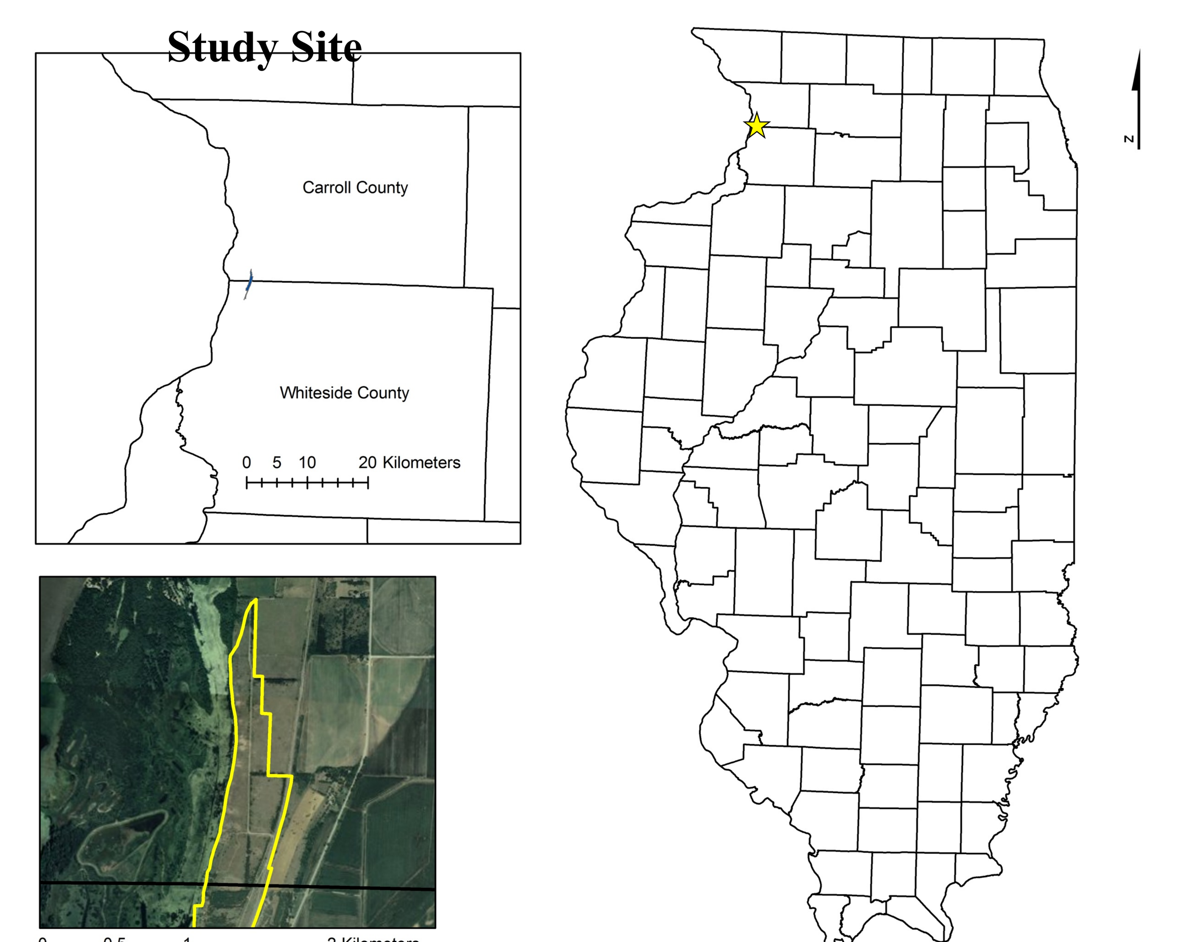


Figure 5: Effects of an interaction between mass and sex on duration of inversion.

Figure 2: Sand prairie habitat in Carroll County, Illinois

Study Site



Discussion

- The time-of-capture effect can be explained by the relatively greater amount of energy available to snakes encountered in the late-morning, a consequence of ectothermy.
- *Heterodon* exhibit sexual dimorphism in adrenal gland size (8, 13, 14), present at birth (2). These glands are known to play a role in both detoxification and regulation of stress hormones. Corresponding differences in death-feigning behavior could be expected.
- Male *H. nasicus* do not seem to exhibit an ontogenetic shift in behavior, but adult females death-feign longer than juveniles. This could be attributed to differences in size, conspicuousness, diet, fitness, or any combination of these factors.
- Female *H. nasicus* in this population are typically larger than males (6).

Future Directions

Several authors have suggested an interaction between death-feigning and the bufotoxin-rich diets of these toad specialists, in part because several other snake species exhibit both bufophagy and death-feigning, but are unrelated to *Heterodon* (5; Fig. 6). We plan to quantify *H. nasicus* diet using stable isotope analysis of carbon and nitrogen, a technique for determining animal diets at small spatial scales (7, 9, 11; Fig. 7).

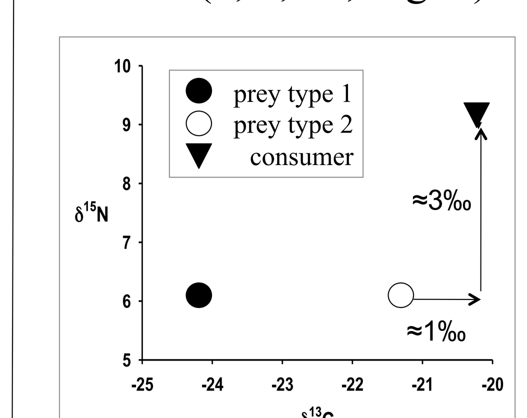
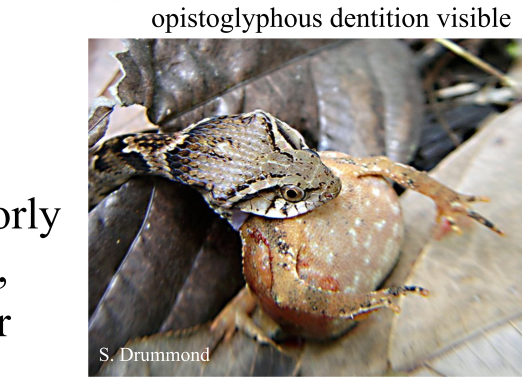


Figure 7: Hypothetical conventional stable isotope plot.
from Pilgrim 2005 (8)

The diet of *H. nasicus* is still poorly known, but includes amphibians, small mammals, lizards and their eggs, and turtle and bird eggs. Individual-level variation in diet may be present along sex, age or other divisions.

Naja haje death-feigning

H. platirhinos eating *Acris crepitans* opistoglyphous dentition visible



Xenodon rhabdocephalus

Rhabdophis tigrinus with *Bufo* prey item

Figure 6: Other death-feigning toad specialist snake species.

We wish to acknowledge the Janzen lab of Iowa State University for critical logistic support of this field work

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