Reproductive investment in female copperheads (Agkistrodon contortrix) at the extreme of their northern range: do large females produce large progeny?

Introduction

• Female investment in reproduction may entail trade-offs, i.e. energetic tradeoffs between (1) current and future reproductive investment; (2) neonate size versus neonate number; and (3) frequency of reproduction versus energy allocated at each reproductive event.

• Trade-offs may be more pronounced in ectotherms because their morphology, physiology, behavior, and reproduction are strongly tied to the environment, particularly in higher latitudes or elevations.

• While larger neonates have been shown to have better performance and higher survival rates, female viviparous snakes typically produce more neonates rather than larger neonates as female body size increases.

• We tested the hypothesis that increase in female body size results in the production of larger neonates, rather than more neonates, in northern populations of viviparous snakes (Viperidae: Agkistrodon contortrix) where ingress to hibernation occurs shortly after parturition (thus strong selection on neonate survival).

Methods

The study site is 4.75 km NW of Meriden, Connecticut. Females suspected of being pregnant (n = 24) were provided private enclosures in the laboratory. Immediately following parturition (<1 hr post-parturition), females and neonates were weighed and measured. We used the residuals of an ordinary least squares (OLS) linear regression of pre-parturient female mass against SVL as an index of adult female condition (Body condition index = BCI).

Statistical tests were performed using IBM (SPSS, version 22.0) and R (version R 3.6.3). All analyses used a 0.05 significance level. Multiple comparisons were made using Tukey tests for pairwise comparisons for post-hoc tests.

Results

We found no effect of female BCI, or female pre-birth mass or SVL, on individual neonate mass or individual neonate size (SVL). We did, however, find that larger females produced more neonates (F = 7.3753, P < 0.0142, df = 19, n = 20, Figure 1) and litter size of greater total mass (F = 12.6916, P < 0.0025, df = 19, n = 20, Figure not shown).

In addition, we found an inverse relationship between female condition and percent mass loss at parturition (F = 5.08, P = 0.03, df = 18, n = 19; Figure 2), meaning that females in poor condition invest proportionally more energy in reproduction than females in good condition. However, the greater investment among poor condition females did not translate into producing larger neonates or more neonates.

Discussion

Contrary to our hypothesis, an increase in female body size in A. contortrix does not result in larger neonates. Rather, larger females produce more neonates consistent with previous studies. The results are surprising given that hibernation may entail high mortality in all life stages, and larger neonates may have greater survival during the period before and during hibernation. Because thermal dependence of embryonic development is widespread among squamate reptiles, female copperhead snakes in northern latitudes may be constrained from producing larger neonates, perhaps by extending gestation length, due to decreasing environmental temperatures in late summer months.

Additionally, we found that females in poor relative condition invest more energy in reproduction. Given that there may be an optimal neonate size for a particular environment and that females should invest the necessary resources to produce neonates of this size, poor condition females may be expected to invest proportionally more energy in reproduction.