# Relative clutch mass in four exotic reptile species from southern Florida

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## INTRODUCTION

Florida is home to 57 exotic species of amphibians and reptiles (Krysko et al., 2016; Meshaka, 2011). Reproductive cycles and clutch characteristics are known for some of these species in Florida (Meshaka, 2011); however, relative clutch mass (RCM) is poorly known. RCM expresses clutch or litter mass as a proportion of the combined mass of the female body and the clutch or litter. It provides a measure of female reproductive investment, putting clutch or litter size into a broader context.

Four exotic species established in Florida, Oustalet's chameleon (*Furcifer oustaleti*), the Argentine black and white tegu (*Salvator merianae*), Nile monitor (*Varanus niloticus*), and Burmese python (*Python bivittatus*), lay relatively large clutches of eggs (Krysko et al., 2008; Meshaka, 2011; Hanslowe et al., 2016; Smith et al., 2016; Wolf et al., 2016). Feeding habits of the latter three species threaten a wide range of vertebrates (Snow et al., 2007; Dove et al., 2011; Meshaka, 2011), and they are dispersing rapidly in the state (Meshaka, 2011). Here, we used clutch data from these four species to calculate RCM and interpret our findings within the context of predictions associated with their body form and life history traits (Shine, 1992) and what these values could mean with respect to colonisation success.

## MATERIALS AND METHODS

Relative clutch mass (RCM) was estimated by the equation: Clutch mass/clutch mass + female body mass. Data for Oustalet's chameleon were derived from Smith et al. (2016). For the remaining three species, masses were measured to 0.1 g. We measured snout-vent length (SVL) to the nearest 0.1 cm in lizards and to the nearest cm in the Burmese python. Means are followed by ± 1 standard deviations. All statistics were calculated on Excel 2016. Statistical significance was recognised at $p < 0.05$.

## RESULTS

Oustalet's chameleon (*F. oustaleti*) – Data from 10 females were available from Smith et al. (2016). To calculate pre–oviposition mass, we added clutch mass to the unpublished post–laying mass of the female. Body size (SVL) was available for nine females (mean = 16.5 ± 1.6 cm SVL; range = 14.5–19.5 cm). For 10 females, clutch size averaged 43.4 eggs (± 9.0; range 34–62), and RCM averaged approximately one–third of the mass of ovigerous females (mean = 0.35 ± 0.03; range = 0.32–0.43).

Argentine black and white tegu (*S. merianae*) – Three females from Florida City, Miami-Dade County, were available for estimation of RCM. The first two were captured alongside their nests at which time we recorded their clutch characteristics. A 39.4 cm SVL female weighing 1950.0 g was captured on 13 May 2015. The nest contained 27 eggs weighing 621.0 g. We calculated an RCM of 0.32 for this female. A 35.9 cm SVL female weighing 1550.0 g was captured on 14 May 2015. The nest contained 27 eggs weighing 646.0 g. We calculated an RCM of 0.42 for this female. Neither date nor clutch size was recorded for a third female that measured 36.6 cm SVL; however, we calculated an RCM of 0.33 for this female.

Nile monitor (*V. niloticus*) – A 41.6 cm SVL female Nile monitor was captured on 30 June 2014 from along a canal in Palm Beach County. Once thawed, we found the female to contain 20 shelled eggs; 11 eggs in the left oviduct and 9 eggs in the right oviduct. We calculated an RCM of 0.05 for this female.

Burmese python (*P. bivittatus*) – Data were available to calculate RCM from four ovigerous female Burmese pythons captured during June–July 2013 and in July 2014. Number of eggs in left and right oviduct, respectively are shown in parentheses. A female of 251 cm SVL containing 22 eggs (14 and 8) had an RCM of 0.15. A female of 239 cm SVL containing 24 eggs was calculated to have a RCM of 0.22. A female of 296 cm SVL containing 41 eggs (27 and 14) had an RCM of 0.38. A female of 252 cm SVL containing 13 eggs had an RCM of 0.28. For all four females, the RCM averaged 0.26 (± 0.1). A female of 264 cm SVL from Everglades National Park having laid 22 eggs lost 54% of her body weight (Wolf et al., 2016). Among captives in a study, 30.0–38.1% of body weight was lost in nesting females (Brashears & DeNardo, 2013).

## DISCUSSION

The RCM values of the three lizard species we examined conflicted in-part with predictions associated with foraging strategy and predator escape (Vitt & Congdon, 1978; Vitt & Price 1982). As expected, Oustalet's chameleon, a cryptic sit–and–wait or ambush predator, produced a high RCM. Counterintuitively, however, RCM values of the Argentine black and white tegu, a widely-foraging species that takes flight from predators, were similar to those of Oustalet's chameleon and were much higher than those of other widely-foraging teiid lizards (Vitt & Congdon, 1978; Vitt & Price 1982). Furthermore, RCM of the Nile monitor measured in our study, although conforming to predictions of low RCM associated with their ecology, was contrary to findings in this species elsewhere (Buffrénil & Rimblot-Baly, 1999). We proffer that the Argentine black and white tegu, and possibly the Nile monitor, adjust their behaviour to accommodate a high RCM as reported for the broad-headed skink (*Plestiodon laticeps*) (Cooper et al., 1990). Females of this skink adopt sit-and-wait cryptic behaviour when gravid, thereby offsetting the danger of compromised locomotor escape associated with a high RCM (Cooper et al., 1990).

The Argentine black and white tegu and broad-headed skink share two relevant aspects in their ecologies associated with reproduction. Both species produce a single large clutch annually, and parental solicitude is developed strongly in both species. For a highly seasonally-active species like the Argentine black and white tegu, an ovigerous female has little if any room for food and has somatic fat stores (WEM, FJM, and MRR unpubl. data). Moreover, the eggs are laid in a nest of the female's making and guarded, which would enforce reduced movements as the female approaches oviposition and is most vulnerable to a predator. To that end, captures of ovigerous females in southern Florida are uncommon in standardised trapping (WEM, FJM, and MRR unpubl. data), thereby corroborating an inability or unwillingness to forage actively at that reproductive stage. The Nile monitor likewise produces a single large clutch with a high reproductive investment with only a portion of adult females laying eggs each year (Buffrénil & Rimblot-Baly, 1999). Abdominal body volume: body mass ratio is a strong predictor of RCM (Shine, 1992), and a high value in the Nile monitor would be indicative of a high RCM. However, unlike the broad-headed skink and Argentine black and white tegu, the Nile monitor does not guard the clutch. Thus, it remains to be seen if and in what way females of the south Florida population adopt a cryptic and sendentary disposition prior to oviposition.

Snakes generally produce a higher RCM than lizards (Seigel & Fitch, 1984), and Shine's (1992) findings corroborate that pattern in association with an abdominal body volume: body mass ratio of snakes being nearly twice that of lizards. The RCM values of our Burmese pythons ranged widely. Because female Burmese pythons can easily exceed the body sizes in our study and because our sample size was small, a larger sample that includes larger–sized females would provide a stronger assessment of RCM of the Florida population.

High fecundity is a correlate of successful colonisation (Baker, 1965). This ecological correlate, generally measured by clutch size and frequency, is associated with many established exotic species of amphibians and reptiles in Florida (Meshaka, 2011), including the four species of this study. Interspecific differences in RCM in our study conformed to predictions associated with behaviour. These differences underscore the importance of RCM as an important measure of fecundity, apart from clutch size and frequency, when evaluating fecundity as a correlate of success in members of Florida's exotic herpetofauna.

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