

Communal egg-laying and thermal isolation in a nest of *Erythrolamprus epinephelus* (Dipsadidae)

Oviposition site is critical for reproduction, considering the time and energy invested by the nesting female and the need to maximize offspring fitness. Gravid females need to be efficient while finding a suitable site for laying eggs (Refsnider & Janzen 2010). Reptiles display a broad range of reproductive behaviors, particularly selection of the microclimate of nesting site, ensuring the optimal incubation conditions (Shine 1980).

Selection of previous nesting areas, used by the same female or different females, is a way to maximize reproductive success (Brown & Shine 2005). These females could be conspecific as well as heterospecific (Braz et al. 2008). This maternal behavior is known as communal egg-laying (Espinoza & Lobo 1996), and has been reported in sphenodontians, lizards, snakes, turtles and crocodylians (Doody et al. 2009). In snakes, oviposition modes are relatively unknown; mothers are so successful at hiding their eggs that nests are rarely found (Braz et al. 2008). Communal egg-laying for snakes has been observed in less than 4% of oviparous species (Doody et al. 2009). We report a case of intraspecific communal egg-laying of the Golden-bellied Snake *Erythrolamprus epinephelus* (Cope, 1862). We also provide data on nest temperature, clutch size, and egg and hatching attributes.

Erythrolamprus epinephelus is a small snake with a maximum known length of 80 cm and dorsal coloration consisting of black, red or orange bands (Solórzano 2004). The species is distributed from Costa Rica to southern Peru (Solórzano 2004, Uetz & Hošek 2016). It is oviparous, laying clutches of up to 10 eggs (Solórzano 2004).

On 23 October 2012, we located a snake nest in the Distrito de Conservación de Suelos Barbas-Bremen at the western slopes of the Central Andes of Colombia, Department of Quindío (04°45'–04°37' N, 075°41'–075°32' W; 1650–2500 m above sea level). The nest was located in a hole on a slope beside a path at 0.84 m above the ground surface and at 0.42 m from the top of the slope. The hole was 42 cm deep and had an elliptic entrance with a height of 8.8 cm and a width of 15.3 cm (Fig. 1A).

There were eight unhatched eggs and at least five previously hatched shells (Fig. 1B). Four eggs were at a depth of 16 cm and the others were at a depth of 25 cm. Communal egg-laying consisted of at least three different clutches based on coloration, orientation, and distance between egg groups. We collected three eggs and incubated them, with nest substrate at ~18.5 °C. We measured both egg length and width with a digital caliper (to the nearest 0.1 mm), and weight was measured with a digital balance (to the nearest 0.1 g). In addition, a data-logger ThermoChron iButtons® was placed inside the nest (20 cm depth), and another immediately above the nest, in the pastureland. Both data-loggers were programmed to record thermal fluctuations every hour. We estimated an ap-

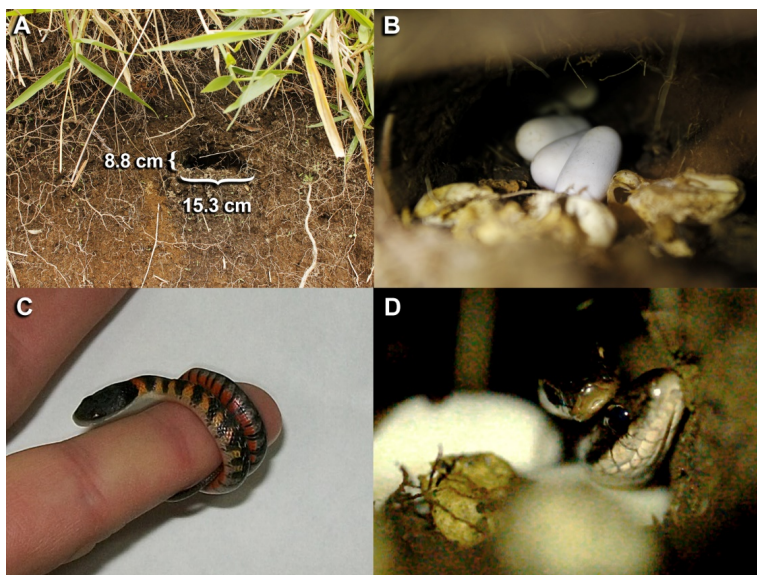


Figure 1. Communal nest of *Erythrolamprus epinephelus* in the Distrito de Conservación de Suelos Barbas-Bremen. (A) Dimensions of the nest entrance, (B) hatched and unhatched eggs, (C) hatchling from one of the collected eggs, (D) adults in the studied nest.

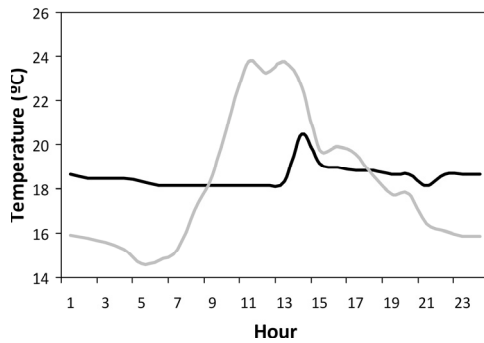


Figure 2. Temperature fluctuation inside (black line) and outside (gray line) the nest of *Erythrolamprus epinephelus*, at Distrito de Conservación de Suelos Barbas-Bremen, Colombia.

proximate incubation period from the time of discovery of the nest to hatching. Statistical data are given as mean \pm 1 SD. To compare the variation among samples we used the Wilcoxon rank sum test. Statistical analyses were developed using R (R Core Team 2015).

The three eggs had the exact same dimensions: 27.0 mm of length, 11.0 mm of width, and egg mass of 6.7 g. Of the three eggs, only one hatched on 16 December 2012 (Fig. 1C), after an approximate incubation period of 54 days. The other two eggs were presumably unviable.

On 23 December 2012, at night, we observed two *E. epinephelus* adults inside the nest (Fig. 1D). After 19 minutes, both snakes left the nest in which we found eight unhatched eggs. Consequently, there were at least three new eggs, if we assumed that the five eggs registered in our previous visit had not hatched. In the afternoon on 24 December 2012 we found the nest cavity fully disturbed. Unfortunately, because of this the study concluded prematurely.

The mean temperatures inside and outside the nest were similar, 18.4 ± 0.25 °C, and 18.03 ± 3.16 °C, respectively. However, the mean coefficient of variation (CV) of daily thermal fluctuation inside the nests was 4.7% (range = 1.3–8.1), which is lower than the daily external temperature CV (17.0%, range = 16.1–18.0). In addition, daily thermal fluctuation varied between inside and outside the nest ($W = 1847$, $p = 0.01$; Fig. 2), while the mean nest temperature was stable (min: 18.15 °C; max: 18.65 °C; \pm 1 SD: 0.25). This enabled us to identify the buffer effect of the nest (Fig. 2).

The selection of a nest site suitable for off

spring survival is an essential component of fitness (Clotuche et al. 2013). The explanation of communal oviposition in reptiles is focused mainly on the constraint hypotheses, where suitable oviposition sites are constrained by high population density and/or heterogeneous environment, and the adaptive hypotheses, which involves both females and offspring fitness benefits (Doody et al. 2009). A high frequency of communal nests would be predicted in habitats with few suitable laying sites and/or in places where eggs have been previously laid, since it provides cues about the quality and success of a nesting site (Peñalver-Alcázar et al. 2015). Adaptively speaking, the explanations for communal nesting include metabolic heating, tending of nests by multiple females, and saturation of nesting sites to reduce risk of predation (Montgomery et al. 2011). Our observations are inadequate to support that conspecific communal oviposition in the studied species could be explained by the scarcity of suitable nest sites.

However, microclimate could explain offspring performance benefits for communal egg-laying in snakes. Webb et al. (2001) observed for the Keelback *Tropidonophis mairii* that eggs incubated with low thermal variation showed differences on morphological traits from eggs incubated with high thermal variance. Blouin-Demers et al. (2004) showed that incubation temperature from communal nest was higher than single nest in the Black Rat Snake *Elaphe obsoleta*. Eggs incubated at similar temperatures compared to those observed in communal nests hatched in a shorter period, the hatchlings were longer, swam faster, and had fewer scale anomalies than the hatchlings incubated with temperatures similar to those from single nests. Our data showed that nest cavity maintained low thermal fluctuation despite large fluctuations of external temperature, which could be favorable to hatchling development.

The costs and benefits of selecting sites that contain conspecifics have attracted considerable research (Doody et al. 2009). Therefore, the physiological and behavioral benefits to both females and offspring must be studied in more detail for Neotropical snakes.

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