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Notes on Reproduction of *Caraiba andreae peninsulae*: A Poorly-known Subspecies of the Cuban Lesser Racer (Squamata: Dipsadidae)

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Abstract.—The Cuban Lesser Racer (*Caraiba andreae*) belongs to a monotypic genus endemic to the Cuban Archipelago. The species comprises six subspecies, some of which have restricted distributions. The natural history, particularly the reproductive biology, of some subspecies is virtually unknown. Herein we provide the first data on reproduction and growth of *C. a. peninsulae*, a subspecies restricted to the westernmost tip of the main island.

Key words: Cuba, endemic snake, eggs, incubation time, neonates, West Indies

The monotypic snake genus *Caraiba* (Dipsadidae) is endemic to Cuba (Hedges et al. 2009; Zaher et al. 2009). The Cuban Lesser Racer (*C. andreae*) comprises six subspecies that range across the archipelago (Schwartz and Henderson 1991; Henderson and Powell 2009; Estrada 2012); these differ primarily in dorsal color patterns (Schwartz and Henderson 1991). These are diurnally active oviparous snakes that occupy a wide variety of habitats at elevations that range from sea level to nearly 1,300 m (Schwartz and Henderson 1991; Henderson and Powell 2009; Rodríguez et al. 2010; Estrada 2012). Despite the fact that this is one of the most common and widely distributed snakes in Cuba, its natural history is poorly known (see Henderson and Powell 2009 for a review), although aspects of its reproductive biology have been treated in some detail for three subspecies (*C. a. andreae*, *C. a. nebulata*, and *C. a. orientalis*; Rodríguez-Cabrera et al. 2015).

Caraiba a. peninsulae (Fig. 1) is restricted to the Guanahacabibes Peninsula at the westernmost tip of the main island of Cuba (Fig. 2), and is one of nine reptilian taxa endemic to the Peninsula (Rodríguez et al. 2009). The information available on this subspecies is limited to taxonomy and distribution (Schwartz and Thomas 1960; Garrido and Schwartz 1968; Rodríguez et al. 2009, 2013) and no data exist on its natural history. Herein we describe eggs, incubation time, hatching behavior, hatchlings, and growth of *C. a. peninsulae*, based on a clutch obtained in captivity from a free-ranging female.

Materials and Methods

We incubated eggs in a plastic container (basal diameter 10 cm, upper diameter 12 cm, depth 7 cm) with small holes in the top (Fig. 3). The substrate was a 1-cm deep coconut-fiber

Fig. 1. Adult female *Caraiba andreae peninsulae* from La Bajada, Guanahacabibes Peninsula, Pinar del Río Province. Photographs © Raimundo López-Silvero.

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layer, which we dampened twice a week in order to keep relative humidity above 90%. We kept the incubator in the dark and maintained air temperature at 28–32 °C.

We measured hatchlings for snout-vent length (SVL), tail length (TL), and head length (HL), and the eggs to the nearest 0.05 mm with a Stainless Steel Vernier Caliper and weighed them to the nearest 0.1 g with a Pesola® spring scale. Because eggs of the same clutch were strongly adherent and separating them entailed high risk of rupture, a mean mass per egg was determined by dividing the total clutch mass by the number of eggs per clutch (see Rodríguez-Cabrera et al. 2015).

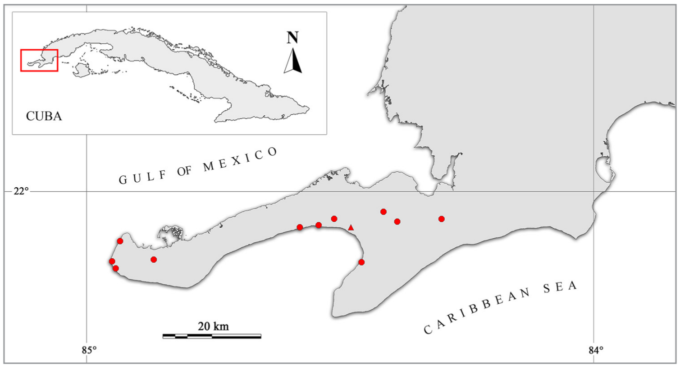

Fig. 2. The distribution of *Caraiba andreae peninsulae* in the Guanahacabibes Peninsula, Pinar del Río Province. Dots represent records from the literature, the triangle marks the site near La Bajada where we collected the female described in this work.

Fig. 3. Plastic container used as an incubator for the eggs of *Caraiba andreae peninsulae.*

Because we could not observe the entire hatching process and hatchlings left the eggs suddenly, the exact time of each emergence was sometimes difficult to determine; we also were unable in all cases to connect each individual to a specific egg number. Thus, hatchling numbers do not correspond to egg numbers; instead, hatchlings were identified and numbered based on individual-specific dorsal patterns. We kept them together in a plastic container (same as that used in the incubator), with toilet paper as substrate, until the post-hatching molt. During this period, we did not feed them or offer water, relying instead on residual yolk reserves. We moistened the paper slightly every 2–3 days and provided additional toilet paper as extra surface to facilitate the molting process.

After the first molt, we kept one individual (neonate No. 1; Table 2) to study growth. Initially, we placed it in a glass terrarium (8.5 x 16.5 x 14.5 cm) and fed it once every 4–5 days on hatchling anoles (< 25 mm SVL and < 0.5 g); water was provided *ad libitum.* It progressively accepted larger anoles (to 2.5–3 g at five months of age).

All means are presented ± one standard deviation (SD).

Results

At 12:50 h on 21 July 2016, we captured an ovigerous female *C. a. peninsulae* (450 mm SVL, 262 mm TL) that had been basking on the soil in a forest light gap on the trail to “Cueva Las Perlas” (21°55’48”N, 84°28’45”W; ca. 3 m asl), La Bajada, Guanahacabibes Peninsula, Sandino Municipality, Pinar del Río Province (Fig. 2). On 22 July (the day after collection), the female laid a clutch of seven eggs in the bottle in which she was being transported. Six were cemented to each other and the seventh was detached from the clutch (Fig. 4). The initial total mass of the clutch was 9.8 g; the female weighed 33 g after laying for a relative clutch mass of 0.297.

Fig. 4. Clutch of *Caraiba andreae peninsulae* obtained in captivity during different times of the incubation period: (A) day of oviposition; (B) second week after oviposition; (C) sixth week after oviposition, just before hatching. Scale bars = 10 mm.

The eggs showed a parabolic-like increase in growth rates (Figs. 5 and 6). The mean mass per egg increased very little during the first week (0.04 g/week), then rapidly increased during the second week (mean = 0.21 g/week) before slowing down progressively until the fifth week (0.05 g/week) and decreasing slightly during the sixth week (-0.05 g/week) just before hatching (Fig. 5). The eggs also increased in size, particularly in width, throughout most of the incubation period before decreasing slightly just before hatching (Fig. 6). Progressive measurements of eggs are presented in Table 1. The largest egg was the one detached from the clutch (No. 1), which initially measured 4 mm longer than the largest (No. 2) in the joined group (Fig. 4).

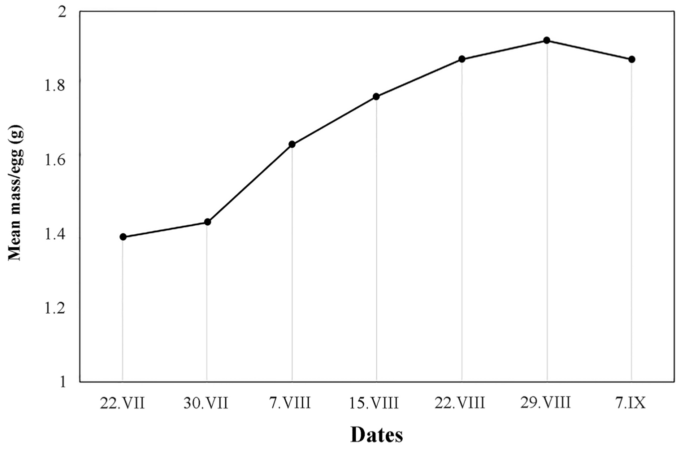

Fig. 5. Mean mass per egg estimated from the clutch of *Caraiba andreae peninsulae* obtained at one-week intervals during the entire incubation period. Notice the slight decrease during the final week.

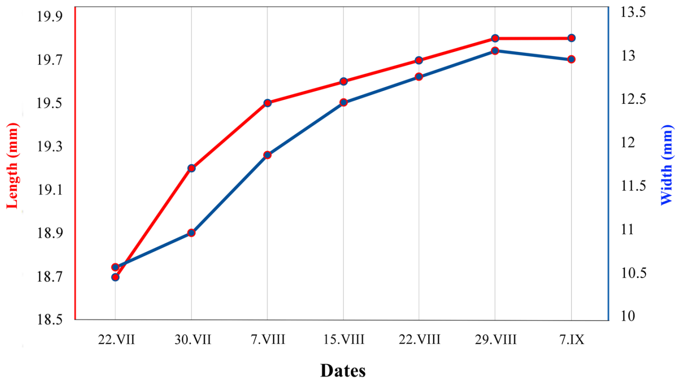

Fig. 6. Measurements of length and width of eggs of *Caraiba andreae peninsulae* obtained at one-week intervals during the entire incubation period. Notice the slight decrease, particularly in width, during the last week.

In late August, one egg (No. 6) changed in color from off-white to brownish and greenish and the shell collapsed. On 25 August, we opened it to reveal a dead developing embryo and considerable yolk (Fig. 7). At 1640 h on 8 September (48 days after oviposition), we noticed that the shell of one egg (No. 3) was longitudinally split with the hatchling extending its snout cautiously, "tasting" the fluids and air with its tongue, and forming bubbles during its first breathing attempts (Figs. 8A–B). The remaining eggs broke at 1955 h (No. 2) and at 2249 h (No. 4) that same day, at 0449 h (No. 7) and 0712 h (No. 5) on 9 September, and at 0747 h on 10 September (No. 1; Figs. 8C–F). Once the shells broke, hatchlings remained inside for several hours (see below), moving frequently but never extending more than part of their heads through the openings. We noted a considerable amount of residual yolk surrounding the hatchlings inside the eggs when the shells first ruptured (Fig. 8C); this disappeared a few hours before they left the eggs (Figs. 8E–F). At 1425 on 9 September, 18 h and 30 min after the initial rupture, the hatchling from egg No. 2 emerged suddenly. Most of the remaining hatchlings emerged from eggs after periods ranging from 16 h and 15 min to 22 h and 30 min (Figs. 9A–C). The exception was egg No. 1, the one detached from the rest of the clutch, which first ruptured at 0747 h on 10 September (50 days after oviposition); the hatchling emerged at 1830 h that same day after a period of 10 h and 43 min (Fig. 9D). The shortest periods detected between shell rupture and hatchling emergence was 10–11 h. Residual yolk

Table 1. Progressive measurements (in mm) of the eggs of Cuban Lesser Racers (*Caraiba andreae peninsulae*). Measurements are listed as means ± one standard deviation, with the range in parentheses.

Date	Length	Width	Increased Length	Increased Width
22.VII	18.7 ± 2.5 (16.3–23.7)	10.6 ± 0.3 (10.3–11.1)	0	0
30.VII	19.2 ± 2.4 (16.8–23.8)	11 ± 0.4 (10.5–11.5)	0.4 ± 0.2 (0.1–0.5)	0.4 ± 0.1 (0.2–0.5)
7.VIII	19.5 ± 2.5 (17.0–24.4)	11.9 ± 0.6 (11.1–12.8)	0.4 ± 0.1 (0.2–0.6)	0.9 ± 0.3 (0.6–1.3)
15.VIII	19.6 ± 2.4 (17.7–24.5)	12.5 ± 0.7 (11.5–13.5)	-0.01 ± 0.5 (-0.7–1)	0.8 ± 0.4 (0.4–1.5)
22.VIII	19.7 ± 2.5 (17.7–24.8)	12.8 ± 0.6 (11.9–13.6)	0.1 ± 0.1 (0–0.3)	0.3 ± 0.2 (0.1–0.4)
29.VIII	19.8 ± 2.8 (17.7–25)	13.1 ± 0.4 (12.5–13.6)	0.1 ± 0.1 (0–0.2)	0.2 ± 0.3 (0–0.6)
7.IX	19.8 ± 2.8 (17.7–25)	13 ± 0.3 (12.4–13.3)	0	-0.1 ± 0.4 (-0.6–0.5)

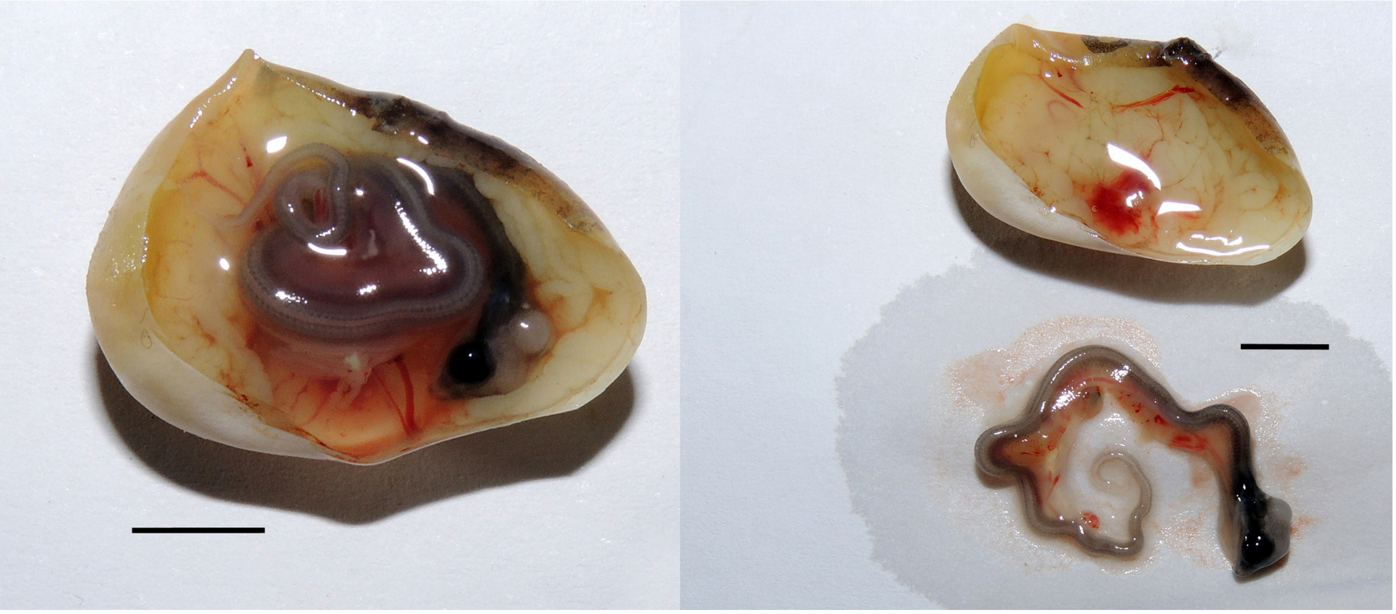

Fig. 7. Embryonic *Caraiba andreae peninsulae* from egg No. 6 at the fifth week of incubation. Scale bars = 5 mm.

absorption was easily detectable inside the posterior half of the body cavity and at the site of the umbilical scar (Fig. 10).

Hatchling measurements are presented in Table 2. Dorsal ground color was black on the head and neck before becoming progressively dark grayish-brown posteriorly (Fig. 11). The head has two prominent white canthal-temporal stripes. The usual dorsal pattern consisted of white markings composed of two wide stripes on the nape followed by a series of more or less prominent stair-like spots on the anterior third of the body that extended onto tail as two whitish dorsolateral stripes (Figs. 11–13). The exception was hatchling No. 1, the dorsum of which was almost solid black with only a few small whitish markings on the neck (Figs. 11–13). Ventral coloration was grayish-white (Fig. 10).

A few days after hatching, the skins of neonates became dull and the eyes bluish (Fig. 12A) and they molted between 13–15 September (5–7 days after the first shell rupture; Fig. 12B). All neonates decreased in mass by 0.1 g by the time they molted (Table 2). After the post-hatching molt, they started feeding and drinking water.

On 31 December 2016 (112 days/3.7 months after birth), juvenile No. 1 weighed 3.8 g and measured 190 mm SVL and 98 mm TL, for a total increase of 2.6 g in mass, 83 mm in SVL, and 43 mm in TL (average increase/month: 0.7 g and 34.1 mm in length). On 19 April 2017 (221 days/7.4 months after birth, and 109 days/3.6 months after the latter measurement), it weighed 11.5 g and measured 273 mm SVL and 145 mm TL, for a total increase since birth of 10.3 g in mass, 166 mm in SVL, and 90 mm TL (average increase/month during the latter trimester: 1.8 g and 36.1 mm in length). During this period, it molted six more times, for an average of one molt every 35 days (intervals from 27–46 days). The dorsal color pattern changed to brownish, the skin between scales to bluish, and ventral scales to grayish dur-

Table 2. Measurements of hatchling Cuban Lesser Racers (*Caraiba andreae peninsulae*). Abbreviations: SVL = snout-vent length, TL = tail length, HL = head length. Mass 1 refers to just after hatching, and Mass 2 refers to post-molting mass.

No.	SVL (mm)	TL (mm)	HL (mm)	Mass 1 (g)	Mass 2 (g)
1	107	55	8.4	1.2	1.1
2	105	57	8.6	1.2	1
3	108	61	8.5	1.2	1.1
4	103	56	8.6	1.1	1
5	107	60	8.4	1.2	1.1
6	108	57	8.4	1.3	1.2
Mean ± SD	106.3 ± 2.0	57.5 ± 2.4	8.5 ± 0.1	1.2 ± 0.1	1.1 ± 0.1

Fig. 8. Sequence of shell ruptures of eggs of *Caraiba andreae peninsulae*: (A) first rupture, at 1640 h on 8 September; (B) bubbles formed during initial efforts to breathe; (C) at 2025 h on 8 September (arrow indicates residual yolk); (D) at 0913 on 9 September; (E) at 1318 on 9 September; (F) detail of hatchling inside the egg. Notice the absence of residual yolk in the same egg (No. 2) several hours later (E, F).

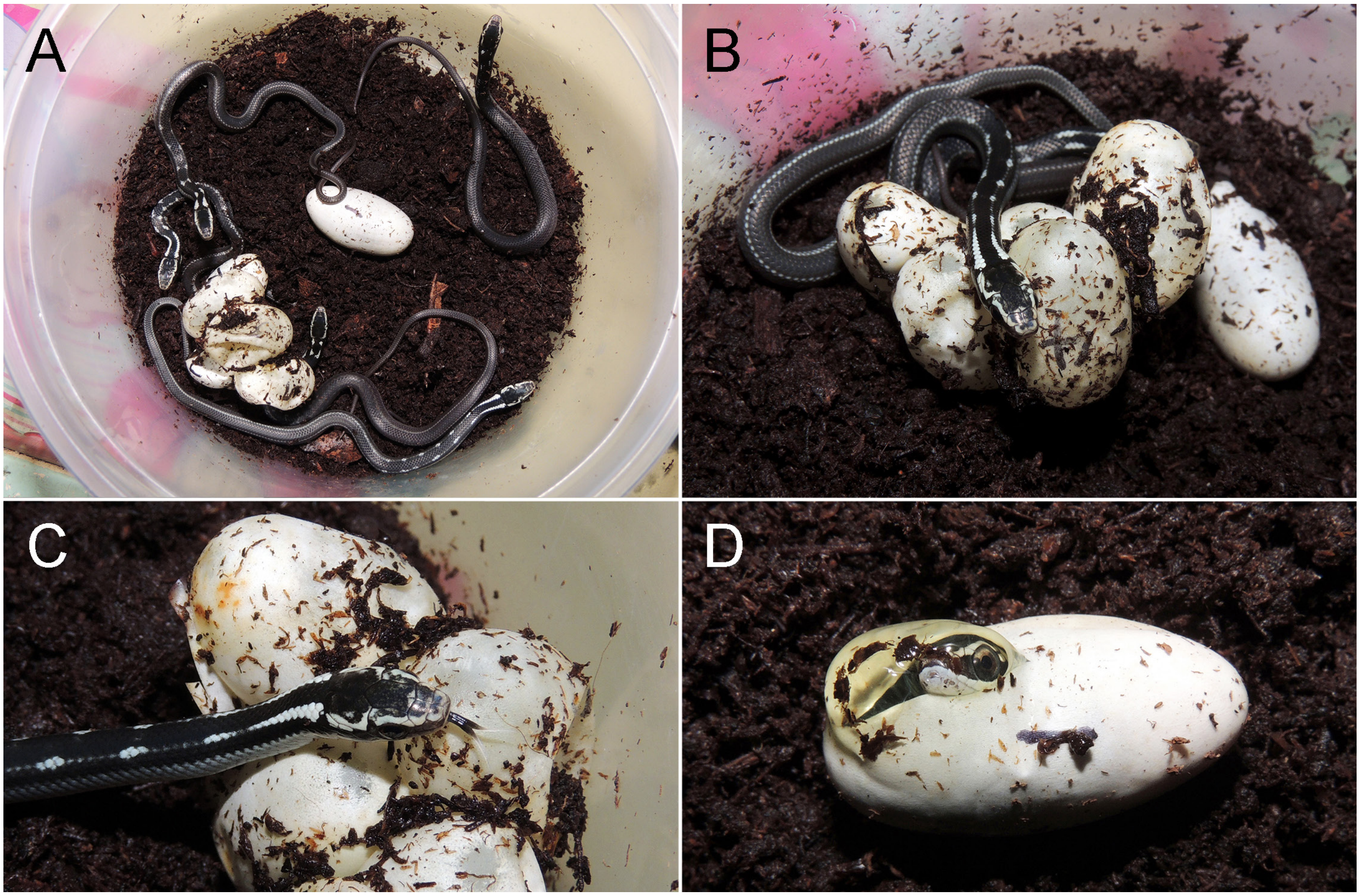

Fig. 9. Sequence of hatching in a clutch of eggs of *Caraiba andreae peninsulae*: (A) at night on 9 September, five neonates already emerged, with egg No. 1 still intact; (B–C) details of hatchlings while exploring their surroundings; (D) egg No. 1 just after shell rupture at 0747 on 10 September.

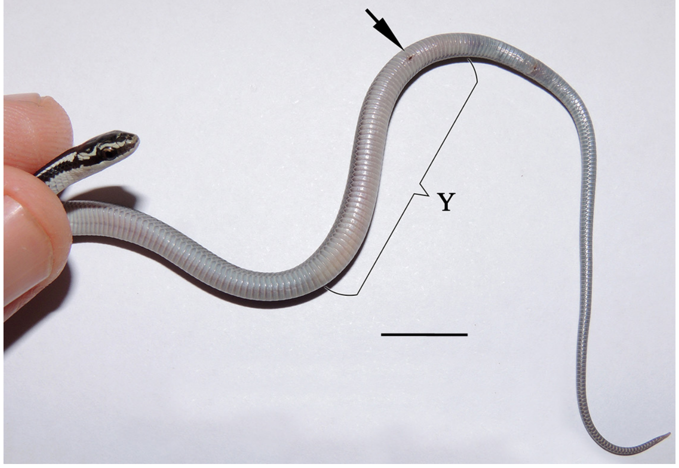

Fig. 10. Ventral region of a hatchling *Caraiba andreae peninsulae* showing a lighter posterior swelling where residual yolk was absorbed (Y) and the umbilical scar (arrow). Scale bar = 1 cm.

ing the first three months (Fig. 14A). Then the dorsal color pattern became progressively darker to dark-brown, almost black (Fig. 14B), whereas the venter became lighter (to whitish) with irregular black spots and some greenish and pinkish areas after the seventh month (Fig. 14C).

We also made some behavioral observations in captivity of hatchling No. 1. We exposed it to direct sunlight for thermoregulation for about 10–15 min about once a week, preferably early in the morning or late in the afternoon. Immediately after being exposed to sunlight, it always came out of its shelter in the terrarium and dorsoventrally flattened its neck in a cobra-like fashion (Fig. 15) during the first 2–3 min of the basking period; this is similar to a typical defensive behavior of snakes in this group. The snake always turned its body so the flattened surface was perpendicular to the incidence of sunlight. Of interest is the fact that the snake never reacted defensively to the keepers under any circumstance, nor did it display this behavior when exposed to artificial white light when we tested the hypothesis that light alone was the triggering factor.

Discussion

Most of the observations made here are consistent with information available for other subspecies of the Cuban Lesser Racer (see Rodríguez-Cabrera et al. 2015 and references therein). In particular, the incubation time coincides with the minimum of 54 days reported by Rodríguez-Cabrera et al.

Fig. 11. Captive-born litter of *Caraiba andreae peninsulae* showing dorsal color patterns and corresponding numbers assigned to each individual for monitoring.

Fig. 12. Neonatal *Caraiba andreae peninsulae* five days after hatching: (A) showing the typically dull skin and bluish eyes just before molting, and (B) the molting process.

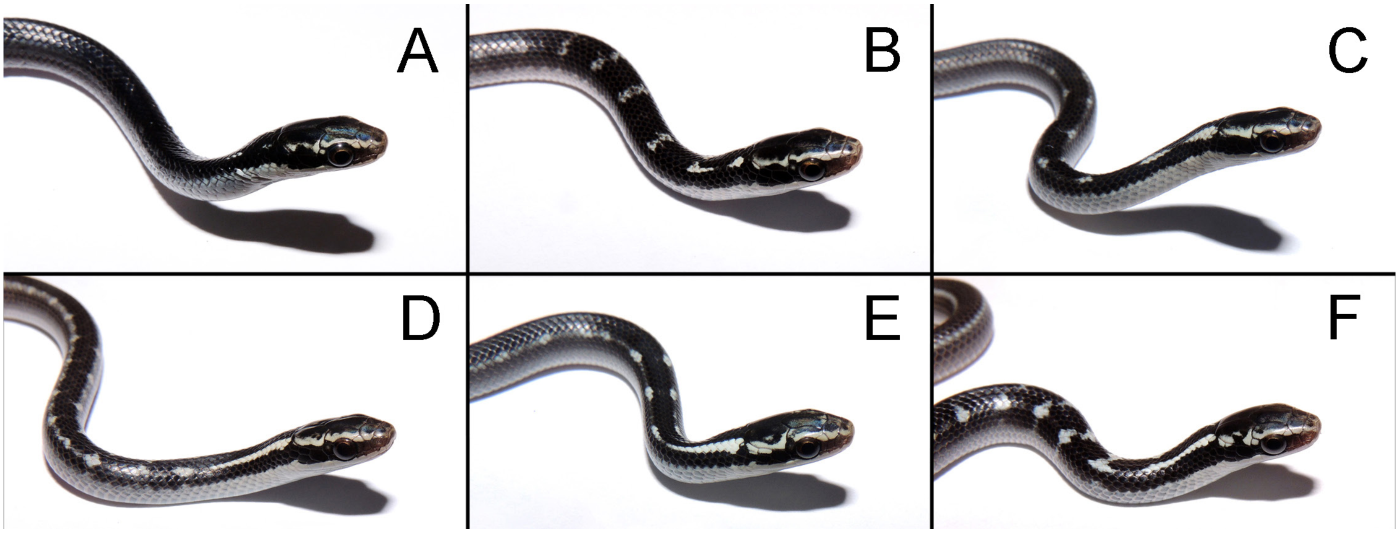

Fig. 13. Dorsolateral views of heads and anterior bodies of six neonatal *Caraiba andreae peninsulae* hatched in captivity, showing individual-specific color pattern: (A) No. 1; (B) No. 2; (C) No. 3; (D) No. 4; (E) No. 5; and (F) No. 6.

Fig. 14. Juvenile *Caraiba andreae peninsulae* (No. 1) on 31 December 2016 (112 days after hatching), showing the brownish dorsal color pattern (A). Same individual on 19 April 2016 (220 days after hatching), with a darker dorsal pattern (B) and irregularly spotted venter (C).

Fig. 15. Juvenile *Caraiba andreae peninsulae* (No. 1) at seven months of age displaying dorsoventral neck-flattening while basking.

(2015) and neonatal sizes fall within the range reported by those authors. However, a thorough monitoring of the eggs' growth and the hatching process has not been previously reported; however, Amaro-Valdés and Morell-Savall (2017) reported a similar increase in size for one egg of the Short-tailed Racerlet (*Arrhyton vittatum*).

We found strong evidence for residual yolk absorption occurring mostly during the period extending from shell rupture to just before hatchlings left the eggs. This suggests that completion of yolk absorption might require the oxygen provided by breathing after shell rupture. Residual yolk is rich in nutrients that support hatchling maintenance and growth for some time and noticeably enhances survival (Ji et al. 1997a, 1997b, 1999; Stahlschmidt and DeNardo 2011). Hatchling snakes may contain up to 11–25% of total dry mass of residual yolk, conferring a selective advantage (see Stahlschmidt and DeNardo 2011 for a review). A similar delay in hatchling emergence after shell rupture has been reported in other subspecies of the Cuban Lesser Racer, in the Cuban Racer (*Cubophis cantherigerus*), and in the Short-tailed Racerlet (Arango 2008; Rodríguez-Cabrera et al. 2015; Amaro-Valdés and Morell-Savall 2017).

Interestingly, hatchlings described herein had a dorsal color pattern similar to that of adults of this subspecies and which is considered diagnostic for these snakes (Schwartz and Thomas 1960). This phenomenon has not been reported for other subspecies of *C. andreae*, which suggests a strong genetic component for this phenotypic character. Moreover, an intermediate brownish dorsal color pattern like that of the juvenile No. 1 after three months was reported in some populations of *C. a. orientalis* (Stejneger 1917; Grant 1957). In fact, such an ontogenetic color change occurs in two subspecies of *C. andreae* (*C. a. peninsulae* and *C. a. orientalis*) with prominent dorsal patterns comprised of white to pale-blue markings (see Rodríguez-Cabrera et al. 2015).

The growth rate of juvenile No. 1 was more than three times greater than that reported by Rodríguez-Cabrera et al. (2015) for the nominal subspecies during an equivalent span and feeding frequency. Also, the first two measurements suggest an exponential increase in mass and a lineal increase in length, which is typical of amphibians and reptiles in general (Vitt and Caldwell 2014). Nonetheless, additional studies, including larger sample sizes and comparisons among neonate groups subjected to different feeding rates, are necessary before drawing definitive conclusions.

Dorsoventral cobra-like neck-flattening combined with anterior body-raising is a common defensive behavior in West Indian dipsadids (Henderson and Powell 2009; Rodríguez-Cabrera et al. 2014, 2015). However, the behavior observed in specimen No. 1 suggests that instead of serving as a defensive display, this behavior also might be used to increase surface area during basking. The dark coloration of the dorsum also might contribute to accelerating heat absorption (but see White et al. 2002). Such a strategy might help minimize exposure to possible predators during basking periods, particularly in open and thus more visible areas like that where we found the mother.

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