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HERPETOCULTURE NOTES

TESTUDINES — TURTLES

MANOURIA EMYS PHAYREI (Burmese Mountain Tortoise). NESTING BEHAVIOR. Nest construction by most chelonians is relatively simple; after selecting a suitable site, the female excavates a hole, and then deposits and buries her clutch, with little if any subsequent investment in nest maintenance, guarding, or care of the eggs and hatchlings (Ehrenfeld 1979. In Harless and Morlock [eds.], *Turtles: Perspectives and Research*, pp. 417–434. John Wiley and Sons, New York, New York). *Manouria emys* is one of the few exceptions to this general rule (see also Iverson 1990. *Can. J. Zool.* 68:230–233), exhibiting a complex repertoire of nesting behaviors not observed in other chelonians (Stanford et al. 2015. *Chelon. Res. Mono.* 5:086.1–086.9). Namely, gravid female *M. emys* scrape leaf litter and ground debris into a pile and deposit a large clutch (30–60 eggs) within this mound (Stanford et al. 2015, *op. cit.*). Females often remain atop the mound for days or weeks, and during this period will aggressively confront intruders at the nest (McKeown et al. 1982. *Zoo Biol.* 1:223–235). Temperature and humidity relations within the nest have yet to be studied, but as with mound nests of other reptiles, are presumably maintained by a combination of solar radiation, rainfall, metabolic heat produced by developing embryos, and decomposition of organic materials comprising the mound (e.g., Magnusson 1979. *J. Herpetol.* 13:439–448; López-Luna et al. 2020. *J. Thermal Biol.* 91:102624). Here we describe a novel behavior observed in a nesting female *M. e. phayrei* and speculate on its functional significance.

Our observations were made at the Turtle Survival Center (TSC), a conservation-breeding facility operated by Turtle Survival Alliance in Cross, Berkeley County, South Carolina, USA. A group adult *M. e. phayrei* consisting of one male and three females is maintained at the TSC in an indoor/outdoor enclosure encompassing approximately 285 m² (indoors = 14.8

m²; outdoors = 270.6 m²). Because overnight air temperatures during the nesting season (March–April) in South Carolina can fall to levels considered unsafe for *M. emys*, tortoises are allowed outdoors during the day, but often moved indoors at night if conditions are unsuitable. Mulch, soil, and dried hardwood leaves are available in the enclosure for nest construction and we provide an abundance of the latter immediately prior to the nesting season. Because tortoises are often indoors during March–April, their nest mounds are likewise constructed indoors. Nest construction usually requires >30 d and the resulting mounds can be >60 cm in height. Owing to the limited space available, females often construct mounds on top of an existing nest and in the process excavate or crush the buried eggs. For this reason, we recover each clutch as soon as possible after laying (usually within 12 h) and transfer the eggs to an incubator.

We first detected signs of nesting by one of the females on 18 March 2019 after finding that a significant amount of substrate had been scraped together into a typical mound in the indoor section of the enclosure. The nesting female (505 mm straight-line carapace length) is a wild-caught individual legally imported into the USA during the late 1990s and later donated to the TSC for breeding purposes. On 19 March 2019, we observed this female drinking for longer than normal (ca. 1–2 min) at a small concrete pond in the enclosure, and then leave the pond, walk to the nest, and clamber atop the mound. Once on top of the nest, the female expelled small amounts of water from her mouth and nares onto the substrate. On 25 March 2020, we observed the same female repeat this sequence on three occasions during the day. Furthermore, at times we noticed the female engaged in what appeared to be buccal pumping while expelling water onto the mound. Although we neglected to record specific dates, the female repeated this behavior several more times between 25 March and 30 April 2019. For the most part the female otherwise

remained on top of the nest, departing only to forage in the pen or eat food provided by us, before returning to the mound. A clutch of 39 eggs was found within the mound on 1 May 2019, presumably deposited during the night of 30 April–1 May 2019.

Cloacal bladder voiding by nesting female tortoises is well-documented (Lee 1963. *Herpetologica* 19:62–65; Geffen and Mendelsshon 1991. *Herpetol. J.* 1:574–577); however, our observations appear to be the first report of buccal transport of water to a nest by *M. e. phayrei* or any other chelonian. Although we can only speculate on the functional significance of buccal water transport, cloacal bladder voiding by nesting female tortoises has been suggested to: 1) soften the substrate and facilitate nest excavation, 2) moisten the nest chamber and eggs, 3) discourage bacterial growth on the eggs, 4) deter predators through smell or taste, and 5) provide olfactory camouflage for the nest (Patterson 1971. *Herpetologica* 27:197–199). Because eggs were not present in the mound until 1 May, transferring water to the nest was unlikely to have any bacteriostatic function, nor serve as a predator deterrent or provide olfactory camouflage. Furthermore, in contrast to turtles that excavate subterranean nests in hard earthen substrates, wetting a mound of leaves and soil would seem to do little to facilitate nest construction by *M. emys*. We instead speculate the female *M. emys phayrei* deposited water on the mound to increase the moisture content of the substrate, raising the humidity within the mound prior to egg-laying. Wetting the mound could also encourage bacterial decomposition of the nest material, thereby generating heat for incubation (Magnusson 1979, *op. cit.*).

Our observations at a conservation-breeding center in Myanmar within the natural geographic range of *M. emys* indicate that nesting occurs during the same time frame as at the TSC (March–April). In Myanmar, this period coincides with last quarter of the annual dry season (Roy and Kaur 2000. *Int. J. Climatol.* 20:913–928) when the moisture content of nesting materials (soil, leaves, and grass) is minimal. For chelonians, low levels of moisture within the nest can play a greater role than temperature in determining embryonic growth and survival (Cagle et al. 1993. *Funct. Ecol.* 7:653–660). Therefore, we posit that buccal water transport is an adaptive response to the extremely dry conditions that prevail during the nesting period, driven by the need to maintain humid conditions within the nest mound.

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SQUAMATA — LIZARDS

FURCIFER LATERALIS (Carpet Chameleon). IMPACT OF ULTRAVIOLET LIGHT ON GROWTH. *Furcifer lateralis* is a small (maximum 92 mm SVL for females, 98 mm for males) chameleon that is widespread throughout eastern Madagascar (Florio et al. 2012. *J. Evol. Biol.* 25:1399–1414). In recent years, it has gained

popularity in the pet trade, due to its small size and brilliant coloration. While climatic data from some of its native range are available, *F. lateralis* naturally inhabit a wide spectrum of environments and few studies have focused on identifying optimal care parameters for raising this species in captivity.

It has long been established that many animals, including chameleons, require ultraviolet (UV) light to convert provitamin D to vitamin D₃ (Ferguson et al. 1996. *J. Zoo Biol.* 15:279–299). Vitamin D₃ is essential for calcium homeostasis and its deficiency can cause metabolic bone disease, a common disease in captive reptiles (McWilliams and Leeson 2001. *In* Edwards et al. [eds.], *Proceedings of the Fourth Conference on Zoo and Wildlife Nutrition*, pp. 120–129). While D₃ can be provided as a supplement in the diet in lieu of UV lighting, data on appropriate dosages of this fat-soluble vitamin are lacking for virtually all captive reptiles. Moreover, D₃ production in sunlight is naturally self-limiting, preventing overproduction of D₃ and resultant hypervitaminosis D when acquired via UV exposure (Baines et al. 2016. *J. Zoo Aquar. Res.* 4:42–63). The ultraviolet light index (UVI) has been utilized in modern herpetoculture to identify a scalable metric to ensure appropriate UV exposure for captive reptiles. However, UV exposure has the potential to cause cellular and DNA damage in addition to its beneficial effects on D₃ synthesis (Ravanat et al. 2001. *J. Photochem. Photobiol. B.* 63:88–102). Therefore, UV exposure must be present to facilitate appropriate D₃ synthesis but must be limited to prevent excessive cytotoxic damage. Further, improper UV availability may cause deleterious changes in behavior such as increased time spent hiding. It is not currently clear how to best simulate wild UV conditions in captivity, specifically for chameleon hatchlings or juveniles, which are difficult to study in the wild.

It has been suggested that *F. lateralis* may have lower UV requirements than other chameleon species, namely *F. pardalis* and *F. oustaleti*, despite *F. lateralis* living in sun-exposed areas in the wild (Ferguson et al. 2002. *J. Zoo Biol.* 21:525–537). Here, we raised two groups of captive-bred *F. lateralis* hatchlings, one with exposure to a maximum UVI of 3 and one with exposure to a maximum UVI of 7. Since there are no studies investigating optimal UV exposure for *F. lateralis* to draw upon, we selected a UVI level of 3 due to its effectiveness in captive rearing and breeding *F. pardalis* females, a related chameleon species (Ferguson et al. 2002, *op. cit.*; Ferguson et al. 2021. *J. Zoo Biol.* 40:150–159). On the other hand, UVI 7 is near the maximum UVI observed in habitats in Ferguson Zone 3, and in the middle of the range of UVI observed in Ferguson Zone 4, corresponding to the measured environmental UV exposures of partial or open sun basking reptiles and open sun basking reptiles respectively (Baines et al. 2016. *J. Zoo Aquar. Res.* 4:42–63). Importantly, drawing again on proposed similarities between *F. pardalis* and *F. lateralis*, *F. pardalis* were found to occupy Ferguson Zone 4 in the wild, and as such, we emulated similar UV exposure conditions in our study with UVI 7 (Ferguson et al. 2021, *op. cit.*). All animals hatched within 1–2 d of each other in May 2021 and were all from the same clutch and incubated identically. Animals were housed in groups of three, with four enclosures total used in this study (two under UVI 3, two under UVI 7). We then measured their growth rate by weighing each animal at 6 weeks, 8 weeks, and 10 weeks. Conditions were similar for both groups and consisted of an enclosure with screen mesh on top and solid expanded PVC sides, back, and bottom, with an acrylic front door (Tamura Designs, Inglewood, California). Dimensions were 25.4 cm wide × 40.6 cm tall × 45.7 cm deep, with the bottom 7.6 cm filled with

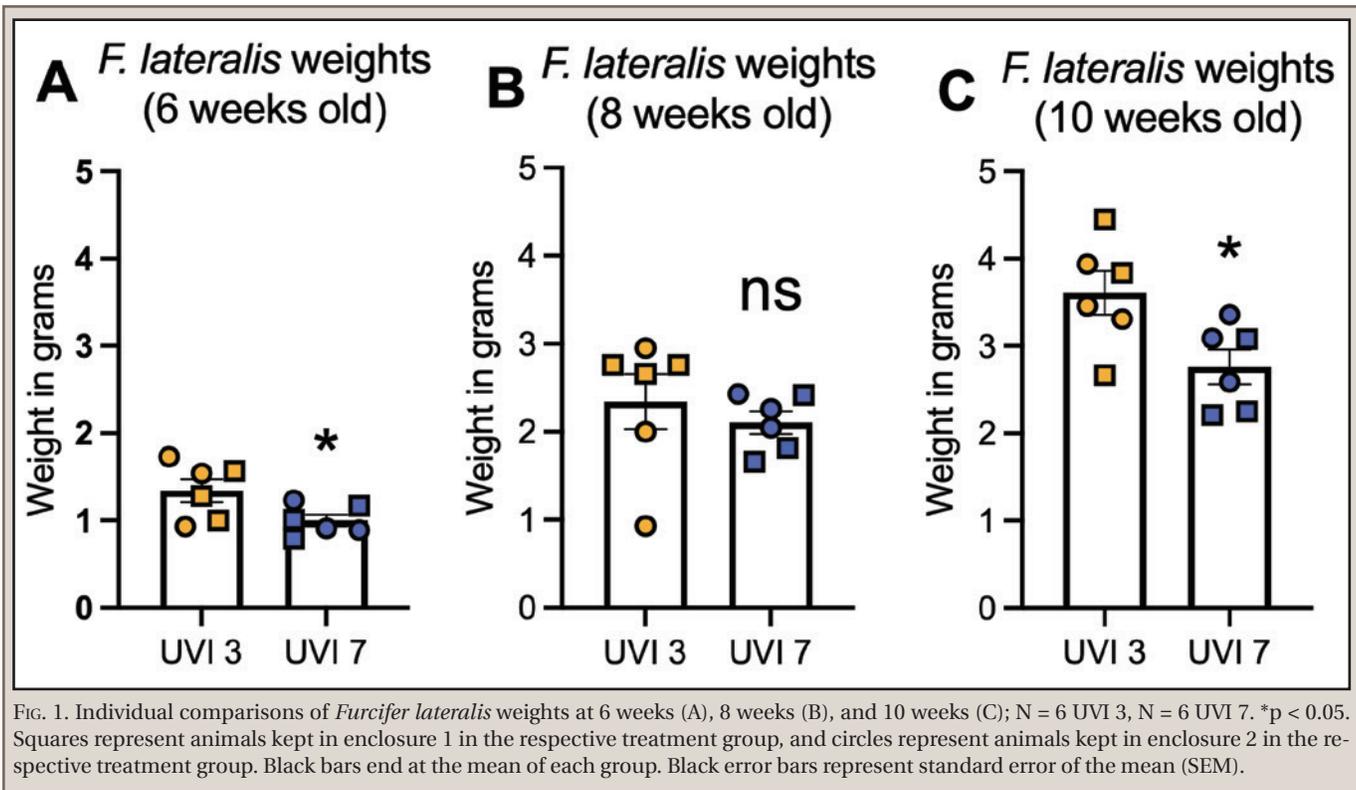


FIG. 1. Individual comparisons of *Furcifer lateralis* weights at 6 weeks (A), 8 weeks (B), and 10 weeks (C); N = 6 UVI 3, N = 6 UVI 7. * $p < 0.05$. Squares represent animals kept in enclosure 1 in the respective treatment group, and circles represent animals kept in enclosure 2 in the respective treatment group. Black bars end at the mean of each group. Black error bars represent standard error of the mean (SEM).

Atlanta Botanical Garden Mix (Josh's Frogs, Owosso, Michigan), with one small *Radermachera sinica* and various horizontal and vertical branches for perching. Lighting was provided by a dual T5 Odyssey fixture with a single reflector (Odyssey Aquarium Appliance Co., Ltd., Guangdong, China), fitted with one 6500K daylight bulb and one Reptisun 5.0 UVB bulb (Zoo Med, San Luis Obispo, California). The maximum UVI reading was measured with a Solarmeter 6.5 (Solar Light Company, LLC, Glenside, Pennsylvania) at the top of horizontal branches, which was also the highest spot in each enclosure accessible to the chameleons. The UV index below these branches was present in a gradient and decreased gradually until it reached 0 near the substrate. Further, ample hiding places were available, so animals were not forced to expose themselves to UV. UVB bulbs of different ages were used to obtain different UV strengths (approximately six months old for the UVI 3 group, two months old for the UVI 7 group). A small 20-watt halogen puck light (Hampton Bay (Home Depot, Atlanta, Georgia) was offered for basking. All lights were on from 0700–1900 h. Temperatures were identical between enclosures and treatments, although overall, varied slightly day to day depending on weather. Temperatures in the enclosures ranged from 18.8°C at the coldest, on the substrate at the bottom, to 22.2°C in the middle of the enclosures, to 23.9°C near the basking spot, and basking temperature was 27.8°C degrees. The young chameleons were fed *Drosophila hydei* fruit flies and 0.3–0.6 cm *Gryllobates sigillatus* crickets once a day, alternating between *Drosophila* and crickets every other day. *Drosophila* were reared on fruit fly culture and crickets were fed a diet of dandelion greens, oats, and bee pollen. *Drosophila* were obtained from Josh's Frogs (Owosso, Michigan) and crickets were obtained from Ghann's Crickets (Augusta, Georgia). Immediately prior to feeding, all prey items were supplemented with Zoo Med plain calcium without D_3 (San Luis Obispo, California), with a twice-monthly supplementation of Zoo Med Reptivite without

D_3 in lieu of plain calcium. Water was offered by misting system (MistKing, Ontario, Canada) once in the morning and once in the evening.

Due to the small size and fragility of neonate *F. lateralis*, we waited until week 6 to begin weighing the animals. Differences in weights were assessed via an unpaired two-tailed student's *t*-test comparing every animal in the UVI 3 group vs. every animal in the UVI 7 group, regardless of whether they were kept in the first or second enclosure in each respective UVI treatment group. By week 6, the UVI 3 group was significantly ($p < 0.05$) heavier than the UVI 7 group (Fig. 1A). At week 8, the two groups were not significantly different from one another ($p = 0.5$; Fig. 1B). At week 10, the UVI 3 group was also significantly ($p < 0.05$) heavier than the UVI 7 group (Fig. 1C). At week 10, the UVI 3 group was 23% heavier than the UVI 7 group, whereas at week 6, they were 24% heavier (Fig. 1). When animal weights from enclosure 1 vs. 2 in the UVI 3 group were compared, there were no significant differences, and the same was true for animals in the UVI 7 group (Fig. 1A–C, 2B).

Our results suggest that high UVI exposure to young *F. lateralis* may be associated with a slower growth rate from 6–10 weeks of age. Overall difference in weight between the groups was ca. 25% throughout the study (Fig. 2A), suggesting that the effects of UVI on growth rate may be consistent throughout this period of development. While average weights between the groups were not different at the 8-week timepoint, this is due to one of the juveniles in the UVI 3 group being much lighter than the others reducing the average mass and increasing the variance within the group (Fig. 1B). This individual was still lighter than the others at week 10 but had increased in mass enough to not preclude statistical significance (Fig. 1C). Whether this individual was light in weight due to an illness or other factors is not clear, as no problems in development post-10 weeks were noted. When this individual is removed from the analysis during week 8, the UVI 3

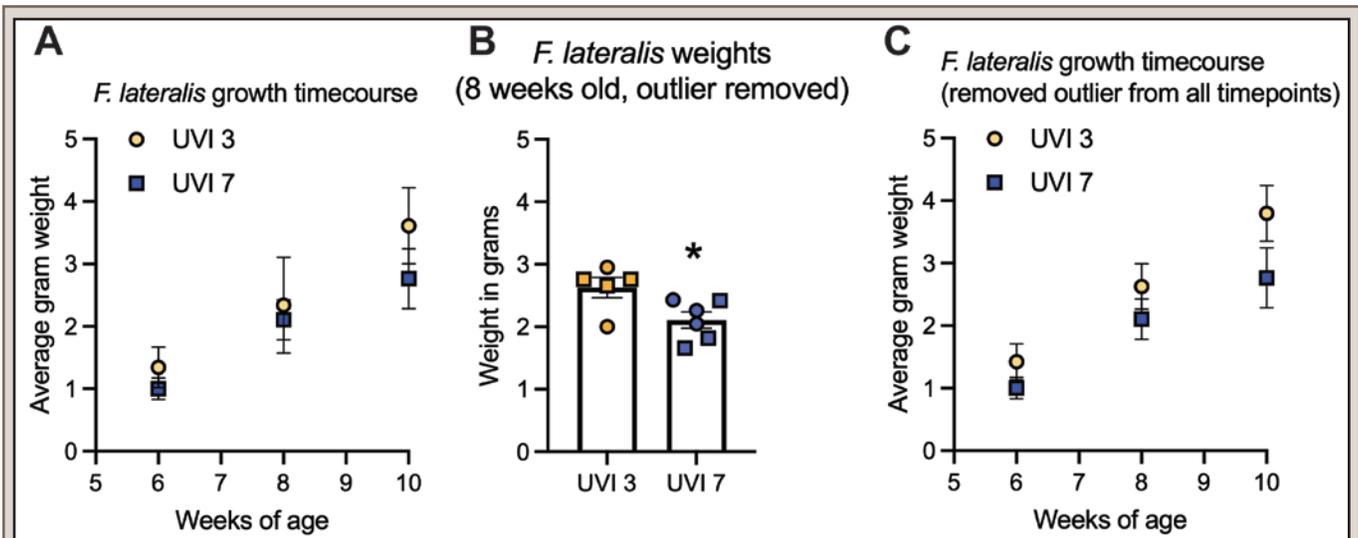


FIG. 2. A) *Furcifer lateralis* weights at 6, 8, and 10 weeks; B) weights at 8 weeks, with the lightest animal in UVI 3 group removed; squares represent animals kept in enclosure 1 in the respective treatment group, and circles represent animals kept in enclosure 2 in the respective treatment group; C) timecourse of *F. lateralis* weights at 6, 8, and 10 weeks of age, with the one outlier in UVI 3 group removed at all timepoints. Blue squares represent the mean of the UVI 7 group, and yellow circles represent the mean of the UVI 3 group. Black error bars represent SEM for each group at each timepoint. N = 6 (or 5) UVI 3, N = 6 UVI 7. * $p < 0.05$.

group is overall heavier than the UVI 7 group (Fig. 2B). Further, when this animal was removed from each timepoint, the results became more consistent (Fig. 2).

Neonate and juvenile *F. lateralis* might be more sensitive to UV light compared to adults, as reported previously in *F. pardalis* (Ferguson et al. 2002, *op. cit.*). As such, individuals in the UVI 7 group may have spent more time hiding in the foliage to limit UV exposure. All enclosures had higher ambient temperatures (due to the temperature gradient) and UV levels near the upper levels vs. the bottom, so hiding in the cooler foliage more might have ultimately led to less time spent in a warmer environment or limited the ability of individuals in the UVI 7 group to forage for food as effectively as under UVI 3 conditions, limiting growth. However, it is currently unclear whether a chameleon can voluntarily adjust its exposure to artificial sources of UV to optimize growth, reproductive success, or other aspects of its physiology (Ferguson et al. 2002, *op. cit.*; Ferguson et al. 2021, *op. cit.*). Previous research has suggested that female *F. pardalis* may not be able to regulate UV exposure under artificially high or low UV conditions, as when given ample enclosure space and hiding opportunities, female *F. pardalis* were not able to increase exposure to UV to sufficient levels for producing viable offspring (Ferguson et al. 2002, *op. cit.*). This brings to light the possibility that *F. lateralis* were unable to effectively regulate their UV exposure due to the artificial conditions provided, and that higher UV exposure may slow growth through means other than behavioral modulation of UV exposure. Despite these findings, another study demonstrated that *F. pardalis* are able to effectively regulate D_3 levels through basking in natural sunlight, in response to varying degrees of D_3 supplementation in the diet (Karsten et al. 2009. *Physiol. Biochem. Zool.* 82:218–225). Therefore, it is possible that the artificial lighting used in this study and others did not allow for the same natural behaviors that would have been present if natural sunlight were available. However, rearing chameleons outdoors is not feasible nor practical for many individuals, and as such, identifying how chameleons behave under readily available artificial UV lighting is of immense value.

Our results reinforce the practice of accounting for physiology at the species-level when identifying optimal husbandry conditions, as *F. lateralis* has previously been thought to have lower UV requirements than other chameleon species (Ferguson et al. 2002, *op. cit.*). Overall, our study suggests that high levels of UV light do not increase juvenile *F. lateralis* growth rates, supporting the use of moderate levels of UV when raising *F. lateralis*, at this early stage in development. Further work is needed to address whether higher UVI is advantageous to growth rates, longevity, or reproductive success at later or earlier developmental timepoints not assessed in this study.

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SCINCOPUS FASCIATUS (Peters's Banded Skink). REPRODUCTIVE BIOLOGY. Six genera comprise the North African skinks (family Scincidae), including *Chalcides*, *Trachylepis*, *Ablepharus*, *Eumeces*, *Scincus*, and *Scincopus*. These first three genera are relatively highly diversified and not closely related to each other. By contrast, the remaining three genera form a well-supported clade (Carranza et al. 2008. *Mol. Phyl. Evol.* 46:107–1094; Perea et al. 2012. *Afr. J. Herpetol.* 61:69–80) which is poor in species diversity, formed by six species in the genus *Eumeces*, four in *Scincus* and a single species in *Scincopus* (*S. fasciatus*). Different molecular studies have reported the paraphyly of *Eumeces*, with one of the species (*E. algeriensis*) more closely related to *Scincopus* than to the type species *E. schneideri*, suggesting that a taxonomic re-assessment of this group is needed (Perea et al. 2012, *op. cit.*).

The reproductive biology of the monospecific *Scincopus* remains unknown (Schleich et al. 1996. *Amphibians and Reptiles of North Africa*. Koeltz Sci. Books, Koenigstein. 630 pp.; Greer 2001. *J. Herpetol.* 35:383–395). Therefore, little is known about basic biological aspects of *S. fasciatus*, and despite its wide distribution across the Sahel ecoregion, from Mauritania to Sudan, and along the northern edge of the Sahara, between Morocco and western

TABLE 1. Available data on clutch size, egg size (mm), incubation, and hatchling SVL (cm) of *Eumeces algeriensis*, *E. schneideri*, *Scincus albifasciatus*, and *Scincopus fasciatus*.

Species	Clutch size	Egg size (mm)	Incubation	Hatchling SVL (cm)	Source
<i>Eumeces algeriensis</i>	3–20	40 × 22	56–63	6.2	Schoeich et al. 1996; authors pers. obs.
<i>Eumeces schneideri</i>	3–20	32 × 18	35–42	4.7–6.0	Schoeich et al. 1996; authors pers. obs.
<i>Scincus albifasciatus</i>	6	22.1 × 11.5	unknown	unknown	Schoeich et al. 1996
<i>Scincopus fasciatus</i>	4–5	25 × 13	40–45	3.5–4	This study

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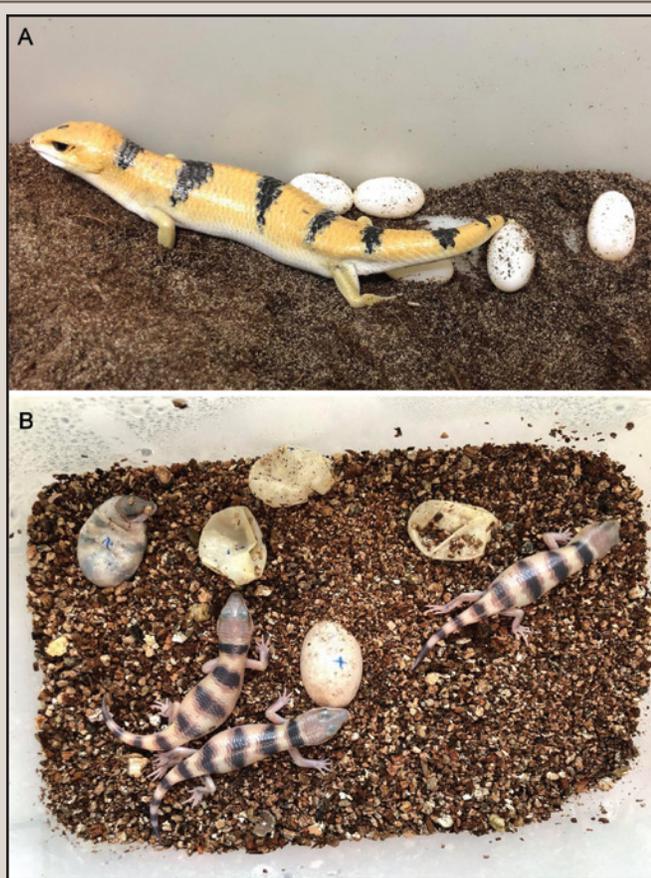


FIG. 1. A) Female *Scincopus fasciatus* laying eggs; B) eggs and hatchlings of *S. fasciatus* from a single clutch.

Libya, it represents one of the most enigmatic skink species in northern Africa. It includes two recognized subspecies: *S. f. melanocephalus*, from a single locality in Sudan, at Suakin, and *S. f. fasciatus*, distributed across the rest of the species' range.

To gain insight into the unknown reproductive biology of *S. fasciatus*, the second author acquired a male and two female *S. fasciatus* through the Chinese pet-trade in January 2017. All individuals were wild-caught in origin and were ca. 14 cm SVL. Unfortunately, their geographic origins are unknown, although most *Scincopus* available in the Asian pet-trade are collected from the West African Sahel and Sahara and shipped abroad from Togo or Egypt, which represents two major exportation hubs of African reptiles (Jensen et al. 2019. *Biodivers. Conserv.* 28:1–19; D'Cruze et al. 2020. *Nat. Conserv.* 40:65–91). As no native populations of *Scincopus* occur in Togo or Egypt, these specimens were likely collected from the neighboring Sahelian or Saharan countries and exported via Togo or Egypt, respectively (Jensen et al. 2019, *op. cit.*; D'Cruze et al. 2020, *op. cit.*).

These three specimens were housed together in a well-ventilated 60 × 30 cm plastic box with a 3 cm deep sand substrate. The enclosure was maintained at room temperature (24–27°C) without strong thermal fluctuations and natural lighting provided illumination (avoiding direct sun exposure). Diet consisted of insects, mainly *Gryllus*, *Acheta*, and *Zophobas*.

In captivity, the breeding season begins in February/March. In February 2017, one of the females laid a clutch of four eggs that resulted in deceased embryos. Copulation was first observed after a year in captivity, in February 2018. After 35 d, oviposition was observed by the same female that produced eggs the year before. On this occasion, it laid a clutch consisting of five eggs (Figs. 1A, B) with each egg measuring 25 × 13 mm. Incubation took 40–45 d in vermiculite at 32°C and 80% humidity, using an Exoterra incubator. Hatchlings emerged with a total length of around 5.5–6 cm (Fig. 1B). Their first shed occurred at around 8 d old. Juveniles grew slowly, taking almost four years to reach adult size.

Some insights on the reproductive biology of *Eumeces* and *Scincus* have been previously reported, with both being oviparous (Schleich et al. 1996, *op. cit.*). The available data on the reproduction (clutch size and incubation period) of the genus *Eumeces*, *Scincus*, and *Scincopus* are presented in Table 1. Our findings on the reproductive biology of *S. fasciatus* are congruent with that of its oviparous sister taxa, suggesting that oviparity is the ancestral state of the clade that includes the *Eumeces schneideri* group, *Scincopus* and *Scincus*.

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SQUAMATA — SNAKES

SISTRURUS CATENATUS (Eastern Massasauga). RATTLE SLIPPAGE ACCOMPANYING ECDYSIS. *Sistrurus* is a genus of small rattlesnakes, known for their diminutive rattles in which slippage-induced loss of distal segments is common in *S. miliarius* (Rowe et al. 2002. *In* Schuett et al. [eds.], *Biology of the Vipers*, pp. 385–404. Eagle Mountain Publishing, Eagle Mountain, Utah). Rowe et al. (2002, *op. cit.*) differentiated between loss of segments because of passive slippage versus traumatic breakage, attributing the former phenomenon to the reduced profile of the longitudinal groove between the first and second lobes of the segments in *S. miliarius*.



FIG. 1. Detail of terminal segment of an adult male *Sistrurus catenatus* (Zoo Atlanta #16R026) that has experienced multiple instances of rattle loss owing to breakage, but never slippage. Arrow indicates the clearly demarcated and non-reduced longitudinal groove that is more typical of species of rattlesnake with larger rattles.

I documented repeated slippage in sequential ecdysis events on 8 August 2021 and 16 September 2021 in an adult, captive-bred, female *S. catenatus* (born 2009) housed at Zoo Atlanta (Zoo Atlanta #11R006) after multiple years of normal accumulation of segments, with some obvious rattle-breakage events. In the rattle of a captive bred adult male of the same species (born 2015) housed at Zoo Atlanta (Zoo Atlanta #16R026), I observed breakage, but not slippage. The longitudinal groove appeared to be well-developed (Fig. 1) and much more substantial than the reduced description represented in *S. miliarius* and other small-bodied rattlesnakes described by Rowe et al. (2002, *op. cit.*). The longitudinal groove in the segment of the individual experiencing slippage was markedly reduced (Fig. 2) compared to the individual experiencing only breakage. This condition closely matches the description by Rowe et al. (2002, *op. cit.*) in *S. miliarius*, and I confirmed that the condition was also present in previously slipped segments, indicating that the structure likely is congenital and not a developmental anomaly appearing in adulthood.

These observations indicate individual differences in rattle-segment morphology in *S. catenatus*, leading to different pathways of rattle-loss among individuals. One can speculate that if such individual variation in rattle morphology is present in small populations (e.g., founders of the insular *Crotalus catalinensis*) they can become fixed in the population leading to high frequencies of shortened or altogether absent strings of segments.

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FIG. 2. Detail of terminal segment of an adult female *Sistrurus catenatus* (Zoo Atlanta # 11R006) that has experienced multiple instances of rattle loss owing to slippage. Arrow indicates the evidently congenital reduced longitudinal groove, likely the cause of the slippages.

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THAMNOPHIS MARCIANUS (Checkered Gartersnake). LONGEVITY. Natricines are a group consisting of both short-lived and long-lived snakes, with lifespans ranging from 2 years to more than 20 years (Biegler 1966. *Int. Zoo Yearb.* 6:487–493; Myhrvold et al. 2015. *Ecology* 96:3109). *Thamnophis marcianus* reportedly has a short lifespan with a maximum record of 7 years (Bowler 1977. *Herpetol. Circ.* 6:1–32), although this longevity data is likely out of date. This species is primarily diurnal, feeds on wide variety of prey, has a broad range in the southern United States and northern Mexico, with isolated populations in Central America (Rossman et al. 1996. *The Garter Snakes: Evolution and Ecology*. University of Oklahoma Press, Norman, Oklahoma. 332 pp.) and is one of the most common species of the genus *Thamnophis* kept in captivity.

A juvenile male albino *T. marcianus* was purchased by the author from a local reptile dealer in October 2008. The snake was kept in a simple, plastic bin enclosure (490 mm L × 320 mm W × 150 mm H). A water bowl and two hiding places were provided, and paper or aspen shavings were used as substrates. Ambient temperature was maintained within the range of 24–28°C, with a hot spot of up to 32°C. The snake's diet consisted mainly of pieces of commercially available fish, frozen-thawed pinky mice and occasionally earthworms and brown frogs (*Rana* sp.). During its life, this snake sired three litters: in 2009, 2010 and 2014. The snake was euthanized on 22 October 2020 after 12 years under the care

of the author due to suspected neoplasia and progressive body condition loss. Necropsy revealed the presence of renal tumors, with one mass located in the left kidney and two masses located in the right kidney. These tumors were previously detected by palpation as three lumps in the posterior body, which slowly increased in size and eventually became visually noticeable. Histological examination of the tumors was not performed.

The author's observations suggest that the lifespan of *T. marcianus* may exceed the previous longevity record in captivity available from the literature. Moreover, there are non-peer reviewed reports that this species could live longer than indicated in this report (www.stevenbolgartersnakes.com; 15 Feb 2022).

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THAMNOPHIS RUFIPUNCTATUS (Narrow-headed Garter-snake). LONGEVITY. There is little information available on the longevity of the federally threatened *Thamnophis rufipunctatus* in the wild or in captivity, and what is presently known is from rough approximations. Rosen and Schwalbe (1988. Unpublished report from Arizona Game and Fish Department to U.S. Fish and Wildlife Service, Albuquerque, New Mexico) suggested wild *T. rufipunctatus* may live as long as 10 years according to body size frequency distribution of captured snakes, not from mark-recaptured snakes, which may not provide a reliable longevity estimate. The oldest confirmed *T. rufipunctatus* was a marked female born at the Phoenix Zoo in 2009 which was released into an outdoor semi-wild wetland enclosure managed by the Arizona Game and Fish Department in 2014 and recaptured in the of fall 2018 at the age of nine years (Holycross et al. 2020. In Holycross and Mitchell [eds.], Snakes of Arizona, pp. 440–455. ECO Publishing, Rodeo, New Mexico). Here, we present the first longevity record for a male *T. rufipunctatus* maintained in captivity.

On 17 July 2007, a 260 mm snout–vent length (SVL) male *T. rufipunctatus* was captured from the Black River, Gila County, Arizona, USA and brought to the Phoenix Zoo as one of the founding animals for the Phoenix Zoo's managed *T. rufipunctatus* breeding program. On 7 September 2020 this snake died after 13 years, one month, and 20 days (540 mm SVL) at the Phoenix Zoo, which is three years greater than the previous longevity estimates for the species. In the wild, neonate *T. rufipunctatus* are typically born between mid-June to mid-September with SVLs ranging from 192–254 mm (Rosen and Schwalbe 1988, *op. cit.*; Holycross et al. 2020, *op. cit.*) and based on this snake's SVL and capture date it could have been born in late 2006 or June of 2007; if the former, its age would have been closer to 14 years.

Longevity would be expected to differ between wild snakes and those under human care, and our observation may not reflect longevity in the wild and should be interpreted carefully. However, there is evidence that longevity between the two conditions may be similar. For example, wild *T. elegans* have been reported to live >15 years (Sparkman et al. 2007. Proc. R. Soc. B. 274:943–950) compared to the maximum known longevity of 17.8 years under human care (Tacutu et al. 2018. Nucleic Acids Res. 46:D1083–D1090). Longevity rates are a key demographic trait that can be used to estimate population turnover rates for managed zoo-based breeding programs or in wild populations. Because *T. rufipunctatus* is the focus of an active breeding program for future wild releases this information can guide how the Phoenix Zoo's snakes are managed as they age.

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