FURCIFER LATERALIS (Carpet Chameleon). IMPACT OF ULTRAVIOLET LIGHT ON GROWTH. *F. 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 for 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 D_3 (Ferguson et al. 1996. J. Zoo Biology. 15:279–299). Vitamin D_3 is essential for calcium homeostasis and its deficiency can cause metabolic bone disease, a common disease in captive reptiles (McWilliams and Leeson 2001. Nutrition Advisory Group 19:120-129). While D_3 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, D_3 production in sunlight is naturally self-limiting, preventing overproduction of D_3 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 in order 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 D_3 synthesis (Ravanat et al. 2001. J. Photochem. Photobiol. B. 63:88–102). Therefore, UV exposure must be present to facilitate appropriate D_3 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 Biology. 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 no studies investigating optimal UV exposure for *F. lateralis* were present 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. J. Zoo Biology. 21:525–537 and Ferguson et al. 2021. J Zoo Biology. 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 and Aquarium Research. 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. J Zoo Biology. 40:150–159). All animals hatched within one to two days of each other in May of 2021 and were all from the same clutch and incubated identically. Animals were housed in groups of three, with 4 enclosures total used in this study (2 under UVI 3, 2 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, CA). Dimensions were 10" wide x 16" tall x 18" deep, with the bottom 3" filled with Atlanta Botanical Garden Mix (Josh's Frogs, Owosoo, MI), with one small *Radermachera sinica* plant and various horizontal and vertical branches for perching. Lighting was provided by a dual T5 Odyssea fixture with a single reflector (Odyssea Aquarium Appliance Co., Ldt., Guangdong, China), fitted with one 6500K daylight bulb and one Reptisun 5.0 UVB bulb (Zoo Med, San Luis Obispo, CA). The maximum UVI reading was measured with a Solarmeter 6.5 (Solar Light Company, LLC, Glenside, PA) at the top of horizontal branches, which was also the highest spot in each enclosure accessible to the chameleons. 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, GA) 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 1/8–1/4" *Gryllodes sigillatus* crickets once a day, alternating between *Drosophila* and crickets every other day. *Drosophila* were reared on fruit fly culture from Josh's Frogs (Owosso, MI) and crickets were fed a diet of dandelion greens, oats, and bee pollen. *Drosophila* were obtained from Josh's Frogs and crickets were obtained from Ghann's crickets (Augusta, GA). Immediately prior to feeding, all prey items were supplemented with Zoo Med plain calcium without D_3 (San Luis Obispo, CA), 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, b, 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 approximately 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 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 *Furcifer pardalis (*Ferguson et al. 2002. J. Zoo Biology. 21:525–537). 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. J. Zoo Biology. 21:525–537 and Ferguson et al. 2021. J Zoo Biology. 40(2):150–159). Previous research has suggested that female *Furcifer 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. J. Zoo Biology. 21:525–537). 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. J. Zoo Biology. 21:525–537). 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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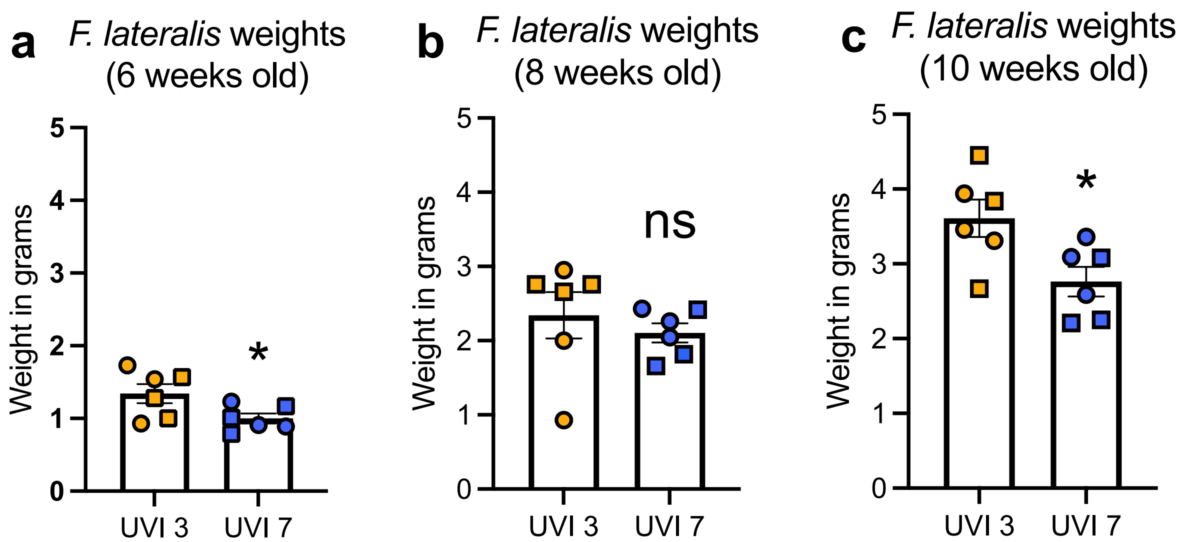

FIG. 1. Individual comparisons of *F. lateralis* weights at 6 weeks (**a**), 8 weeks (**b**), and 10 weeks (**c**); N = 6 UVI 3, N = 6 UVI 7. **P* < 0.05. Squares represent animals kept in enclosure 1 in the respective treatment group, and circles represent animals kept in enclosure 2 in the respective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

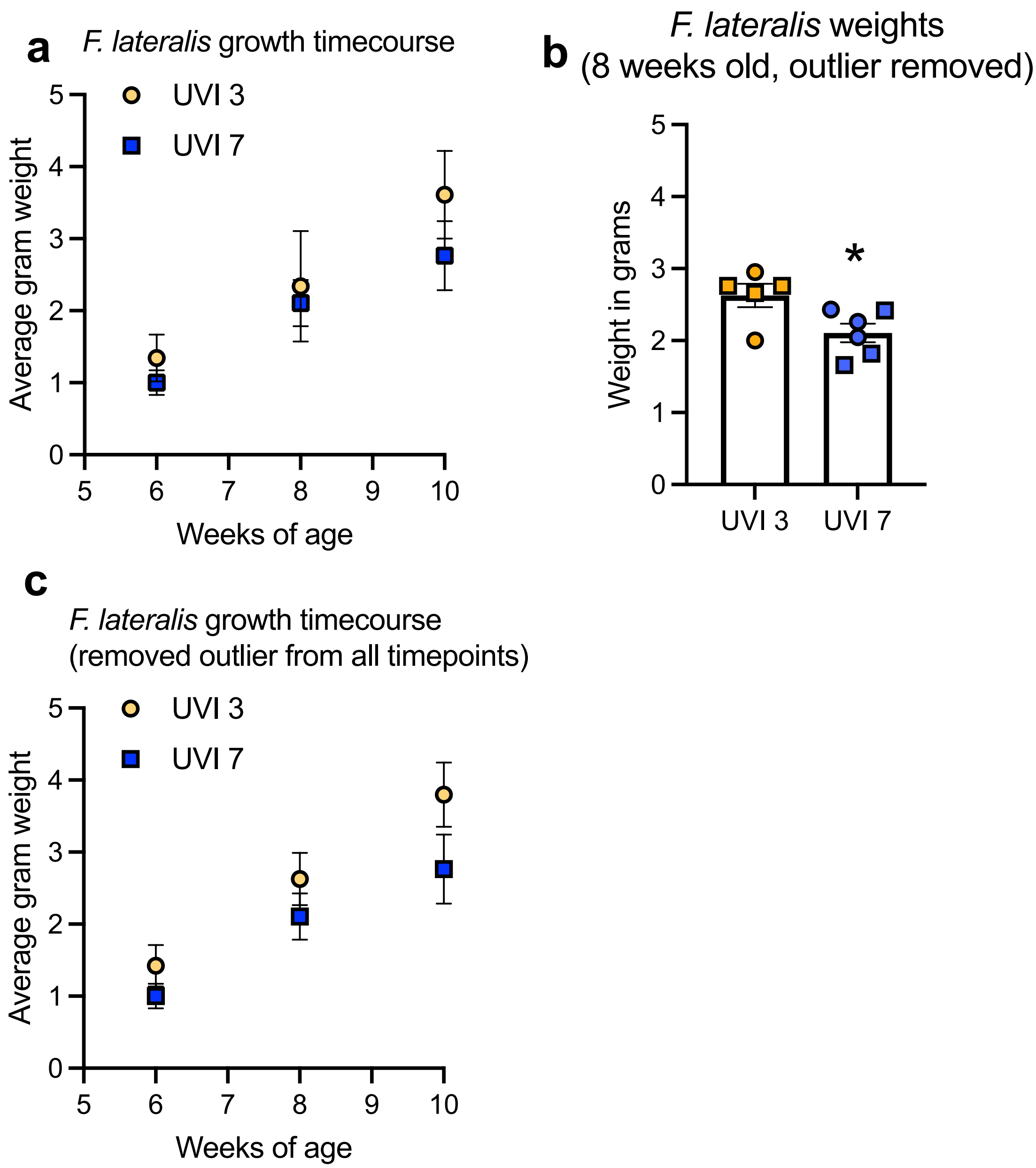

FIG. 2. *F. lateralis* weights at 6, 8, and 10 weeks (**a**). Weights at 8 weeks, with the lightest animal in UVI 3 group removed; squares represent animals kept in enclosure 1 in the respective treatment group, and circles represent animals kept in enclosure 2 in the respective treatment group (**b**). 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 (**c**). 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 N= 5 UVI 3, N= 6 UVI 7. *$P < 0.05$.