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The Effect of Temperature on Weight Gain in Hatchling Mexican Kingsnakes, *Lampropeltis mexicana*

Temperature is an important component of microhabitat selection (Burger 1991) as well as influencing both behavioral and physiological changes in reptiles (Brattstrom 1965; Fitch 1968). Individuals within a species may seek various substrate temperatures based on sex, life stage, or reproductive status (Aldridge 1975; Blazquez 1995). Growth of neonates often is associated with increased energy demands (Bronikowski 2000; Bronikowski and Arnold 1999; Bronikowski and Vleck 2010; Case 1978). Consequently, neonates are thought to seek temperatures in the warmer extents of their range to facilitate more rapid growth (Dorcas 2004). However, evidence suggests both genetics and locality can both impact growth rate (Bronikowski 2000).

Thermal variation in high-elevation environments makes montane snake species an interesting group on which to conduct thermal studies. Such montane species can be found within the *Lampropeltis mexicana* complex, a popular animal in reptile husbandry where most successful breeders recommend a substantial thermal gradient (Lassiter 2012). Widely distributed, but comprised of locally isolated groups, the *Lampropeltis mexicana* complex is currently in a taxonomic state of flux with various species and subspecies designations often in contradiction with one another (Bryson et al. 2005; Bryson et al. 2007; Gartska 1982). In general, Mexicana populations are found in high-elevation environments where great fluctuations in temperature are commonplace (Bryson et al. 2007; Gartska 1982).

Given the thermal characteristics of their habitats and their prevalence in reptile husbandry, we exposed hatchling Variable Kingsnakes, *L. m. thayeri*, to two temperature regimes to investigate the impact of temperature on feeding rates, growth rates, weight gain, and efficiency of biomass accumulation.

Materials and Methods.—Each snake was placed into a container (33 L × 20 W × 12.7 cm H) containing an identical setup: a water dish, hide box containing approximately 2.5 cm of sphagnum moss (ZooMed Laboratories), and aspen cage bedding (ZooMed Laboratories) approximately 2.5–5 cm in depth. The cages had four ventilation holes drilled through each side and three on the lid. Each cage was placed into a larger cage set up (Boaphile Plastics) that contained under-cage heating tape. Temperatures were maintained within 0.6°C using two thermostats set for treatment specific temperatures (Ranco Model #ETC-111000). Data loggers (HOBO TEMP Loggers; ± 0.5°C) were used to ensure consistency within treatment groups and to quantify any variation from the programmed temperature.

Samples sizes totaled 11 hatchling snakes with 9 individuals from the same clutch and 2 from other captive clutches. Individual snakes were assigned to one of two groups ($N_{group1} = 5$, $N_{group2} = 6$) to minimize potential impacts of any differences associated with initial weights (± 0.04 g starting difference between treatments). Based upon recommended thermal gradients for the species in captivity (Lassiter 2012), we chose two treatment temperatures (23.3°C and 28.9°C). Once placed in the treatments the snakes were fed commercially obtained, frozen and thawed mice (Big Cheese Rodent Factory; 4.5 ± 3 g) twice a week, with a 3 or 4-day period between feedings. Prior to the first feeding each week, the snakes were weighed (O'Haus Adventurer balance: ± 0.002 g). Mice were left in the cages overnight and removed the next day if uneaten. Measurements were taken on the snakes from 1 Dec 2010 to 28 Mar 2011 (27 total feeding opportunities and 14 weight measurements). The process was repeated from 28 Mar 2011 to 18 Jul 2011 (27 total feeding opportunities and 15 weight measurements) with the animals switched between treatments (ex. 23.3°C is now 28.9°C, and vice versa) to minimize potential bias associated with inherent differences among individual snakes.

Throughout the experiment, cages were spot cleaned and provided with fresh water as needed. Monthly bedding changes occurred with the cleaning of all cage materials (Chlorohexidine solution).

Using repeated measures ANOVA, we evaluated the impact of both time series and temperature on weight gain. Using simple linear regression, we generated growth equations for each period and treatment and compared the slopes. Finally, we compared amount of prey refusals between treatments using a G-test while we compared the ratio of weight consumed to weight added between treatments.

Results.—Data were collected on 11 hatchling kingsnakes from 01 Dec 2010 to 18 Jul 2011, resulting in a total of 927 weight measurements taken and 14 and 15 weighings per snake per treatment (Table 1). Initial and final hatchling weights did not differ for either period (Table 2). There is an risk associated with live prey capture that would impact wild populations. Similar growth rates with the observed fewer feedings in colder temperature may better suggest optima. Growth rates for our study

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are greater than those reported by Gartska (1982) over a 2.5-year period for *L. alterna* females, suggesting a difference in growth rate over time, species differences, or different feeding regimes. Furthermore, possible costs associated with increased growth rates have been documented in many ectotherms (Gotthard 2001; Sibly and Atkinson 1994).

Our results may also have implications for husbandry. No detectable differences between temperatures suggest reptile keepers of the Mexicana kingsnakes may be able to conserve financial and logistic resources without negatively impacting growth rates of hatchlings. However, hatchling refusal of prey has been reported with this species and decreased temperature increased this propensity in our study. Furthermore, it is unknown whether the increase in efficiency of weight gain in period 2 was a consequence of the physiology of the animals or a component of increased mass of the prey items.

The sample size of our study, as well as switching snakes between temperatures, merit caution when interpreting our results. We suggest future studies maintain snakes in the same temperature for the duration of the experiment. Although the majority of our snakes were from the same clutch, our study suggests individual variation was minimal among snakes despite the presence of an outlier. We feel a study or numerous studies could be conducted on captive populations to examine the impact of faster growth rates on other aspects of individual fitness and call for increased collaborative, large-scale experiments involving both scientists and those involved in reptile husbandry.

Table 1. Summary weight gain data on 11 hatchling Mexican Kingsnakes during a captive study. Temperature, Initial Weight (g), Final Weight (g), Growth Rate (g/day), Ratio (grams of intake/1 g growth) for individual snakes in each time.

	Period 1					Period 2				
Snake ID	Temp (°F)	Initial Weight	Final Weight	Growth Rate	Ratio	Temp (°F)	Initial Weight	Final Weight	Growth Rate	Ratio
1	84	13.16	39.05	0.24	2.82	74	39.05	70.97	0.23	2.28
2	74	17.74	35.48	0.14	3.01	84	35.48	88.90	0.48	2.46
3	84	19.91	41.26	0.20	3.47	74	41.26	93.28	0.45	2.27
4	84	19.65	46.15	0.23	2.82	74	46.15	102.80	0.45	2.21
5	74	17.22	42.87	0.22	2.67	84	42.87	97.55	0.51	2.53
6	74	20.50	45.66	0.21	2.69	84	45.66	106.06	0.57	2.21
7	84	15.22	36.66	0.19	3.41	74	36.66	70.76	0.27	3.04
8	84	18.25	45.43	0.23	2.95	74	45.43	105.28	0.57	2.43
9	84	14.95	40.77	0.22	2.87	74	40.77	83.11	0.37	2.85
10	74	14.38	43.64	0.26	2.86	84	43.64	88.65	0.42	2.97
11	74	14.67	20.07	0.05	6.03	84	20.07	63.13	0.43	2.54

Table 2. Summary weight data (mean ± std. dev.) at the beginning and end of treatments in a study of hatchling growth rates at different temperatures for a six-month period.

	Period 1		Period 2	
Temperature	Begin	End	Begin	End
28.9°C	16.86 ± 2.79 g	41.55 ± 3.66 g	39.58 ± 12.13 g	87.70 ± 15.21 g
23.3°C	16.90 ± 1.12 g	37.54 ± 10.50 g	43.71 ± 4.09 g	88.86 ± 16.07 g

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ART IN HERPETOLOGY

IN THE LARDER.

The inclusion of the Diamondback Terrapin (*Malaclemys terrapin*), or saltwater terrapin, as a New World dietary staple dates back to the arrival of European colonists in the United States in Maryland and Virginia in the late 1500s. In the United States' early years, Diamondback Terrapins were so abundant and inexpensive they were purportedly fed to pigs and, in the Chesapeake Bay region, to servants and slaves to such excess that this practice led to a slave rebellion in the 1700s. But by the 1800s, the Diamondback Terrapin became a staple in the well-to-do's larder, attaining a gourmet status in such dishes as Terrapin Maryland and Terrapin Philadelphia. The culinary status of the diamondback was brought to life in an illustrated plate prepared for the article "Canvas-Back and Terrapin," featured in an 1877 issue of *Scribner's Monthly*. The illustration in question, *In the Larder*, depicts two terrapins—one balanced atop the foot of a wine glass, the other upside-down—surrounded by the finer things in life: oysters, canvas-back ducks, a box of Flor Fina cigars, a case of Bordeaux wine from the Château Pontet-Canet. To meet this demand for terrapins, diamondbacks were collected all along the Eastern Seaboard and the Gulf Coast. Those collected from northern waters were allegedly more flavorful and considered superior to their southern cousins. "Chesapeakes" (or "Delawares") from the Delaware and Chesapeake bays commanded a higher price than did "Southerns" from North and South Carolina southward. That didn't prevent shippers and their middle-men, however, from "relocating" southern Diamondback Terrapins to more northerly latitudes, mixing them with their Chesapeake stock, and then selling the ensemble as "Chesapeakes."

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