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Letter to the Editor

Thermophilic response to feeding in adult female velvet geckos

Buddhi Dayananda[a,b,*] and Jonathan K. Webb[a]

[a]School of Life Sciences, University of Technology Sydney, Broadway, NSW 2007, Australia and [b]School of Agriculture and Food Sciences, The University of Queensland, Brisbane, QLD 4072, Australia

*Address correspondence to Buddhi Dayananda. E-mail: b.dayananda@uq.edu.au

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Fluctuations in food availability occur in many ecosystems and pose challenges to the organisms that inhabit them (Berg et al. 2017). Because lizards have significantly lower field metabolic rates than endotherms, they are often considered "low energy specialists" that can cope with food shortages (Brown and Griffin 2005). However, active reptiles that maintain high body temperatures during periods of low prey availability can still incur significant energetic costs because metabolic rates scale with body temperature. To reduce these energetic costs, some reptile species select lower body temperatures and/or reduce their activity levels when food is scarce (Angilletta 2009). While the adaptations of lizards to seasonal food shortages are reasonably well documented (Berg et al. 2017), the thermoregulatory responses of lizards to short-term food shortages are less well studied (Brown and Griffin 2005). According to an energetic model of temperature regulation, the body temperature under which net energy gain is maximized is higher for high food availability than for low food availability; therefore, lizards ought to select lower temperatures when food is scarce to maximize their net energy gain (Huey 1982). However, this model only considers energetic costs. That is, selection of lower body temperatures may involve costs associated with a reduction in performance of other fitness-enhancing activities, such as locomotion. In some species, individuals may maintain high body temperatures during fasting in order to carry out important fitness-related activities such as defending territories or searching for mates. For example, male spiny lizards *Sceloporus jarrovi* maintained high body temperatures during periods of fasting, presumably because the maintenance of higher body temperatures facilitated important functions such as territory defence and predator escape behaviors (Schuler et al. 2011). Thus, the degree to which ectotherms depress body temperatures during periods of low prey availability will depend on both the energetic and non-energetic costs and benefits of thermoregulation (Huey 1982; Angilletta 2009). At present, it is unclear whether the thermoregulatory strategies of many lizard species are influenced by food availability (Brown and Griffin 2005; Angilletta 2009).

In this study, we investigated the effect of fasting on thermoregulation by females of the nocturnal gecko *Amalosia lesueurii*. One week after the females had laid eggs, we fasted them for 5 days, fitted them with miniature data loggers, and then measured their preferred body temperatures in a cost-free thermal gradient (10–50°C). We then fed the lizards with live crickets *ad libatum*, and recorded their body temperatures within the same thermal gradient for 24 h (see Supplementary Material). We found that females maintained lower body temperatures after fasting (mean = 23.6°C, standard deviation [SD] = 0.30) than they did following food consumption (mean = 26.3°C, SD = 0.64 paired *t*-test, $t_{31} = -20.30$, $P < 0.001$, Figure 1). While fasting, lizards also maintained a narrower set-point temperature range (22.4–25.2°C) than they did after feeding (24.0–28.7°C). Lizards also attained higher maximum temperatures after feeding (mean = 33.4°C) than during fasting (mean = 28.2°C; $t_{31} = -28.0$, $P < 0.001$), but mean minimum temperatures of lizards were similar (17.1°C vs. 17.4°C, $t_{31} = -0.607$, $P = 0.55$). Repeated measures ANOVA revealed that body temperature was influenced by food consumption ($F_{1,31} = 376.03$, $P < 0.001$), time of day ($F_{1,31} = 258.71$, $P < 0.001$), and hour of the day ($F_{23,713} = 4.51$, $P < 0.001$). Body temperatures of lizards were higher during the day than at night, irrespective of their feeding status (Figure 1). Mean diurnal and nocturnal body temperatures, and associated set-point temperatures, were 27.4°C (25.2–29.7°C) and 25.3°C (22.9–27.6°C) for fed lizards respectively, and 24.3°C (23.1–25.9°C) and 23.0°C (22.0–24.4°C) for fasting lizards, respectively. Based on the thermal performance of sprint speed for adult females (Dayananda et al. 2017), fasted lizards maintained diurnal temperatures that would allow them to sprint at 91% of their maximal sprinting capacity (Figure 1).

Our results demonstrate that in a cost-free thermal gradient, female velvet geckos selected higher body temperatures after feeding
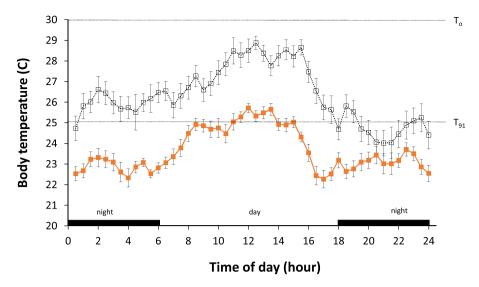
Figure 1. Mean body temperatures of 32 adult female velvet geckos in a thermal gradient during fasting (closed squares, solid line) and following feeding (open squares, dotted line). Horizontal dotted lines show the performance breadth for sprint speed, where T_o is the optimal temperature for sprinting, and T_{91} is the temperature at which sprint speed is 91% of the maximum. Data for sprint speed were taken from Dayananda et al. (2017).

than when fasting. Selection of higher body temperatures after feeding likely maximizes digestive efficiency and rates of energy assimilation (Angilletta 2009). Potentially, increases in postprandial metabolism resulting from specific dynamic action may have elevated body temperatures of female geckos after feeding, as occurs in some small lizards (Brown and Au 2009). The thermophilic response to feeding recorded in geckos (mean increase of 2.7°C) is higher than that recorded in other lizard species that were fasted 5 days or longer and showed only subtle increases in body temperature (Brown and Griffin 2005). Thus, thermophilic responses to feeding may well depend on a species' activity temperatures relative to optimal temperatures for digestion and the ecological costs associated with thermoregulation (Wall and Shine 2008; Schuler et al. 2011). For example, species that rely on crypsis (ambush foragers) may not alter temperatures following feeding due to the increase in predation risk associated with movement (Wall and Shine 2008).

Irrespective of their feeding status, geckos selected higher body temperatures during the day time than at night (Figure 1). This diel pattern in T_b variation has been observed in other gecko species in the field (Nordberg and Schwarzkopf 2019), and may reflect an endogenous circadian rhythm for thermoregulation or activity (Tawa et al. 2014). Interestingly, after fasting, geckos maintained lower nighttime temperatures, suggesting that they were either more active or voluntarily chose lower temperatures to save energy (Huey 1982). However, the reason why fasting individuals elevated their body temperatures above nighttime temperatures by day is less clear. Potentially, selection of daytime temperatures may represent a trade-off between conserving energy and minimizing ecological costs (Angilletta 2009). Although female *A. lesueurii* have broad performance curves (Dayananda et al. 2017), daytime temperatures selected by fasting geckos would still permit individuals to sprint at 91% of their maximum speed (Figure 1). Thus, fasting females might increase their body temperatures during the day to facilitate predator escape or to maximize the chances of capturing prey. Studies on thermoregulation by other gecko species in the laboratory in response to food shortages, and in field active geckos, would help to evaluate the generality of the patterns observed in this study.

Supplementary Material

Supplementary material can be found at https://academic.oup.com/cz.

References

Angilletta MJ, 2009. *Thermal Adaptation: A Theoretical and Empirical Synthesis*. New York: Oxford University Press.

Berg W, Theisinger O, Dausmann KH, 2017. Acclimatization patterns in tropical reptiles: uncoupling temperature and energetics. *Sci Nat* **104**:91.

Brown RP, Au T, 2009. The influence of metabolic heat production on body temperature of a small lizard, Anolis carolinensis. *Comp Biochem Physiol Part A: Mol Integr Physiol* **153**: 181–184.

Brown RP, Griffin S, 2005. Lower selected body temperatures after food deprivation in the lizard *Anolis carolinensis*. *J Therm Biol* **30**:79–83.

Dayananda B, Ibarguengoytia N, Whiting MJ, Webb JK, 2017. Effects of pregnancy on body temperature and locomotor performance of velvet geckos. *J Therm Biol* **65**:64–68.

Huey RB, 1982. Temperature, physiology, and the ecology of reptiles. In: Gans C, Pough H, editors. *Biology of the Reptilia*. London: Academic Press. 25–91.

Nordberg EJ, Schwarzkopf L, 2019. Heat seekers: a tropical nocturnal lizard uses behavioral thermoregulation to exploit rare microclimates at night. *J Therm Biol* **82**:107–114.

Schuler MS, Sears MW, Angilletta MJ, 2011. Food consumption does not affect the preferred body temperature of Yarrow's spiny lizard (*Sceloporus jarrovi*). *J Therm Biol* **36**:112–115.

Tawa Y, Jono T, Numata H, 2014. Circadian and temperature control of activity in Schlegel's Japanese gecko, *Gekko japonicus* (Reptilia: Squamata: Gekkonidae). *Curr Herpetol* **33**:121–128.

Wall M, Shine R, 2008. Post-feeding thermophily in lizards (*Lialis burtonis* Gray, Pygopodidae): laboratory studies can provide misleading results. *J Therm Biol* **33**:274–279.