# Body Temperature Variation in Free-Ranging Hognose Snakes (*Heterodon platirhinos*)

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Abstract.—Body temperatures ($T_b$) of eight free-ranging *Heterodon platirhinos* were measured with radiotelemetry throughout the year. Body temperature ranged from 5–37°C and varied with air temperature and activity. During the active season, $T_b$ of active snakes (~30.5°C) averaged about 3°C higher than that of inactive snakes (~27.4°C). Body temperature did not differ between the sexes or between resident and nonresident snakes. At air temperatures below 30°C, $T_b$ averaged ~3°C above air temperature; at air temperatures above 30°C, $T_b$ averaged ~0.2°C below air temperature. Basking appears to be important in the thermal ecology of *H. platirhinos*. Body temperature of free-ranging active *H. platirhinos* monitored with radiotelemetry was similar to previous reports on $T_b$s of active *H. platirhinos* measured with cloacal thermometers. A thorough knowledge of basic thermal requirements of *H. platirhinos* may be useful in its conservation.

The physiology of reptiles is affected by body temperature ($T_b$), which, in turn, influences behavior and ecology. The ability to maintain a $T_b$ within a certain range by behavioral thermoregulation is an important proximate factor affecting habitat selection by diurnal terrestrial snakes, especially in temperate climates (Reinert, 1993; Blouin-Demers and Weatherhead, 2001, 2002; Row and Blouin-Demers, 2006). Thus, a thorough understanding of the distribution and abundance of snakes requires knowledge of how $T_b$ varies under natural conditions in a wide range of taxa (Peterson et al., 1993). Unfortunately, basic thermal information is poorly known for approximately 95% of snake species (Peterson et al., 1993) including the Eastern Hognose Snake, *Heterodon platirhinos*.

*Heterodon platirhinos* is a diurnal species that prefers open grassy habitats on sandy well-drained soils (Platt, 1969; Ernst and Barbour, 1989; Plummer and Mills, 2000; Seburn, 2009). Limited $T_b$ data on *H. platirhinos* collected opportunistically with cloacal thermometers are available on both free-ranging (Platt, 1969) and captive snakes (Kitchell, 1969; Smith, 1976), but repeated $T_b$ measurements on free-living individual *H. platirhinos*, which would provide greater insight into their thermal ecology, are unavailable. Cunnington et al. (2008) collected $T_b$s on 20 radio-tracked *H. platirhinos* but did not provide descriptive statistics of the $T_b$ data. In this paper, we use radiotelemetric $T_b$ data collected incidental to habitat and movement studies on *H. platirhinos* (Plummer and Mills, 2000) to analyze body temperature variation in free-ranging *H. platirhinos* throughout the year. Body temperature data may be useful in conservation efforts for *H. platirhinos*, a species of conservation concern in some parts of its range (Seburn, 2009).

## MATERIALS AND METHODS

This study took place on approximately 250 ha bordering the Little Red River 5 km north of Searcy, White County, Arkansas. Topography is mostly hilly and varies in elevation from approximately 60–120 m above sea level. Soils are loose, sandy, thin, and often rocky. The stunted vegetation of the xeric higher areas is upland deciduous woodland, whereas that of the more mesic lower areas is upland deciduous forest (Foti et al., 1994). Numerous natural and human-made grassy openings and edges provide habitats preferred by *H. platirhinos* (Plummer and Mills, 2000).

Temperature-sensitive transmitters (Telonics CHP-2P) were calibrated in water baths and implanted into recently captured *H. platirhinos* following the procedures of Reinert (1992). All snakes were assumed to be adults based on Platt's (1969) estimates for minimum snout–vent length (SVL) at maturity (males, 45 cm; females, 50 cm). Transmitter mass ranged from 3–6% of snake body mass. Snakes were released in the field and tracked daily during the activity season and 1–3 times per week during the nonactive months. Each time a snake was tracked, we recorded its location, habitat, activity (active = visibly crawling, mating, eating, outstretched, or tightly coiled in the open; inactive = loosely or tightly coiled under groundcover and not visible from above), and air temperature 1 m above the snake. To obtain $T_b$s, we counted transmitter pulses for 30 sec and later converted the counts to °C using previously determined calibration equations.

In our initial study examining the habitat use and behavioral ecology of *H. platirhinos* (Plummer and Mills, 2000), eight resident snakes and eight nonresident snakes (collected offsite in White County, Arkansas, and introduced onto the study site) were tracked from 1992–94. Because we wanted to compare $T_b$s of active and inactive snakes in this paper, we included snakes tracked during the activity season for which we had at least five $T_b$s when both active and inactive. This criterion excluded snakes that were either implanted with nontemperature-sensing transmitters (two snakes) or for which we had inadequate $T_b$ data (six snakes). Consequently, the results in this paper are based on data collected from five resident snakes (three males; two females) and three nonresident females.

The nonresident snakes captured offsite and translocated to the study area moved abnormally and suffered higher mortality compared to the resident snakes (Plummer and Mills, 2000). We hypothesized that the nonresident snakes might also demonstrate

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atypical variation in $T_b$. To determine whether $T_b$ variation in the nonresidents was atypical, we compared $T_b$s of resident and nonresident snakes on days for which we had $T_b$ data on both groups and on which the snakes could have achieved sustained activity $T_b$s. Conservatively, we estimated these days to be activity season days when $T_{air}$ was between 20°C and 30°C (Platt, 1969).

Data were analyzed with SYSTAT 12 (SYSTAT Software, Inc., Richmond, CA). We calculated mean $T_b$s for each of the eight snakes and used the means as independent data points for testing hypotheses between groups. We used paired $t$-tests and independent samples $t$-tests to measure differences between means when the assumptions of normality and homogeneity of variances were met; otherwise, we used nonparametric Wilcoxon Tests. Although a repeated-measures ANOVA was the preferable analysis for our data, we were unable to use this analysis because of unequal sample sizes resulting from missing data for specific time periods in six of the eight snakes. We chose a 30°C breakpoint to compare $T_b$ and $T_{air}$ because 30°C is a common preferred $T_b$ for many snakes (Lillywhite, 1987). Normality was assessed with Komolgorov-Smirnov tests. Alpha was 0.05. Descriptive statistics are given as mean ± SE.

## RESULTS

A total of 1,019 $T_b$s was recorded from eight snakes in 1992–94 (Table 1). Over the course of a year, mean $T_b$ varied with $T_{air}$ (Fig. 1) and ranged from 4.9–37.1°C. A total of 820 $T_b$s was recorded from mid-April to mid-October (Table 1), the normal activity season for *H. platirhinos* at this locality (Plummer and Mills, 2000), during which monthly (April to October) mean $T_{air}$ exceeded 20°C (Fig. 1) and $T_b$ averaged 28.1 ± 0.69°C. Mean $T_b$ of resident and nonresident snakes were statistically identical (resident, 28.0 ± 0.97 °C, range 24.5–30.1°C; nonresident, 28.3 ± 1.10°C, range 26.1–29.5°C; $t_6 = -0.171$, $P = 0.870$); thus, we pooled resident and nonresident $T_b$ data for further analyses. Active snakes maintained $T_b$s approximately 3°C higher than when inactive (active 30.5 ± 0.59°C, inactive 27.4 ± 0.73°C; paired $t_7 = 8.920$, $P < 0.001$). Body temperatures of males and females did not differ ($t_6 = 0.321$, $P = 0.759$); no female was known to be gravid during the course of the study.

The distribution of $T_b$s was skewed toward lower temperatures ($K$-$S_{820} = 0.061$, $P < 0.001$). At $T_{air}$ less than or equal to the mean $T_b$ for activity (≤30°C), the difference between $T_b$ and $T_{air}$ averaged 2.90 ± 0.802°C ($N = 8$) above $T_{air}$, whereas at higher $T_{air}$ (>30°C), mostly in July and August (Fig. 1), the difference between $T_b$ and $T_{air}$ averaged 0.18 ± 0.850 ($N = 8$) below $T_{air}$. The temperature differences between $T_b$ and $T_{air}$ at $T_{air} \leq 30$°C and $T_{air} > 30$°C were significantly different ($Z = 2.380$; $P = 0.017$; $N = 8$). Significant within-group differences existed between $T_b$ and $T_{air}$ when $T_{air} \leq 30$°C ($Z = -14.60$, $P < 0.001$; $N = 635$) and when $T_{air} > 30$°C ($Z = 4.11$, $P < 0.001$; $N = 186$). Variation in mean active $T_b$ was relatively low among individuals (Coefficient of Variation = 5.4%). $T_{air}$ explained only 36.9% ($r^2$; $P < 0.001$) of the variation in $T_b$.

We observed 49 cases during the activity season in which *H. platirhinos* were tightly coiled, fully exposed

TABLE 1. Body temperatures of *Heterodon platirhinos*. Shown are snake number, sex, SVL (cm), status, dates tracked, and total number of $T_b$s measured over the tracking dates. Also shown are $T_b$s (°C) of active, inactive, and all snakes measured during the activity season. Descriptive statistics are mean ± SE (N).

| No. | Sex | SVL | Status | Dates tracked | N $T_b$s | $T_b$s during the activity season | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | | | | Active | Inactive | All |
| 1 | F | 67.0 | resident | 04/15/92–10/08/93 | 324 | 30.4 ± 0.58 (32) | 27.2 ± 0.32 (206) | 27.6 ± 0.30 (238) |
| 2 | F | 76.0 | nonresident | 05/13/92–06/25/92 | 43 | 28.8 ± 1.31 (11) | 25.2 ± 0.76 (32) | 26.1 ± 0.69 (43) |
| 6 | M | 58.0 | resident | 04/15/93–10/15/94 | 231 | 32.3 ± 0.73 (18) | 28.6 ± 0.29 (190) | 28.9 ± 0.28 (208) |
| 7 | F | 61.0 | resident | 05/06/93–07/03/93 | 58 | 30.9 ± 0.88 (12) | 28.7 ± 0.76 (46) | 29.1 ± 0.64 (58) |
| 8 | M | 49.0 | resident | 04/22/93–08/26/94 | 174 | 27.4 ± 0.51 (29) | 23.5 ± 0.39 (101) | 24.5 ± 0.35 (130) |
| 10 | F | 69.0 | nonresident | 07/02/93–04/29/94 | 59 | 32.0 ± 1.95 (6) | 27.3 ± 1.70 (7) | 29.5 ± 1.40 (13) |
| 11 | M | 47.5 | resident | 04/29/93–10/15/93 | 78 | 31.4 ± 0.91 (24) | 29.5 ± 0.63 (54) | 30.1 ± 0.53 (78) |
| 12 | F | 73.0 | nonresident | 05/21/92–07/12/92 | 52 | 31.1 ± 1.38 (8) | 29.0 ± 0.79 (44) | 29.3 ± 0.71 (52) |
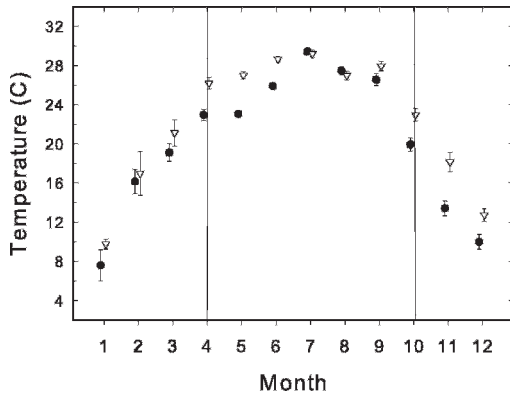
FIG. 1. Mean body temperature (open triangles) of *Heterodon platirhinos* and air temperature (closed circles) by month. The activity season for *H. platirhinos* falls between the vertical lines at months 4 and 10. Plotted are mean ± SE.

to solar radiation, and judged to be ''basking.'' In 40 of the 49 cases, $T_b$ ranged from 0.3–11.7°C (mean = 4.8°C) above $T_{air}$ (mean = 23.1°C; range 14–29°C). In nine cases, $T_b$ ranged from 0.0 to −5.5°C (mean = −1.9°C) below $T_{air}$ (mean = 22.7°C; range 16–28°C).

DISCUSSION

The primary contribution of our *H. platirhinos* study is that it provides data on field body temperatures of inactive snakes, which typically have not been available in studies that depend on opportunistically encountered snakes, and compares these to $T_b$s of active snakes under similar environmental conditions. In addition, we were able to compare the thermal ecology of resident and translocated nonresident snakes, which could provide insight into the efficacy of various translocation strategies for reptile conservation (Germano and Bishop, 2008).

The mean $T_b$ for active radio-telemetered *H. platirhinos* in our study (males 30.4°C; females 30.6°C) was comparable to mean activity $T_b$s of many temperate zone snakes (Lillywhite, 1987) and mean $T_b$s previously found for active *Heterodon* measured opportunistically with cloacal thermometers. For example, it was similar to active *H. platirhinos* in an outdoor enclosure (30.5°C; Smith, 1976) and slightly higher than active *H. platirhinos* in the field (29.4°C; Platt, 1969). Continuous monitoring of a radio-telemetered gravid female *H. platirhinos* throughout oviposition yielded an average $T_b$ of 30.5°C (Cunnington and Cebek, 2005). Additionally, the mean active $T_b$ of *H. platirhinos* is virtually indistinguishable from that of its close relative *Heterodon nasicus* (Platt, 1969; Leavesley, 1987). The slightly higher mean preferred $T_b$s selected by *H. platirhinos* (31.8°C; Kitchell, 1969) and *H. nasicus* (31.2°C; Leavesley, 1987) in laboratory thermal gradients raises the question if the active field $T_b$s shown by *H. platirhinos* in our study were constrained by available environmental temperatures (Peterson et al., 1993).

Unlike many inactive terrestrial snakes in the activity season, *H. platirhinos* rarely takes refuge under cover such as rocks, logs, or other surface objects (Platt, 1969). In our study area, inactive *H. platirhinos* typically were hidden under and coiled in or at the base of grass clumps (Plummer, 2000; Plummer and Mills, 2000). Refuge sites were usually located in the same macrohabitats used by active *H. platirhinos* (open or edge areas exposed to solar radiation); yet the grass clump microhabitats permitted inactive snakes to maintain $T_b$s ~3°C cooler than active snakes. The mean inactive $T_b$ of the eight *H. platirhinos* in this study (27.4°C) corresponded closely to the mean $T_b$ of three inactive *H. platirhinos* that were being monitored for frequency and duration of shedding (27.0°C; Plummer, 2000).

Single environmental temperature measurements often explain only a relatively small amount of $T_b$ variation in snakes (Peterson et al., 1993). For example, ground surface temperature explained less than 50% of $T_b$ variation in *H. platirhinos* in Canada (Cunnington et al., 2008) and $T_{air}$ explained only 37% of $T_b$ variation in our Arkansas study. Contributing to the unexplained variation between $T_b$s and single environmental temperature measurements is the common temperate zone behavior of basking (Peterson et al., 1993). Our observation of elevated $T_b$s in *H. platirhinos* that were tightly coiled and fully exposed to solar radiation support the notion that basking was occurring. These observations suggest that basking plays an important role in the thermal ecology of *H. platirhinos* as previously suggested by Platt (1969).

The hierarchal process of habitat selection by snakes results from a number of complex biotic and abiotic factors and often is initiated by internal physiological factors (Reinert, 1993; Weatherhead and Madsen, 2009). Despite our data demonstrating similar overall $T_b$s for resident and translocated *H. platirhinos*, it would be premature to conclude that the difference we observed in movement patterns and survivorship in the two groups (Plummer and Mills, 2000) was unaffected by their thermal ecology. For example, resident and nonresident tortoises (*Testudo hermanni*) exhibit similar levels of overall $T_b$s, but residents attain their daily preferred $T_b$ about two hours before nonresidents, and $T_b$s of residents are more independent of $T_{air}$ (Chelazzi and Calzolai, 1986). The differences in the time it takes to reach preferred $T_b$s could affect daily activity time and, thus, affect fitness traits such as finding mates and egg maturation times (Chelazzi and Calzolai, 1986). Our results of similar $T_b$s of resident and nonresident *H. platirhinos* should be regarded as preliminary because of the incidental nature of data collection and our small sample size, which provided low statistical power to identify differences that may have existed. Further research is needed to determine whether unfamiliarity with an area affects the normal thermal ecology of *H. platirhinos*. Additional thermal ecology knowledge could possibly provide, in company with spatial ecology and survivorship, information useful in the conservation of *H. platirhinos* populations.

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