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Transactions of the Illinois State Academy of Science
(2009), Volume 102, #1&2, pp. 65-70

received 6/5/08
accepted 1/10/09

# Thermoregulation of Male *Elaphe spiloides* in an Agriculturally-Fragmented Forest in Illinois

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## ABSTRACT

Anthropogenic forest fragmentation increases the amount of edge habitat. Although edges are harsh environments for many native species, ratsnakes often prefer this habitat. We examined thermoregulatory effectiveness of Central Ratsnakes (*Elaphe spiloides*) using forest edges preferentially to determine if edge preference is driven by increased thermoregulatory efficiencies. Six male subjects were located every 1-2 days using radio-telemetry and temperature sensitive transmitters. Subjects did not thermoregulate more efficiently in edges than in forest. Snakes were thermoconformers in both habitat types suggesting edge preference might be driven by other factors.

*Key Words*: Central Ratsnake, *Elaphe spiloides*, Radio-telemetry, Thermoregulation

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## INTRODUCTION

Forest fragmentation resulting from agricultural practices is prevalent in the midwestern US, particularly Illinois (70% cropland; Bretthauer and Edgington 2003). In addition to a loss of forest, this practice is responsible for creating large amounts of edge habitat. Edges are subjected to more extreme abiotic influences (i.e., wind and temperature patterns, see Saunders et al. 1991), increased predation and/or competition among species (Bolger et al. 1991, Donovan et al. 1995, McCollin 1998), and proliferation of exotic species (Yahner 1988, Murcia 1995) making this habitat type harsh to many organisms. However, ratsnakes (*Elaphe* spp.) preferentially use edge habitat (Weatherhead and Charland 1985, Durner and Gates 1993, Blouin-Demers and Weatherhead 2002).

Edge preference of *Elaphe* might reflect an increased number of avian (Gates and Gysel 1978, Paton 1994) and small mammalian prey (Weatherhead and Charland 1985, Blouin-Demers and Weatherhead 2001a). Alternatively, because edges experience warmer temperatures (Flaspohler et al. 2001, Kolbe and Janzen 2002) due to increased sun exposure (Weatherhead and Charland 1985), edge preference might be due to increased ability to thermoregulate in this habitat. Thermoregulation facilitates quicker digestion of meals, decreases gestation time of gravid females, and is critical during ecdysis. Therefore, thermoregulation might be the most important factor in determining squamate habitat use patterns (Grant 1990, Peterson et al. 1993, Reinert 1993). Ratsnakes in the northeastern US (*E. spiloides*, following Burbrink 2001) thermoregulate more efficiently in edges (Blouin-Demers and Weatherhead 2001a), but little is known about the thermoregulatory abilities of *Elaphe* in other geographic regions. We examine the thermoregulatory abilities of Central Ratsnakes (*Elaphe spiloides*) preferentially using edge habitat in Clark County, Illinois (see Foster et al. 2006), and test the hypothesis that this preference is due to increased thermoregulatory abilities in this habitat.

## MATERIALS AND METHODS

This study was undertaken between 20 May 2003 and 7 November 2004 on ca. 280 ha of privately-owned land located 14 km southeast of Martinsville, Clark County, Illinois. Agriculture row-crops (soybeans [*Glycine max*] and corn [*Zea mays*]) surround and fragment a mixed mesic hardwood forest in a ridge-valley landscape, creating a large amount of edge habitat. Numerous creeks flow into a man-made lake of ca. 30 ha, which has further fragmented the forest habitat. A county road and power line bisecting the site provide additional edge habitat.

Radio transmitters with thermistors (calibrated prior to implantation; model SI-2T, Holohil Systems, Ltd., Ontario, Canada) were surgically implanted into collected ratsnakes (see Reinert 1992, Hardy and Greene 1999, 2000). Subject body temperature (± 0.1 °C) was calculated without disturbance to the snake based on the rate of emitted pulses. These values were compared to ambient temperatures recorded at the time of subject location. All subjects were located daily or on alternate days using a Telonics TR-4 receiver (Wildlife Materials, Inc., Carbondale, Illinois).

Because ratsnakes exhibited preference for edges over forest (Foster et al. 2006), thermoregulation data were analyzed in these habitats. The preferred body temperature range ($T_{set}$) was assumed 26.5-29.8 °C (following Blouin-Demers and Weatherhead 2001b). Following Blouin-Demers and Weatherhead (2002): $d_a - d_b$ = effectiveness of thermoregulation, where $d_a$ is the deviation of ambient temperature from $T_{set}$, and $d_b$ is the deviation of snake body temperature from $T_{set}$. We used this equation to compare thermoregulatory abilities between forest and forest edges (following Blouin-Demers and Weatherhead 2001c, defined as ± 15 m of the boundary between forest and any open habitat). Negative values of $d_a - d_b$ arise when snakes use thermally favorable habitats less than their availability, zero represents thermoconformity, and positive values indicate snakes that are thermoregulating efficiently. Values of $d_a$ and $d_b$ were not calculated for subjects in hibernation (between 5 November 2003 and 6 April 2004). Univariate analyses of variance (ANOVAs) were used to analyze thermoregulation data; non-independence of data was corrected by treating each snake as a block. All statistical analyses were calculated using SPSS (SPSS Inc., 2003).

## RESULTS

Six male ratsnakes (mean snout-vent length ± 1 standard error = 119.8 ± 11.3 cm) were located 186 times in forest and 119 times in edges. Mean (± 1 SE) ambient temperature and snake body temperature during locations was 23.6 ± 0.3 °C and 23.2 ± 0.3 °C, respectively. Ambient temperatures ranged from 5.2 to 36.3 °C and body temperature ranged from 9.5 to 35.7 °C. Ambient temperature exceeded body temperature 59.2% of all location events. Snake body temperatures were correlated with ambient temperatures for each individual ($r^2 \geq 0.37$, $p < 0.001$) and for data pooled among individuals ($r^2 = 0.73$, $p < 0.001$; Fig. 1).

Ambient temperatures and body temperatures did not differ between forest and edges ($F_{1,302} = 1.14$, $p = 0.29$ and $F_{1,302} = 0.46$, $p = 0.50$, respectively; Table 1). Snake body temperatures were within the preferred temperature range 18.8% of locations in forest habitat and 10.2% in edges, whereas ambient temperatures fell within this range 22% of the time in forest and 11.9% of the time in edges. Thermoregulatory effectiveness did not differ among subjects while occupying edge or forest habitat ($F_{5,4.462} = 3.47$, $p = 0.11$) or between edges and forest ($F_{1,4.611} = 0.40$, $p = 0.56$; Table 1).

## DISCUSSION

Ambient temperatures at our study site were not higher in edges than forest, contrary to other studies (e.g., Flaspohler et al. 2001, Kolbe and Janzen 2002). Male ratsnake thermoregulatory effectiveness did not differ between these two habitats, indicating that edge preference (see Foster et al. 2006) might be due to other factors, possibly an increased number of prey (Gates and Gysel 1978, Weatherhead and Charland 1985, Blouin-Demers and Weatherhead 2001c).

Although we expected to find snakes maintaining body temperatures in the preferred thermal range (assumed 26.5-29.8 °C, following Blouin-Demers and Weatherhead 2001a), this was rarely the case. Several factors suggest that subjects were not attempting to achieve body temperatures in this range. Ambient temperatures were in this range more frequently than snake body temperatures in both habitats. Additionally, snake body temperatures varied greatly and were dependent upon ambient temperatures (Fig. 1). Calculated values for thermoregulatory effectiveness were close to zero in both forests and edges. Both are indicative of thermoconformity rather than active thermoregulation.

## ACKNOWLEDGMENTS

We thank Robert Szafoni of the Illinois Department of Natural Resources (IDNR) for encouragement and IDNR for funding this project. Thanks also to all of the field assistants and the landowners. All specimens were collected under permit #NH03-0946 issued to SJM by IDNR. Surgical procedures were approved by IACUC protocol #04-007.

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Table 1. Mean (± 1 SE) ambient temperature (°C), snake body temperature (°C), and thermoregulatory effectiveness ($d_a - d_b$) of six male Central Ratsnakes (*Elaphe spiloides*) radiotracked in forest and edge habitat in Clark County, Illinois between 20 May 2003 and 7 November 2004.

| Habitat Type | Ambient Temperature (°C) | Subject Body Temperature (°C) | Thermoregulatory Effectiveness |
|---|---|---|---|
| Forest | 23.3 ± 0.5 | 22.8 ± 0.4 | 0.03 ± 0.23 |
| Edges | 22.6 ± 0.4 | 22.4 ± 0.5 | -0.31 ± 0.20 |

Fig. 1. Body temperature as a function of ambient temperature (°C) for six male Central Ratsnakes (*Elaphe spiloides*) radio-tracked between 20 May 2003 and 7 November 2004 in Clark County, Illinois ($r^2 = 0.73$, $p < 0.001$).