

NOTES ON THE ECOLOGY OF GREEN RATSNAKES (*SENTICOLIS TRIASPIS*) IN SOUTHEASTERN ARIZONA

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Abstract.—The Green Ratsnake (*Senticolis triaspis*) has a broad range that extends from Central America north into the Madrean region of southeastern Arizona and southwestern New Mexico, yet very little is known about its ecology. We used radio telemetry to examine activity patterns, thermoregulating behavior, and habitat use of the ratsnake in southeastern Arizona. Telemetered snakes maintained an average temperature near 25°C throughout the active season (May through October), and preferentially used desertscrub and rocky east-facing slopes (females), or riparian areas (male). The scarcity of Green Ratsnakes dictates that ecological information, and a more complete picture of their conservation needs, will be gathered slowly.

Key Words.—ecology, food habits, habitat selection, radio telemetry, *Senticolis*

INTRODUCTION

The Green Ratsnake (*Senticolis triaspis*; Fig. 1) has a wide geographic distribution in Central and North America, ranging north from Costa Rica through Central America and Mexico to the southwestern United States (Degenhardt et al.). The distribution of the species in the U.S. is limited to the Madrean Archipelago of southern Arizona and New Mexico. Anecdotal information suggests that *S. triaspis* occurs in rocky riparian areas in New Mexico and Arizona, USA (Degenhardt et al. 1996). Although Stebbins (2003) suggests that Green Ratsnakes are strongly arboreal, other workers disagree (e.g., Cranston 1989 in Degenhardt et al. 1996). Furthermore, courtship occurs from mid-March to mid-May in Arizona (E. C. Bloom, pers. comm.), but occurs throughout the year in Central America (Censky and McCoy 1988). Limited information indicates that the species feeds predominantly on small mammals (Rodriguez-Robles and De Jesus-Escobar 1999; H. Greene, pers. comm.; W.R.R., pers. obs.).

The restricted geographic range of the species in the U.S. and its secretive habits suggest that *S. triaspis* is rare. The perceived rarity coupled with inadequate regulations throughout its range (Fitzgerald et al. 2004) suggest that additional protection is required to conserve *S. triaspis* in the United States. However, effective protection requires basic life history and ecological information (e.g., Noss 1996; Rivas 1997; Wilcove and Eisner 2000). Applying conservation measures to species for which very little information exists, such as *S. triaspis*, is difficult (Bury 2006). We used radio telemetry to examine activity periods, thermoregulation behavior, home range size, and habitat use of *S. triaspis* in Leslie Canyon National Wildlife Refuge (LCNWR),

in Cochise County, Arizona. Although LCNWR was established to protect native, endangered and threatened fish species, it provides protected areas for many endemic taxa with limited distributions, including *S. triaspis*.

MATERIALS AND METHODS

The ~ 1100 ha LCNWR is located in southeast Arizona, overlying portions of the Swisshelm and Pedregosa Mountains at an elevation range of 1400 – 1720 m. Vegetation is predominantly (> 95%) desert scrub, with both Sonoran and Chihuahuan Desert influences: species include *Opuntia* spp. (Prickly Pear Cactus), *Acacia constricta* (Whitethorn Acacia), *Agave palmeri* (Palmer's Agave), *Nolina microcarpa* (Narrow-leaf Beargrass), and *Foquieria splendens* (Ocotillo). A



FIGURE 1. A Green Ratsnake (*Senticolis triaspis*) from Leslie Canyon National Wildlife Refuge, Cochise County, Arizona, USA. Photographed by William Radke.

narrow riparian gallery forest, occupying < 5% of LCNWR, exists along perennially and seasonally flowing portions of Leslie Creek. *Fraxinus velutina* (Velvet Ash), *Juglans arizonica* (Arizona Walnut), *Salix gooddingii* (Goodding's Willow) and a few *Populus fremontii* (Fremont's Cottonwood) dominate the gallery forest. The vegetation of the low-lying floodplains includes *Sporobolus airoides wrightii* (Giant Sacaton), but *Prosopis glandulosa* (Velvet Mesquite) and *Celtis reticulata* (Net-leaf Hackberry) are also present. More than 40 reptile and amphibian species, > 150 avian species, and > 50 mammalian species occur in LCNWR (US Fish and Wildlife Service. 2002. Watchable Wildlife: San Bernardino and Leslie Canyon NWR. Albuquerque, NM).

We captured individual *Senticolis triaspis* opportunistically between January 2000 and October 2004. We implanted, using methods described by Reinert (1992), Holohil TS-2 temperature variable transmitters (Holohil Systems Ltd., Carp, Ontario, Canada) into five *S. triaspis* with body masses > 100g (transmitter to body mass ratio < 5%). We calibrated the transmitters prior to implantation. We released telemetered snakes at or near their capture point and radiotracked them using a Telonics TR-5 receiver with a 4-element H-antenna (Telonics, Inc., Mesa, Arizona, USA). We checked snake locations at least once every 2-3 d from late February–early November. We checked locations several times a day if an individual was mobile, which we determined by transmitter signal strength and signal direction at a distance of ≥ 25 m. At each snake's location, we recorded substrate, vegetation, height above ground surface, whether or not we saw the snake, and the transmitter pulse period. We estimated body temperature by transforming the pulse period, which inversely and non-linearly relates to snake body temperature, via a transmitter-specific equation; each transmitter had a very good ($r^2 > 0.99$) fit between pulse period and temperature.

We described the annual body temperature variation based on four telemetered snakes (two females and two males) and macro-scale habitat use of three snakes (two females, one male). We excluded one male from habitat analysis because it exhibited very little movement, and we judged that this sedentary behavior was an anomaly. However, changes in signal strength and direction indicated that the snake was moving within the burrows it used and was likely thermoregulating. We used a one-way ANOVA and Tukey's HSD ($\alpha = 0.05$) to estimate mean body temperature and error terms. Although we had small sample sizes, we tested for sex-specific temperature differences using a one-way ANOVA (Neter et al. 1985) using the two female and two male snakes. We checked for any relationship between time-of-day and temperature using a linear model with Gaussian distribution and an identity link (McCullough

and Nelder 1989). We performed all analyses using R 2.5.1 (R Core Development Team, Vienna, Austria).

We mapped habitats using DeLorme's X-Map 3.5 (DeLorme, Yarmouth, Maine, USA) program with geo-referenced aerial photographs (1:10,000 scale). We added layers to delineate two macrohabitat categories: vegetation and slope aspect. We further separated the vegetation category into either riparian or desert shrub habitats. Riparian habitats were dominated by *Fraxinus* spp. and *Juglans* spp.; whereas, desert scrub habitats were dominated by *Opuntia* spp. and *Acacia constricta*. Mountain ridges in the study area follow a north-south orientation, which creates slopes that predominantly face either east or west. Therefore, we used topographic contours to separate the slope aspect category into east-versus west-facing slopes.

We constructed home ranges (HR) by outlining the locality points. We refrained from using the Minimum Convex Polygon (MCP) model, which requires that a line connecting any two points remain totally within the polygon, because it included areas and habitats in the home ranges not used by *S. triaspis*, creating a confounding bias in the results. We overlaid the outline of the HR of each individual snake on vegetation and slope-aspect map layers, and calculated the percentage of each habitat per category within the home ranges (i.e., "used habitat").

RESULTS

We captured nine *S. triaspis* in or immediately adjacent to LCNWR. We also found two live and one dead snakes on roads. Capture dates ranged from 8 April to 20 November, with two in April, one in May, two in June, one in July, three in October, and two in November. Individuals never attempted to flee when approached; rather, they remained motionless even when clearly visible on a roadway, and resisted capture only when touched. Captive snakes exhibited diurnal and crepuscular activity. There were two activity peaks, one

TABLE 1. Summary statistics of time of radio tracking, home range sizes, and habitat used (in percentage area) by three Green Ratsnakes telemetered at Leslie Canyon National Wildlife Refuge, Cochise County, Arizona, USA. Length is the length in m of the long axis of the home range.

	Female 1	Female 2	Male 1
Days tracked	291	20	134
Months tracked	July-April	September-October	May-September
Home Range (ha)	2.20	0.84	1.31
Vegetation (%)			
Desert Scrub	94	93	57
Riparian	6	7	43
Aspect (%)			
East	90	95	95
West	10	5	5
Length (m)	250	140	405

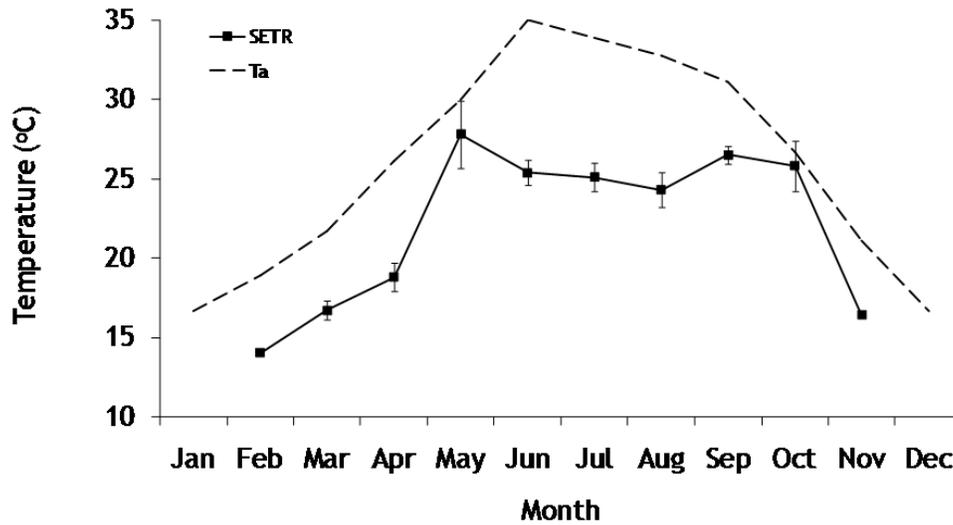


FIGURE 2. Average temperature of four Green Ratsnakes (SETR) telemetered with temperature-variable transmitters in Leslie Canyon National Wildlife Refuge, Cochise County, Arizona. For comparison, the average monthly ambient temperature (Ta) for nearby Douglas-Bisbee Airport is shown. Error bars are $\pm 1SE$.

in the morning (0400 – 0700h) and one in the afternoon (centered around 1815h). Captive mating occurred in spring (23 May 2002).

We implanted five *S. triaspis* with transmitters, but gathered locality data on only three individuals (Table 1). Although we tracked Male #2, which does not appear in Table 1, for 34 d and gathered temperature data, we were not comfortable in including this snake in our HR analyses. Snakes were diurnal or crepuscular depending on season and lacked evidence of prolonged daily activity periods. We could determine time of snake movement in only eight instances. Seven movements occurred in the afternoon or evening and one occurred in the morning. Only one telemetered *S. triaspis* was found in vegetation. This individual climbed vegetation for approximately 45 min after release, and was never again found in an arboreal habitat. Individuals appeared to move through interstitial spaces between rocks on the hill slopes where they spent the majority of their time. Ratsnakes even moved through the interstitial spaces between rocks when crossing under a road that had been built on top of loose rock; that is, we stood on the road surface and the snake was at an undetermined depth under the roadway where spaces between the rocky fill material could have been the only transit route.

Mean monthly *S. triaspis* body temperatures from March through October was approximately 25°C. Based on local weather data (National Weather Service, Western Regional Climate Center. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?azdogl>.

Last Accessed: 27 April 2009) Ratsnakes actively thermoregulated and maintained body temperatures near ambient air temperature in May and October, but lower than ambient air temperatures during the summer (Fig. 2). Female mean temperature was 25.2°C (SD = 3.8, $n = 71$) and male mean temperature was 24.8°C (SD = 2.1, $n = 55$). We had insufficient data to test for a time-by-month effect on body temperature; however, there was no relationship between time-of-day and body temperature ($F_{1,123} = 0.76, P = 0.39$).

We recorded 89 locations of the telemetered *S. triaspis*. Of these observations, 55% ($n = 49$) were in talus, 25% ($n = 22$) were in living vegetation, 11% ($n = 10$) were in woody debris, and 9% ($n = 8$) were in rodent burrows. Vegetation used by *S. triaspis* included *Acacia constricta*, *Agave palmeri*, *Baccharis salicifolia* (Seepwillow), *Fraxinus velutina*, *Opuntia* spp., *Prosopis glandulosa*, and *Sporobolus gigantea*. Most (84%) observations of telemetered *S. triaspis* were in desert scrub, but some (16%) were in riparian habitats. Home range and Length (length of long home range axis) estimates for the three individuals were variable (Table 1). The two females predominantly used desert scrub and east-facing slopes; whereas, the male used riparian areas more than females, but similar to females, desert scrub and east-facing slopes were favored (Table 1).

DISCUSSION

Species that are scarce at the landscape scale present difficulties in our attempts to understand their ecology

and to provide for their conservation. Our data provide information on the natural history and ecology of *Senticolis triaspis*. However, our sample size is small and conclusions should be made with caution: these are pieces of information that will help our general understanding and conservation of the species (Bury 2006).

Our data suggest that *S. triaspis* actively thermoregulate to maintain a body temperature near 25°C during the active seasons. This field-derived data agree with previous findings that there may be a preference for 25°C (Schulz 1996). The apparent preference of *S. triaspis* for east-facing over west-facing slopes (discussed below) may be tied to thermoregulation (Huey et al. 1989). Individuals on east or southeast-facing hillsides may achieve their thermal preference more quickly in cooler months (e.g., October) given increased solar insolation, and the thermal preference may reflect the observed habitat use pattern.

Based on the analysis of our telemetered snakes, as well as ancillary observations in Mexico (WRR and JWM, pers. obs.; J. Malone and J. Meik, pers. comm.), *Senticolis triaspis* tend to be denizens of rocky, east-facing slopes. At LCNWR, these slopes are predominantly desert scrub, although we made a number of observations (16%) in riparian areas. Our use of HR outlines rather than MCPs seemed appropriate: Ratsnakes often used rocky, dry washes perpendicular to the Leslie Creek riparian area, then traveled along the riparian area. This habitat use pattern creates an L-shaped home-range; MCPs overestimate HR size and the proportion of desertscrub habitat used by connecting the opposing ends of the L-shaped habitat. We observed one male *S. triaspis* sufficiently to estimate HR, and it demonstrated a markedly different preference pattern than that for females by using riparian habitats considerably more often. More *S. triaspis* in a variety of locations need to be studied to enable a clear understanding of habitat preferences.

Previous findings based on two telemetered *S. triaspis* (Sherbrooke 2006) also demonstrated extensive use of rocky areas but that study took place at a higher elevation on the eastern slope of the Chiricahua Mountains where the vegetation was characteristic of a Madrean woodland (including *Quercus* spp., *Juniperus* spp., and *Pinus* spp.) rather than desert scrub. The ridges of that study site were primarily east-west oriented (resulting in north and south aspects), making direct aspect comparisons between our results and his observations difficult; however, Sherbrooke (2006) noted evidence of thermoregulatory preferences as snakes moved to south-facing slopes late in the year. Likewise, we did not observe telemetered *S. triaspis* regularly climbing vegetation: our only observation of an arboreal *S. triaspis* was of a telemetered individual who had just been released. This is contrary to some reports

that the species is arboreal (e.g., Stebbins 2003) and supports the observations of Schulz (1996) and Sherbrooke (2006).

Senticolis triaspis is very secretive; consequently, collecting life history information on this species is difficult. As additional studies accumulate more data on this snake, we will achieve a greater understanding of its ecology, behavior, evolution, and conservation.

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LITERATURE CITED

- Bury, R.B. 2006. Natural history, field ecology, conservation biology, and wildlife management: time to connect the dots. *Herpetological Conservation and Biology* 1:56–61.
- Censky, E.J., and C.J. McCoy. 1988. Female reproductive cycles of five species of snakes (Reptilia: Colubridae) from the Yucatan Peninsula, Mexico. *Biotropica* 20:326–333.
- Degenhardt, W.G., C.W. Painter, and A.H. Price. 1996. *Amphibians and Reptiles of New Mexico*. University of New Mexico Press, Albuquerque, New Mexico, USA.
- Fitzgerald, L.A., C.W. Painter, A. Reuter, and C. Hoover. 2004. *Collection, Trade, and Regulation of Reptiles and Amphibians of the Chihuahuan Desert Ecoregion*. TRAFFIC North America, World Wildlife Fund, Washington, D.C., USA.
- Huey, R.B., C.R. Peterson, S.J. Arnold, and W.P. Porter. 1989. Hot rocks and not-so-hot rocks: Retreat-site selection by garter snakes and its thermal consequences. *Ecology* 70:931–944.
- McCullaugh, P., and J.A. Nelder. 1989. *Generalized linear models*. 2nd Edition. Chapman and Hall/CRC, Boca Raton, Florida, USA.
- Neter, J., W. Wasserman, and M.H. Kutner. 1985. *Applied Linear Statistical Models: Regression, Analysis of Variance, and Experimental Design*. 2nd Edition. Irwin Publishers, Homewood, Illinois, USA.
- Noss, R.F. 1996. The naturalists are dying off. *Conservation Biology* 10:1–3.
- Reinert, H.K. 1992. Radiotelemetric field studies of pitvipers: Data acquisition and analysis. Pp. 185–198 *In* *The Biology of the Pitvipers*. Campbell, J.A., and E.D. Brodie, Jr., (Eds). Selva Press, Tyler, Texas, USA.
- Rivas, J.A. 1997. Natural history: Hobby or science? *Conservation Biology* 11:811–812.
- Rodriguez-Robles, J.A., and J.M. De Jesus-Escobar. 1999. Molecular systematics of New World lampropeltine snakes (Colubridae): implications for biogeography and evolution of food habits. *Biological*

- Journal of the Linnean Society 68:355–385.
- Schulz, K.D. 1996. A Monograph of the Colubrid Snakes of the Genus *Elaphe* Fitzinger. Koeltz Scientific Books. Koenigstein, Germany.
- Sherbrooke, W.C. 2006. Habitat use and activity patterns of two Green Ratsnakes (*Senticolis triaspis*) in the Chiricahua Mountains, Arizona. Herpetological Review 37:34–37.
- Stebbins, R.C. 2003. A Field Guide to Western Reptiles and Amphibians. 2nd Edition. Houghton Mifflin Company, Boston, Massachusetts, USA.
- Wilcove, D.S., and T. Eisner. 2000. The impending extinction of natural history. Chronicle of Higher Education, 15:B24.



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