Ecology and Natural History of the Green Rat Snake at Leslie Canyon National Wildlife Refuge, Cochise County, Arizona

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Abstract—*Green rat snakes (*Senticolis triaspis*) appear to be rare throughout their range, and little is known about their ecology and life history. Using opportunistically captured S. triaspis coupled with captive observations, natural observations, and radio telemetry, we document several natural history and ecological aspects of the species. The only known food items are small mammals; the species only rarely climbs in trees; preferred habitats are steep, rocky east-facing slopes with desertscrub vegetation; and active body temperatures typically are 23.4 - 29.7 °C. The species' conservation will depend on knowing its life-history and ecology, and protecting rocky slopes and mammalian food items.*

Introduction

While the green ratsnake (*Senticolis triaspis*) has a geographic distribution ranging north from Costa Rica through Central America and Mexico, it barely enters the United States in and among several Madrean mountain foothills in southern Arizona and New Mexico. Its apparent restricted geographic range in the United States., secretive habits, and cryptic coloration have led to the perception that it is perhaps an uncommon, arboreal species. Little is known regarding the general population ecology and behavior of this species. Recently, Rodriguez-Robles and De Jesus-Escobar (1999) focused on phylogenetics and the evolution of food habits within the lampropeltine snakes, including *Senticolis*.

Basic life history and ecological information is necessary for appropriate conservation (see, e.g., Wilcove and Eisner 2000); it is therefore difficult to apply conservation measures to species such as *S. triaspis*, for which very little information exists. Degenhardt et al. (1996) review what little is known about the species. Anecdotal information indicates that the species is found in "rocky riparian areas" in New Mexico and Arizona (Degenhardt et al. 1996). Cranston (1989 *in* Degenhardt et al. 1996) provides observational information on behavior, reproduction, and food habits. These accounts suggest that *S. triaspis* is not strongly arboreal as implied by other workers (e.g., Stebbins 2003); that courtship occurs from mid-March to mid-May, and incubation lasts 77-88 d at 26 °C; and limited information indicates that the species feeds on small mammals.

Senticolis triaspis inhabit Leslie Canyon National Wildlife Refuge (LCNWR), in Cochise County, Arizona. Although LCNWR was created specifically to protect native, listed (Federally Endangered and Threatened) fish species, it provides protected areas for many range-restricted, endemic, and otherwise unique species. We used opportunistically captured *S. triaspis*, radio telemetry, and captive and natural observations to examine: food habits, activity periods, behavior, home range size, and habitat use.

Study Area

LCNWR is located in southeast Arizona, overlying the Swisshelm and Pedregosa Mountains at an elevation range of 1,400-1,720 m, and encompasses ~1,100 ha. Vegetation is dominantly (>95%) desertscrub, with both Sonoran and Chihuahuan Desert influences; species include *Opuntia* spp., *Acacia constricta*, *Agave palmeri*, *Nolina microcarpa*, and *Foquierria splendens*. A narrow riparian gallery exists along perennially and seasonally flowing portions of Leslie Creek, occupying <5% of LCNWR; species composition is dominated by *Fraxinus arizonica*, *Juglans arizonica*, and *Salix gooddingii*. Low-lying floodplains are dominated by *Sporobolus muhlenbergii*, interspersed with limited *Prosopis glandulosa* and *Celtis reticulata*. The number of animal taxa that inhabit LCNWR is high despite its small size. Over 40 reptile and amphibian species, >100 avian species, >50 mammalian species, and an unknown, but large number, of invertebrate species occur on the Refuge.

Methods

Capture and Captivity

Senticolis triaspis were captured opportunistically between July 2000 and July 2003. All but one individual (DOR) were returned to LCNWR headquarters for captive maintenance. While captive, daily and seasonal activity patterns were recorded for individuals. Captive *S. triaspis* were presented a variety of food items, all of which occur syntopically with the snake in LCNWR, with the exception of *Mus musculus*. Food items were left in the aquaria with *S. triaspis* until they were consumed, or for 24 h.

Radio Telemetry

Captured *S. triaspis* that were large enough (>100 g) were implanted with Holohil TS-2 temperature variable transmitters in the laboratory using methods described by Reinert (1992); transmitter temperature calibration was conducted in the lab prior to implantation. Individuals were released <50 m from the original capture point (some were captured on the road, necessitating a release point slightly different than, but near, the point of capture), and tracked using a Telonics TR-5 receiver with a 4-element H-antenna. Time, location (UTM, WGS 84 and NAD 27 datums), pulse period (transformed to body temperature), substrate, vegetation, height above ground surface, and visual confirmation were recorded. Body temperature summary statistics were grouped by month and individual, and calculated following Neter et al. (1985).

Habitat mapping was accomplished with DeLorme's X-Map 3.5 (DeLorme 2002) program. Using georeferenced aerial photographs (1:10,000 scale), layers were added to delineate two macrohabitat classes, vegetation, and slope aspect. The classes were further separated into 2 categories. Vegetation was categorized as riparian (dominated by *Fraxinus* and *Juglans*) and desertscrub (dominated by *Opuntia* and *Acacia*) habitats. Topographic contours were used to delineate east versus west aspect categories (local ridges follow a north-south orientation, resulting in dominantly east- or west-facing slopes).

Home ranges (HR) were constructed as outlines of the locality points; minimum convex polygons (MCP), although widely used, were not applied in this case because areas that would have been included were never used by the snakes. The inclusion of these areas from the MCP would bias results and lead to incorrect inference. The HR of each individual was overlaid on vegetation and slope-aspect layers, and the percentage of each category per class within the home ranges was calculated; these percentages established "used" habitats.

To examine macrohabitat preferences, we determined "available" habitat using three models of biologically defined availability (figure 1). We used these models because arbitrary definitions of availability can bias preference assessment and heavily introduce anthropogenic views; the logic of the models is that movement rates and distances must restrict what is actually "available." Model 1 (figure 1a) depicts a hypothetical individual that has a home range with a maximum long axis of length *L*; from release, this individual could theoretically travel any compass direction an equivalent distance. Model

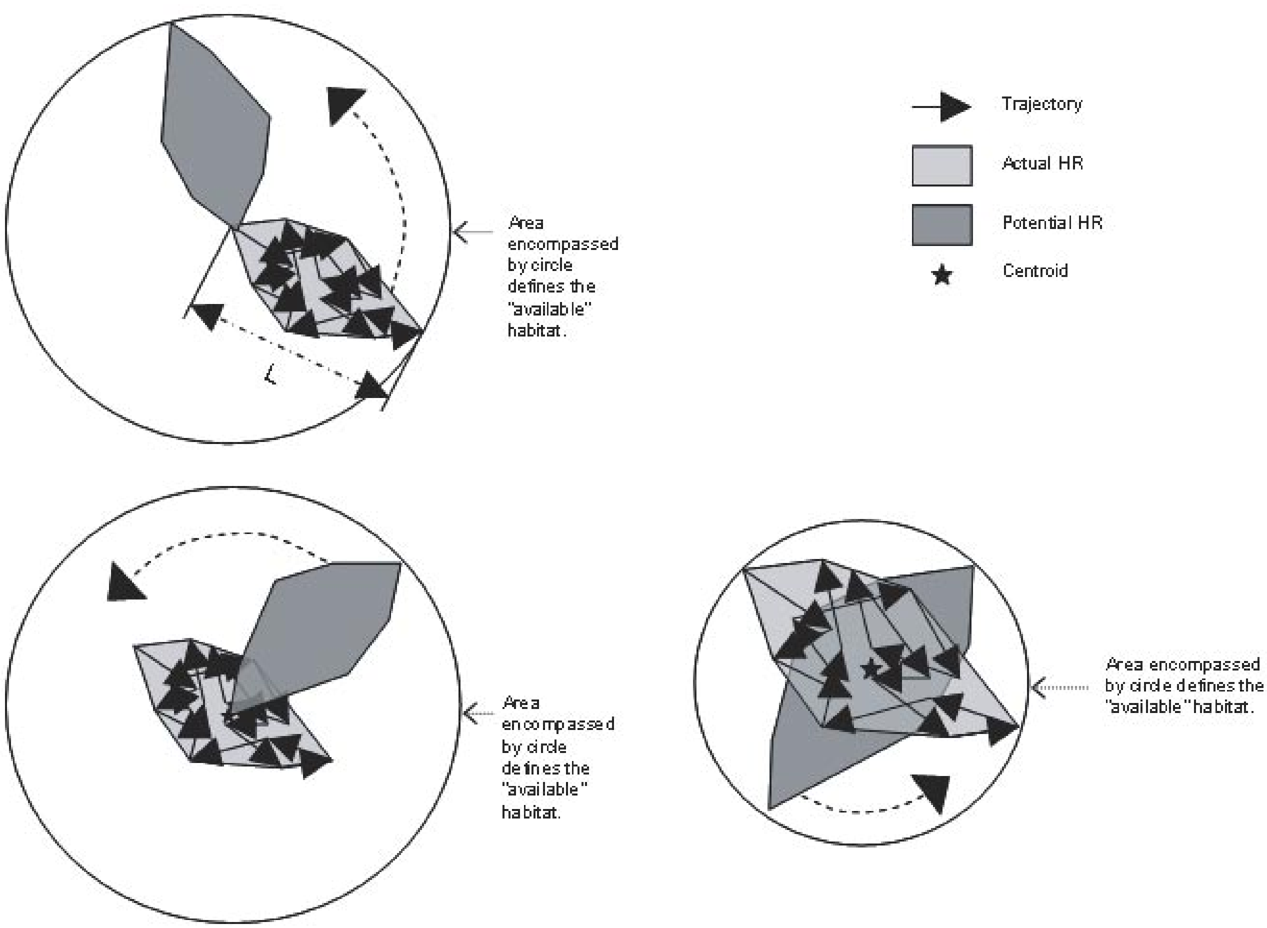

Figure 1—Models of biologically defined availability. a. is Model 1, with an area circumscribed by the radius *L* rotated about the initial release point; b. is Model 2, with an area circumscribed by radius *L* rotated about the observed home range centroid; c. is Model 3, with a radius circumscribed by radius (*L*/2) rotated about the home range centroid.

Table 1—Species consumed or denied by captive *Senticolis triaspis* captured in Leslie Canyon National Wildlife Refuge, Cochise County, AZ.

Species	Accepted	Denied
Peromyscus maniculatus	X	
Peromyscus leucopus	X	
Perognathus baileyi	X	
Perognathus flavus	X	
Baiomys taylori	X	
Mus musculus	X	
Dipodomys ordii	X	
Sceloporus clarkii		X
Urosaurus ornatus		X
Elgaria kingii		X
Aspidoscelis sonorae		X

Table 2—Habitat use and availability according to three models (in figure 1). "Ind" is individual, and all values are given in percent.

		Available		
	Used	a	b	c
Vegetation (%)				
Desertscrub Ind 1	94	92	91	88
Desertscrub Ind 2	93	86	91	95
Riparian Ind 1	6	8	9	12
Riparian Ind 2	7	14	9	5
Aspect (%)				
East Ind 1	90	28	40	47
East Ind 2	95	27	27	97
West Ind 1	10	72	60	53
West Ind 2	5	73	73	3

2 (figure 1b) depicts an "available" area defined by *L* rotated about the home range centroid, under the assumption that the point must remain in any permutation of the observed home range. Model 3 (figure 1c) rotates the home range about the centroid, under the assumption that the centroid must remain the centroid in all permutations. Within each "available" area defined by the models, proportions of each habitat type were calculated. Compositional analysis (Aebischer et al. 1993) was used in part for ranking preference; full ANOVA was not used because of small sample size.

Results

Seven S. *triaspis* were captured in or immediately adjacent to LCNWR; capture dates ranged from April 8 to November 20. Despite the thin, muscular build of the species, similar to that of the syntopic *Masticophis bilineatus*, individuals never attempted to flee when approached: they remained motionless even when clearly visible in a roadway, and resisted capture only once touched.

Senticolis triaspis consumed only endotherms, specifically small mammals; ectotherms were never consumed (table 1). Live mammals were preferred over dead mammals, and food items that were not consumed by *S. triaspis* were ultimately consumed by the control snakes. Feeding trials further suggested that snake body size and food item size are positively correlated. Food items were consumed when presented at any time of day, as well as when the snakes were relatively cool. Captive snakes exhibited diurnal and crepuscular activity, but there was no indication of nocturnal activity. There were two activity peaks, one in the morning and one in the afternoon. Captive mating occurred in spring.

Four *S. triaspis* were implanted with transmitters; of these 4, only 2 individuals (or their transmitters) survived long enough to gather meaningful data. Snakes were diurnal and/or crepuscular depending on season, and did not appear to have prolonged activity periods; nocturnal activity was never documented. Telemetered individuals were found to climb among trees and shrubs only once: an individual climbed for approximately 45min after release, but was never found above the ground again. Movement was evident several times, and in all but the post-release climbing observation and when crossing roads, individuals apparently traveled through interstitial spaces among large rocks. Movement was slow and deliberate when observed. Mean monthly snake body temperatures during through the annual cycle ranged from 13.8-27.8 °C, and active body temperatures documented while snakes were moving through their habitats ranged from 23.4-29.7 °C (July).

HR and *L* estimates for the two individuals were variable (HR = 2.2 versus 0.84 ha; L = 250 versus 140 m), but there was considerable overlap in the home ranges (0.62 ha). Desert scrub and east-facing slopes were predominantly used by both individuals. "Available" habitat proportions varied between the biologically defined models for both individuals, and the changes between models in what was defined as "available" necessarily changed inference of preferences (table 2). Under both Model 1 and Model 2 availability, desertscrub and east-facing slopes were strongly preferred over riparian and west-facing slopes; however, Model 3 availability resulted in ambiguous preference determination (table 3).

Discussion

Natural history and ecological information are important to conserving species, yet little is known about many secretive and range-restricted species such as *S. triaspis*. Feeding experiments supported conclusions in the literature stating that green ratsnakes feed on endotherms, specifically small mammals (e.g., Degenhardt et al. 1996). This finding is consistent with the phylogenetic-constraint hypothesis of food habits presented by Rodriguez-Robles and De Jesus-Escobar (1999), wherein the clade containing *Senticolis* consumes only small mammals.

Radio telemetry data and habitat preference analysis indicated that desertscrub vegetation is strongly preferred over riparian vegetation. However, there is often high spatial autocorrelation in landscape features; in the case of *S. triaspis* in LCNWR, the desertscrub habitat is correlated with very rugged, rocky areas on the sides of the canyon. Based on observations of the species in Central America (J. Malone and J. Meik, personal communication), *S. triaspis* are often found in rocky areas with very different vegetative community structure than that at LCNWR, suggesting that the geologic

Table 3—Average (and standard deviation) of the log-ratio (L-R) differences between used and available habitat categories for two *Senticolis triaspis* radio tracked at Leslie Canyon National Wildlife Refuge. "Effect" indicates affinity (+) or deference (-) for a given habitat category.

	L-R		Effect
	$\bar{x}$	SD	
Vegetation (%)			
Desertscrub			
	a. 0.050	0.040	+
	b. 0.027	0.008	+
	c. 0.022	0.062	-
Riparian			
	a. -0.490	0.287	+
	b. -0.328	0.109	+
	c. -0.178	0.728	-
Aspect (%)			
East			
	a. 1.213	0.064	+
	b. 1.034	0.316	+
	c. 0.314	0.474	-
West			
	a. -2.328	0.500	+
	b. -2.236	0.629	+
	c. -0.578	1.540	-

structure may be more important than the vegetative component. The fact that east-facing slopes appear to be preferred over west-facing slopes may be tied to thermoregulation; the key to refining answers will lie in replication through time and space. The diurnal/crepuscular activity periods, relatively slow movement rates, motionless behavior when approached, and mammalian food preferences implies that *S. triaspis* slowly hunts nocturnally active small mammals in rocky retreats by day—it would not be efficient, given slow movement rates, to actively pursue the prey at night.

Continued research is needed on *S. triaspis*. Our radio telemetry sample size is small, and inferences should be considered preliminary at this point. However, our analysis suggests that a focus on riparian areas may misdirect conservation efforts for the species: rocky hillsides, especially those that are east-facing, may be much more important. If conservation focuses on *S. triaspis* food resources, then efforts to augment or protect lizard populations would also be misdirected given the strict mammalian diet observed.

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