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Home Ranges of Rat Snakes (Colubridae: Elaphe) in Different Habitats

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tical structure and/or less habitat heterogenity when compared with Cayo Pisaje, which may explain, along with the greater spatial isolation, the fewer species present on these keys.

Surprisingly, five species are present on both Monte Chico and Monte Grande (Burns et al. 1992). Unlike Isla Cabras, Monte Chico and Monte Grande are similar in topographical relief to Cayo Pisaje. In addition, sea grapes, present on Monte Grande, and arborescent scrub (predominately *Acacia*), present on Monte Chico (Burns et al. 1992), add a vertical dimension comparable to that of Cayo Pisaje. Because Monte Grande and Monte Chico are similar to Cayo Pisaje in topography and habitat heterogeneity and are smaller, the greater number of species on these keys compared to Cayo Pisaje contradicts the expected pattern.

Anolis cybotes cybotes, Ameiva chrysolaema ficta, Ameiva taeniura vulcanalis, Celestus costatus oreistes, and *Celestus curtissi aporus* are all ecological generalists present along the coast of the main island adjacent to Cayo Pisaje (Schwartz and Henderson 1991). That none has been recorded on Cayo Pisaje is surprising. *Anolis c. cybotes,* a heliophilic trunk-ground anole, requires vertical structure, such as that provided by mangroves and sea grapes, which are present on Cayo Pisaje. *Ameiva c. ficta* and *A. t. vulcanalis,* opportunistic foragers found sympatrically on the main island (Sprosten et al. 1999), can be found in habitats such as mangrove borders and scrublands (Schwartz and Henderson 1991), which are present on Cayo Pisaje. Debris along the beach seemed to be suitable habitat for either *Celestus c. oreistes* or *C. c. aporus* (Schwartz and Henderson 1991). Consequently, this key is seemingly capable of supporting at least some of these additional species, rendering its low diversity of lizard species all the more surprising.

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Several researchers (Durner and Gates 1993; Fitch 1963; McAllister 1995; Stickel and Cope 1947; Stickel et al. 1980; Weatherhead and Hoysak 1989) have examined home range size and habitat use patterns in black rat snakes (*Elaphe o. obsoleta*). Calculated home range sizes vary from 1.4 ha for females in a radio-telemetry study (Weatherhead and Hoysak 1989) to 28.3 ha for males in a mark-recapture study (Stickel et al. 1980). In spite of these data, home range estimates for other members within the genus are relatively scant. We examined movements of radio-telemetered gray rat snakes (*Elaphe obsoleta spiloides*) from both riparian and upland habitats along the northwestern extent of their geographic range. This report provides information concerning home range sizes, body temperatures recorded at time of relocation, and general patterns of habitat use at each of the study sites. Gray rat snakes have a narrow area of sympatry with black rat snakes (Ernst and Barbour 1989); as such, we also discuss briefly our findings relative to those reported for black rat snakes in similar habitats.

Adult gray rat snakes (three females and eight males) were collected from four forested sites in Shelby County, Tennessee, and from a 1500-ha bottomland hardwood site in the White River National Wildlife Refuge (WRNWR), Arkansas County, Arkansas, USA. The sites in Shelby County ranged between 124.7 and 251.2 ha and patches of old field habitat were present at each site. Subjects were returned to the laboratory for snout–vent length (SVL; ± 0.5 cm) measurement, and sex determination (cloacal probe). Transmitters weighing less than 5% of snake body mass (L.L. Electronics model LF1-11357-RS-T) were implanted into the peritoneal cavity of each subject using procedures modified from Wang et al. (1977) and Reinert and Cundall (1982). Following a minimum 3-day recovery period, subjects were released at the site of capture and relocated every 2 or 3 days thereafter (exception below). When relocations were separated by shorter time intervals (e.g., every 24 h), change in subject position was infrequently observed (pers. obs.).

TABLE 1. Sex, locality, home range size (ha, estimated using minimum convex polygon method), inclusive tracking dates, and summary data for gray rat snakes (*Elaphe obsoleta spiloides*) radio-telemetered in two different habitats. Shelby = localities within Shelby County, Tennessee; WRNWR = White River National Wildlife Refuge, Arkansas.

Snake #	sex (M/F)	locality	home range (ha)	tracking dates
15	M	Shelby	13.4	22 Oct 1994 – 14 Jun 1995
20	M	Shelby	0.4	22 Oct 1994 – 16 Apr 1995
27	F	Shelby	1.3	13 May 1997 – 24 Jul 1997
34	M	Shelby	1.8	13 May 1997 – 28 Jul 1997
36	F	WRNWR	5.3	20 Apr 1997 – 13 Jul 1997
37	M	WRNWR	6.8	20 Apr 1997 – 12 Jul 1997
38	M	WRNWR	4.8	5 May 1997 – 14 Jul 1997
40	M	Shelby	0.7	30 May 1997 – 17 Aug 1997
		Pooled home range data (mean ± 1 SE)		
All male subjects		—	6.3 ± 2.1	—
All female subjects		—	3.3 ± 1.9	—
All Shelby subjects		—	5.5 ± 2.7	—
All WRNWR subjects		—	5.6 ± 0.6	—

Two of the Shelby County snakes were telemetered between 22 October 1994 and 14 June 1995. The relocation interval for these individuals was extended to 2 weeks during their hibernation (2 December 1994 to 17 March 1995). Each hibernaculum was located within the area where the snake was radio-tracked during the activity season and snakes did not have separate winter and summer ranges; thus, home range estimates did not exclude movements to and from hibernacula (e.g., Brown and Parker 1976). All other subjects were telemetered between 2 April and 17 August 1997 and relocated at least once every 3 days. During 1997, we were unable to locate three snakes for more than 30 days following their release (possibly a result of transmitter failure, or predation on the subjects). Available data for these individuals underestimated their home range sizes (Rose 1982). Therefore, we excluded data from these subjects, leaving two females and six males for consideration in this study (see Table 1 for summary data).

Relocation sites for telemetered individuals in Shelby County (N = 5) were recorded with a global positioning system (GPS; hand-held Trimble units, accurate to ± 5 m). These relocation data were post-corrected using base station data from the University of Memphis Ground Water Institute (resulting in an accuracy of ± 5 m), and imported into CALHOME software (U.S. Fish and Wildlife Service, in collaboration with Microsoft, Inc., 1992). The relocation sites of the WRNWR snakes (N = 3) were plotted using measured distances and azimuth values from points on a 50 x 50 m grid that was established across a 50 ha study area as part of a separate project at that site (Wilson 1997). Home ranges for each subject were calculated using the minimum convex polygon procedure (MCP; Jennrich and Turner 1969) in CALHOME. Home range MCP estimates were used to facilitate comparison with other studies on rat snakes (Durner and Gates 1993; Weatherhead and Hoysak 1989), and also because of their use in other studies of reptilian spatial activity patterns (Gregory et al. 1987; Rose 1982). Furthermore, differences between home range sizes calculated using the MCP method and the harmonic mean method were absent (t- test; $p > 0.05$). Separate analyses of variance (ANOVA; a = 0.05) were used to determine if home range size differed by study site or tracking season. A low sample size of females (N = 2) precluded analysis of home range size as a function of sex. Differences in home range size as a function of SVL were determined using a Pearson's regression.

At the time of each relocation air temperature (± 0.2°C), cloud cover, and subject position were recorded. If the subject was visible, we also recorded substrate of subject's position (if arboreal, tree species and tree diameter at breast height [DBH, ± 0.5 cm] also were recorded), and subject activity. Subject concealment in arboreal habitats (positioned in a tree cavity or among vines) often prevented accurate measurement of subject height off forest floor. If the snake was accessible, cloacal temperature was obtained using a quick-reading thermometer (Miller & Weber, Inc.).

Sexes did not differ in size (mean SVL ± 1 SE equaled 120.9 ± 7.3 cm and 123.4 ± 8.1 cm for female and male individuals, respectively; unpaired t-test, $P > 0.05$), nor was there any relationship between individual size and home range size (r^2 = 0.21, P = 0.25, N = 8). The mean home range size equaled 5.6 ± 1.6 ha (range = 0.4–13.4 ha; Table 1); males had a mean home range size of 6.3 ± 2.1 ha, whereas females had a mean home range size of 3.3 ± 1.9 ha. Home range sizes did not vary as a function of study site ($F = 1.07$; df = 3,4; $P = 0.46$) or tracking season ($F = 0.21$; df = 1,6; $P = 0.66$).

Subjects were observed ascending into the arboreal habitat on five occasions and were positioned in the arboreal habitat 53.5 ± 11.9 % of all relocations (a grand mean of values for each snake). The DBH of the occupied trees averaged 40.4 ± 10.9 cm. Vines (e.g., *Toxicodendron* [poison ivy], *Vitis* [wild grape], *Parthenocissus* [Virginia creeper]) were present along the trunks of 84% of the trees occupied by snakes, but this value did not differ from the availability of vines on trees in either habitat (based on sampling of all trees within 10 m radius from relocation point; Chi-square test, $P > 0.05$). Use of the arboreal habitat was a function of the habitat in which the snakes were studied ($F = 29.2$; df = 1,6; $P = 0.002$); snakes in bottomland hardwood forest (WRNWR, N = 3) were relocated in arboreal habitat more often than snakes in upland forest sites (N = 5; 90.7 ± 2.3 % and 31.2 ± 8.2 % of relocations, respectively). Accessibility to subjects limited the number of occasions when cloacal temperature could be recorded; these values ranged between 17.8 and 36.6°C.

Although a low sample size precluded statistical verification of the results, the mean male home range size (6.3 ± 2.1 ha) was larger than that estimated for female subjects (3.3 ± 1.9 ha). Weatherhead and Hoysak (1989) reported that home range size for male black rat snakes in Ontario was over five times that of females, and attributed the disparity to differences in activity associated with mate location (Gibbons and Semlitsch 1987; Gregory et al. 1987).

Several observations of predation by subjects occurred during the study. Snakes were recorded ingesting prey on two occasions (*Cardinalis cardinalis* [northern cardinal] nestlings and *Sigmodon hispidus* [cotton rat]). Following initial collection, one of the WRNWR subjects regurgitated three wood duck (*Aix sponsa*) eggs. Additionally, a regurgitated rock dove (*Columba livia*) hatchling was found within 3 m of the subject's position.

Gray rat snakes are known predators of arboreal nest contents (Jackson 1970, 1978; Mullin et al. 1998) and among North American *Elaphe*, tend to be more arboreal than other subspecies (Jackson 1976). Snakes in our study were positioned in arboreal settings in over half of the relocations. Peaks in breeding activity of many forest bird species overlap broadly between April and mid-June (Baker 1938). Thus, snakes remaining in the arboreal habitat throughout the bird breeding season may not experience any decline in prey availability while simultaneously avoiding their terrestrial predators. Snakes were observed in arboreal habitat as early as 20 March and as late as 21 November, but were relocated in this habitat type most often between 1 May and 15 June (56.0 % of relocations within that period).

Snakes in bottomland forests (WRNWR) were positioned in arboreal habitat more often than snakes in upland forests. Part of this discrepancy is a result of portions of the WRNWR site being flooded between March and late-May. Mean home range size for these snakes (5.6 ± 0.6 ha, N = 3) did not differ from the mean size estimate for subjects studied in the upland forest habitat (5.5 ± 2.7 ha, N = 5), suggesting that inundation of bottomland forest habitat does not restrict rat snake movements. Use of aquatic habitats during the activity season has also been shown in black rat snakes in Ontario (McAllister 1995).

The estimated home range size for gray rat snakes (5.6 ± 1.6 ha) fell within the range of home range sizes reported for a closely-related subspecies, the black rat snake. Home range sizes reported elsewhere for black rat snakes studied in a variety of habitats vary 20-fold (Durner and Gates 1993; Fitch 1963; Stickel et al. 1980; Weatherhead and Hoysak 1989). While some of this discrepancy could be attributed to differences in movement patterns associated with habitat or sex (Weatherhead and Hoysak 1989), the relocation method used may confound estimates of home range size. While we concede that our sample size is limited (possibly resulting in a lack of significance in our analyses), our home range estimates were similar to those of other researchers using radio-telemetry to relocate snakes. We suggest that the relatively large home range estimates based on mark-recapture methods (≥ 12 ha: Fitch 1963; Stickel et al. 1980) should be interpreted with caution because individuals cannot be relocated often enough during a single activity season (Madsen 1984; Rose 1982).

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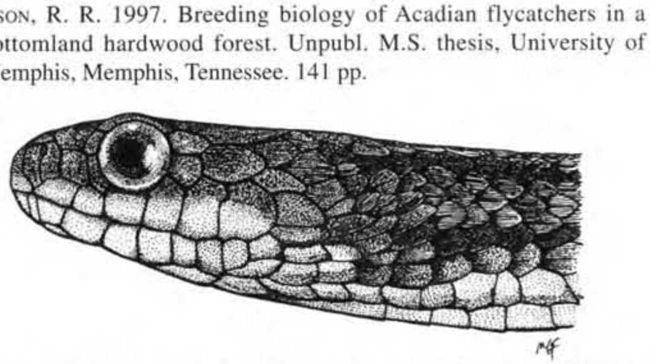

Regina rigida (Glossy Crayfish Snake). Illustration by Michael G. Frick.