

ARTICLES

A FIELD STUDY OF THE TIMBER RATTLESNAKE IN LEAVENWORTH COUNTY, KANSAS

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Introduction

The Timber Rattlesnake (*Crotalus horridus*) is native to the eastern one-third of Kansas, occurring west into the Flint Hills and east to the Atlantic Coast throughout the Deciduous Forest Biome (Braun 1950). Since it occurs in the most heavily populated parts of the United States, it has steadily lost ground from habitat loss and killing by humans. The shrinkage in range and numbers of Kansas Timber Rattlesnakes convinced us of the need for a field study while it was still possible. It is hoped that our findings may be applicable to conservation efforts for the species.

Materials and Methods

Morphological (Pisani et al. 1973) and molecular (Clark et al. 2003) studies indicate that New York snakes are the same species as ours in Kansas. The binomial is thought to be appropriate for all populations, including the canebrake rattlesnake which was formerly recognized as the southern subspecies "*atricaudatus*."

Our study was made in 2003, at or very near the Frank B. Cross Reservoir in Leavenworth County, adjoining the University's Nelson Experimental Tract on the east (Figure 1). Casual observations made in the general area from 1948 to 2003 supplement the main findings. A spring 2003 search of about 100 m of rock outcrop along the north side of the Reservoir yielded 26 rattlesnakes. Six were equipped for radio-telemetry, and all others were scale-clipped for indi-

vidual recognition and equipped with passive integrated transponder (PIT) tags. Radio transmitters were surgically implanted intra-abdominally by the University's Animal Care veterinarian, James Bresnahan. On 26 April 2003, the radio-equipped snakes were released and were trailed almost daily throughout the summer.

The habitat consisted of a mixture of woodland (mainly in narrow bands around hilltop and upper slopes) and grassland. The open areas were mostly dominated by the introduced pasture grass, *Bromus inermis*. Occasionally there were relict clumps of native tallgrasses, big bluestem (*Andropogon gerardi*), and Indian grass (*Sorghastrum nutans*). Goldenrod (*Solidago* sp.) was often dominant. Other common forbs were dogbane (*Apocynum cannabinum*), common ragweed (*Ambrosia artemisiifolia*), aster (*Aster* sp.), tall thistle (*Cirsium altissimum*), oxeye daisy (*Chrysanthemum leucanthemum*), tall eupatorium (*Eupatorium altissimum*), snow-on-the-mountain (*Euphorbia maculata*), ironweed (*Vernonia interior*), and wooly verbena (*Verbena stricta*). There were clumps or isolated bushes of smooth sumac (*Rhus glabra*) and roughleaf dogwood (*Cornus drummondii*). Poison ivy (*Toxicodendron radicans*) was common. Tall weeds growing through dead brush were pokeweed (*Phytolacca americana*) and hemp (*Cannabis sativa*).

Along the rock outcrops were bands of trees 17 to 35 m wide, with trunks up to 30 cm or more in diameter consisting of osage orange (*Maclura pomifera*), honey locust (*Gleditsia triacanthos*), American elm (*Ulmus*

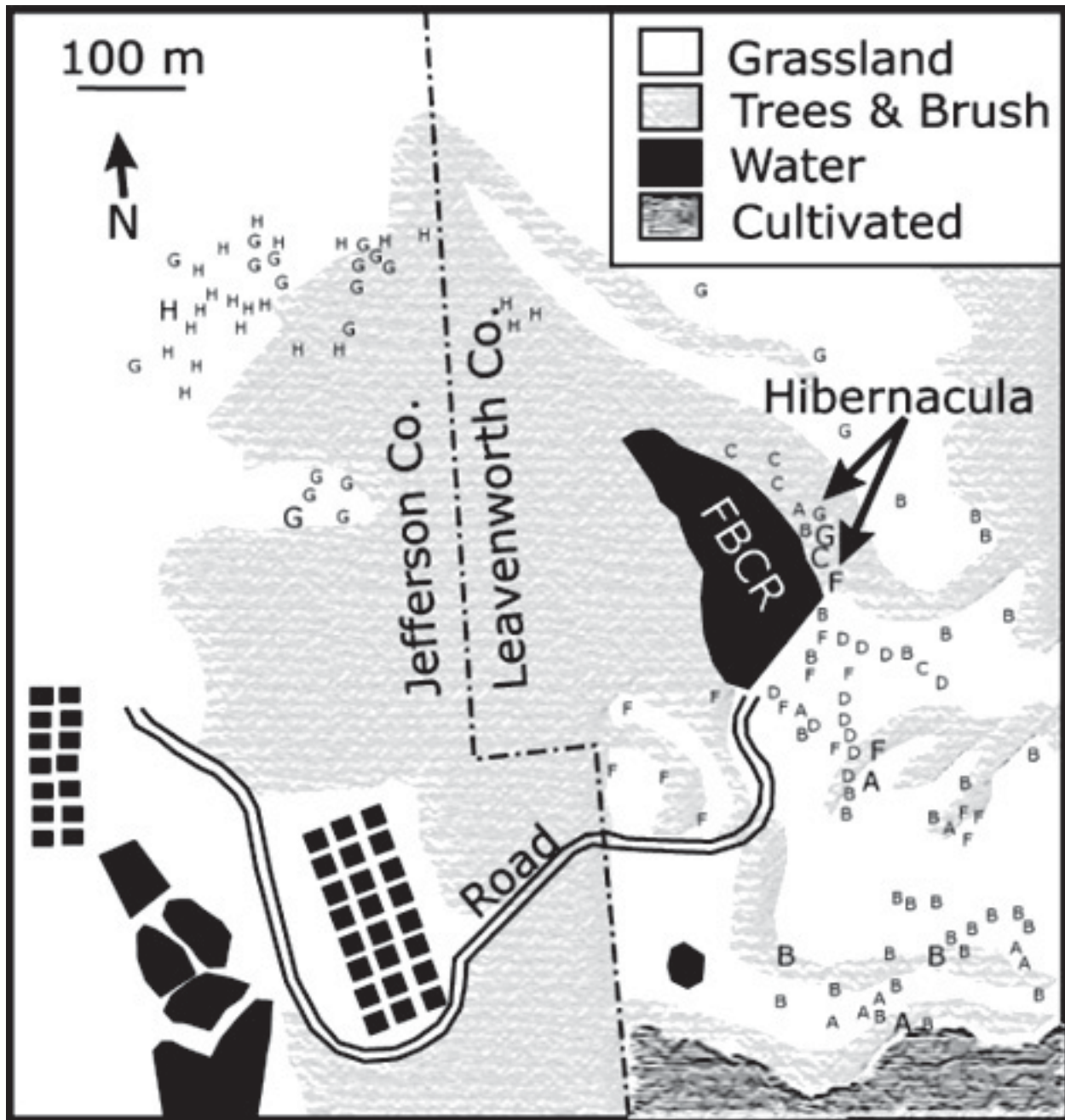


Figure 1. Map of Frank B. Cross Reservoir (FBCR) area, showing locations for all seven Timber Rattlesnakes telemetered and trailed in 2003; A = adult male; B, C and F = gravid adult females; D = nongravid adult female, G and H = immature females. Snakes often spent several or many consecutive days at a given site. Large letters indicate sites that snakes abandoned and later revisited.

Americana), walnut (*Juglans nigra*), common hackberry (*Celtis occidentalis*), cherry (*Prunus serotina*) and various other seral species.

In the grassland, the prairie vole (*Microtus ochrogaster*) is the principal prey species, whereas the Florida woodrat (*Neotoma floridana*), white-footed mouse (*Peromyscus leucopus*) and Elliot's short-

tailed shrew (*Blarina hylophaga*) are associated with trees. The woodrat is important not only for food but also for shelter. Its dome shaped stick houses are favorite hiding places. The rats themselves are subject to periodic die-offs, but their homes last for years, and provide shelter not only for the snakes but also for some of their prey species.

Results

For each of our telemetered snakes there follows a summary of activity during the 2003 season with mention of movements, social interactions, habitat and feeding. These day-to-day records suggest differences between the sexes, between adults and immatures, and between pregnant and nonpregnant females.

The only male of our telemetered snakes was an adult (No. 99, SVL 1120 mm, weight 1426 grams). After release on 26 April, he made several short daily movements eastward along the rock outcrop, then on May 3 moved southeast down a grassy slope to the drainage channel of the reservoir, swam across (about 2 m) and went to a gully that was choked with weeds and dead brush on the southeast side of the reservoir. He stayed there from May 4 to 17, then moved south up the grassy slope to the lower (316 m) rock outcrop, traveled along it for 133 m west, then back east along the rocks. On May 18 he had met our gravid female, No 96 (neither snake seen, but they were under a rock together). From May 19 to June 10, he was back in the same gully where he had stayed in early May. On June 11 he had moved back out of the gully and south up the grassy slope to the hilltop and east along the rock outcrop for 100 m. He was captured and found to have eaten a prey item of wood rat size. After release on June 30 he was found to have moved back west along the rock outcrop. On July 2 his signal could not be detected, and he was missing for the next 47 days, but then was rediscovered on August 12 within 10 m of his last known refuge. On August 13 he moved 95 m west along the outcrop; on August 14 and 15 did not move; on August 17, moved 21 m west along the outcrop; on August 22 did not move; on August 23, moved 5 m east along the outcrop, on August 24, moved 210 m, where he remained August 26 to 29. There was no search August 30 and 31. On September 1, he had moved 210 m east along the outcrop; on September 2, had moved 7 m southwest, stayed there September 3. For the next nine days, he was in a deep crevice and nearby rolls of discarded fence wire blocked his signal except at very close range. He stayed in the same shelter until September 26, then emerged and moved about 50 m down across the grass to the lower outcrop. On September 27, there was no search. On the 28th and 29th he remained at the same place; September 30, no search; on October 1 he had moved an estimated 400 m, back to the denning area, and was under a limestone slab with No. 93A female.

Our telemetered female No. 96 was gravid, probably with her first litter of young (SVL 880 mm, 460 grams, six rattle segments plus the button, seven ova palpated). From April 26 to May 6, she stayed at the

release point; on May 7, moved 200 m east along the outcrop, on May 8, moved 20 m back, on May 9, she moved 17 m to the edge of the reservoir, on May 12 and 13, she moved south about 100 m up the grassy slope to the lower (371 m) outcrop, and there she met our telemetered male No. 99 in a thicket, was with him on May 18 and remained there after he left until May 31. She was almost stationary until June 20, and then she moved 17 m up to the hilltop outcrop, 123 m. She made only slight movements staying essentially in the same place until July 25, and then she moved 29 m east along the lower outcrop. On July 15 she moved 2 m. On July 25, she moved 20 m east along the lower outcrop. On August 2, she moved east along the hilltop rocks, and on August 3, she moved 130 m down to the lower outcrop and moved 146 m west along it. On August 6, she moved 25 m. On August 5, she was back at the gully near its south end, and within a few meters of where she had crossed in May. She stayed at this same spot for three days, then on August 9 made her longest movement of 270 m, up the slope to the hilltop, and east along the rock outcrop to the same woodrat nest where she had stayed a month earlier. The next 14 days were spent at this rat house. On August 26, she moved out, and on August 29, returned to the same rat house where she had been on July 29. On August 30 and 31 there was no search. On September 1, she was in the same rat house, on September 2, moved 2 m east; same September 3 to 15. On September 16, she moved 15 m WSW. She stayed there until October 2, then moved downhill to the gully, crossed it and was beside a large tree near the south end of the dike. On October 6, she had moved across the dike to the hibernation outcrop and seemed to have begun hibernation in a deep crevice.

Our telemetered female No. 93 was the only casualty. She was gravid, probably for the first time (SVL 880 mm, weight 496 grams, six rattles and a button). On May 1, she had moved 66 m east along the rock outcrop from the release point. On May 5 she had turned back 56 m to the south on the downhill side of the dike, out in the grass near the outlet rocks. On May 9, she had moved back 66 m west along the outcrop and was near the water's edge. On May 13, 14 and 15 she was there with a recently scale-clipped adult male. On May 17, 18 and 19 she moved 33 m back east along the outcrop. On May 23, she made a 66 m movement west and was at the water's edge. On May 26, she had made a 46 m movement back east and was in an abandoned beaver lodge at the edge of the water. She remained there until May 31, then moved north up the slope 53 m to the upper end of the band of trees and was in an abandoned woodrat house June 6 to 8. On June 10 she was back in the beaver

den and remained there until June 20. On June 23, her transmitter was found on the ground about 17 m from the beaver den, and it was obvious that she had been caught and eaten by a predator. More than three inches of rain during the night had obscured the evidence.

Our female No. 93A was a replacement for the original No. 93 and used the same transmitter (93A was gravid, SVL 855 mm, weight 660 grams, six rattles and a button). She was captured June 19 at a rock outcrop beside the road, about 100 m south of the boat dock on the south side of the reservoir. She was released July 2. On July 3, she had moved 50 m north along the outcrop on the north side of the road. On July 5, she had moved 47 m northwest across woodland and grass. On July 7, she was at the shore of the reservoir just west of the dock in thick grass and weeds. On July 9, she had moved 64 m west, uphill to the band of trees and stayed in about the same place until a 42 m trip back to the docking area on July 23. She remained in that vicinity until July 29, then moved 148 m across the dike to its northeast end. From July 21 to August 13, she was near the northeast end of the dike, with several movements of up to 13 m between two dilapidated rat houses and a massive limestone slab, always out of sight beneath one of these shelters. On August 14, she had moved 13 m southeast, and on the 15th to 19th was in a rat house. On August 28, she moved 3 m south; on August 29, moved one meter west to a rat house. August 30 and 31 passed with no trailing. On September 1, she had moved 4.5 m north to another rat house and was there Sept. 2 to 5. On September 6, she moved 17 m west to a large boulder and was there September 2 to 22. On September 23 she moved 2 m uphill to another massive slab and was there on September 24 and 25, when she was caught and examined and found to be parturient. On September 25, she moved west along the outcrop; from September 26 to October 10, she was in a den hole with No. 99 male, 83 female and 52 female.

Our telemetered female No. 83 (SVL 1042, weight 490 grams, six rattle segments with the button missing) was the only one that was nongravid. After several days at the release site, she made a series of several short movements to the east. On May 1, moved 20 m east; on May 7, moved 5 m north, then on May 10 had moved 58 m down the grassy slope to the outlet pipe of the reservoir where she remained until May 15. On May 17, she moved 31 m up over the dike to the edge of the water in the reservoir. On May 18, she was back in the pipe, and for the remainder of May she made only short movements, ranging from 1 to 33 m on the downhill (east) side of the dike. On June 2, she had moved 106 m southeast through the grass, crossed the drainage, and was in a brush-filled gully

with No. 99 male. On June 4, 5, 6 and 7, the two were together but were not seen. Mating may have occurred. On June 30, she had moved south about 27 m up the gully and was in a bush at its upper end where she stayed until July 27. Then she moved about 10 m down the gully and stayed there until September 10, when she was caught and weighed. She was released on September 11, and was in the same place on September 12; no search on September 13; on September 14, she had moved down the gully; on September 16, she was at the mouth of the gully where it emptied into the creek, on September 17, she had crossed the creek and moved toward the lake and for the next week was in rocks beside a large elm on the downhill side of the dike. On September 22, she had moved across the dike to the denning area on the north side and was in the same hole with female No. 93A.

Our female No. 81 was an immature in her second year (SVL 646 mm, weight 189 grams, rattle string two segments plus button). Released on April 26, she remained in the same place until May 5, then moved 27 m north out into the grass, then made daily short shifts of 20 m, 7 m, 3 m, 7 m, 3 m, 2 m, 3 m, 0.7 m, same place, 1 m, 0.7 m, 0.7 m, 1.5 m, same place, 0.3 m, same place; May 28 to 30: 1.5 m, same place, same place; June 3, 1 m; June 4, 17 m west along edge of woods; June 5, 3 m; June 6, no movement; June 7, 66 m west; June 8, 17 m west; June 9, same place; June 10, 17 m northwest; June 13 to 20, same place; June 21, 20 m north to upper edge of the trees; on June 26, had moved 360 m west; June 27, 10 m southeast; June 28, same place; June 29, 2 m; June 30 to July 2: same place; July 3, 17 m northwest; July 4, 47 m west; July 5, 3 m west northwest; July 6, 13 m south and 3 m west; July 7 same place at little cedar tree; July 8, coiled on branch of little cedar 0.3 m above ground; July 9 to 14, at same little cedar; July 16, moved 18 m north to fence between open grassy fields; July 20 moved 66 m south of fence in field; July 21 had moved back to fence and climbed locust tree 5 m above ground; July 22, at least 20 feet high in locust and poison ivy vine; July 24, moved 40 m back along fence; July 25 and 26, same place (in locust tree); July 27, moved 18 m west along fence; July 28, moved 2 m south; July 29, moved 1.5 m northeast; July 30, back to fence and 3 m along it, 10 feet high in locust. August 1 and 2, same place. August 3, in locust; August 4, same tree, 12 feet high; August 5, moved 20 m west (inside an abandoned and half buried tire at the fence). August 6 to 9, same place. August 10, moved 3 m east, August 11 to 13, same place. August 14, 2 m east; August 15, inside tire; August 17, moved 65 m east along fence; August 18,

same place. August 19 moved 17 m west along fence; August 20, base of locust tree at fence; August 21 in tree. August 23 had moved 3 m east, August 24 and 25, same place. August 26 moved 17 m east, August 27 moved 21 m west. August 28 moved 21 m east, August 29 was in field 33 m north of fence. August 30 and 31, no search. September 1, 7 m southeast. September 2, same place, 20 m north of fence. September 3 moved 7 m northwest; September 4, 33 m north of fence. September 5 moved 2 m west. September 6, moved 3 m northwest to small osage orange tree. September 7 and 8, same place; September 9, had moved 40 m east. September 10, same; had eaten a short-tailed shrew (*Blarina hylophaga*). September 11 to 14, same place. September 15, in tree at least 20 feet high. September 16 had moved 10 m north. September 17 had moved 100 m east in woods. September 18 no signal on this date. On Oct. 20 her signal was located evidently deep in the rocks about 250 m of the original release point on 26 April.

Our female No. 52 was thought to be a third year young (retarded and still not mature. SVL 665 mm, weight 181 grams, string of six rattle segments and a button). Released on April 26, she remained at the same place until May 4, then moved 20 m northwest, out of the band of trees along the outcrop, into the grass of the north facing slope. May 19, 7 m northeast; May 11, 30 m northwest; May 12, 20 m west; May 13, 12 m west; May 14, into grass on the north facing slope and made short movements there until May 18, when she turned south through the band of trees to the shore of the reservoir. May 21, 0.6 m east; May 22, 0.3 m north; May 25: 0.2 m west. On May 26 she made a 120 m move onto the open grassy slope, on May 29 moved 8 m north; for the next six days, made only short movements in the grass, but then, on June 3, moved 125 m northwest. She made movements of only a few feet on June 4 and 5. On June 6, 3 m west; on June 8 moved 8 m south; on June 11, moved 66 m west to the edge of a grassy field. Through the remainder of June, she stayed in the corner of this field making short daily movements up to 10 m. On July 5, she moved 32 m east southeast and made only short daily movements until July 25, then moved south out of the field and then made only short daily movements until July 27. Could not be found on July 28 nor until August 13, when she was found about 266 m south of where she was last recorded. On August 16, she moved south across a field to a small cedar, and on August 17 to a large dogwood clump. On August 18 she had moved 50 m north. On August 19 she was 83 m south of the fence in the grassy field near its highest point and stayed there for three days. On August 23 she was in a little dogwood clump 15 m

south of the fence and stayed there August 24 and 25. On August 26 she was in the same burrow where she had been on August 17 and stayed there August 27, but on August 28 she had moved 43 m southeast and was coiled in the grass. On August 29 she had moved 8 m northwest and was coiled in the grass. August 30 and 31, there was no trailing. On September 1, she was in the southern part of the field, 32 m north northeast of a small cedar tree and remained there on September 2, then moved 19 m southeast on September 3. On September 4, she had moved 43 m northwest; on September 5, 33 m south; approximately the same place on September 6 and 7; on September 8 had moved 3 m west and had eaten a short-tailed shrew (*Blarina* sp.); on September 9 had moved an estimated 66 m south to a cedar tree within 13 m of the north edge of the woods. She was there until September 17, then made a long movement east across the field to near its eastern edge. On September 18 she made another long movement east to where she had been in May. On September 20 she moved 33 m southeast across grass to the edge of the woods, stayed at the same spot on September 21. On September 22 she moved back into the woods and into the same rock crevice where she had been caught emerging in mid-April.

To summarize the records of movements, three of the five telemetered adults moved to the southeast to private land, and all were consistent in keeping to the bands of trees along outcrops, where there were dead trees, tall weeds and loose rock, except that on rare occasions they crossed open, grassy areas between these shelters. They tended to be sedentary and spent periods of days beneath a woodrat house or a massive boulder without emerging, but sometimes they made a series of short movements (less than 3 m per day) in different directions. They often returned to shelters that they had used earlier.

The two immature snakes differed from the adults in keeping to open terrain. They were usually found coiled in the grass. Often they were beneath a bush or shrub sized sapling. Our immature female No. 81 was the only one of our snakes that was found climbing in trees or bushes, but she was found climbing on several occasions, and once stayed in the same locust tree for six consecutive days.

Evidently the snakes that we studied were a discrete colony. Perhaps there were many more such colonies to the north, northeast and northwest, in hill country where the Cuesta Formation continues, with rocky slopes and not much cultivation. The 26 *Crotalus horridus* captured within a short time as they were emerging from hibernation represents a minimum figure, and doubtless some were missed. There were

thirteen males and thirteen females. Attempt was made to estimate the age of each snake on the basis of its size and the number of its rattle segments. There were eight adult males (940 to 1070 mm SVL), four that may have been three-year-olds (with intact strings of nine segments) and a single second-year snake (three segments plus button). The females included two adults (820 to 883 mm SVL), seven possible three-year-olds (mostly with six segments and a button, 740 to 880 mm SVL), two second-year snakes (with two or three segments plus button) and two first year individuals, each with only a button. Not included in this group was a neonate captured on 22 September.

An adult male captured on 27 April had been caught and marked on 4 September, 1995 on the Biotic Succession Area of the University's Nelson Environmental Study Area. In the interval of 55 months he had gained from 891 to 1007 mm SVL and from 745 to 1125 grams. The two capture points were just 1000 m apart. At first capture he was believed to have recently completed his fourth year, and thus was in his ninth year at the time of recapture.

Discussion

Many ecological studies (e.g., Brown 1993; Martin 1992, 2002; Galligan and Dunson 1979; Gibbons 1972) have been made on this fairly common and widely distributed snake species, revealing a remarkable diversity in life history in different regions. It is still unclear whether such differences result from locally adapted populations, or if instead, individuals have a broad range of flexibility, enabling them to adapt to a spectrum of conditions.

The time required to attain sexual maturity is a good example of such geographic variation. In Brown's (1993) New York population, females reach maturity and produce litters at nine or ten years of age. In contrast, our records indicate that in northeast Kansas, rattlesnakes usually mature in the third year and produce litters when they are three years old, but some may delay maturity until the fourth year. In the time required for one generation of *Crotalus horridus*

in New York, a Kansas pair might mature, multiply and become great- great- grandparents, with hundreds of descendants. Of course the growing season is longer in Kansas than in New York, but in South Carolina, with a growing season even longer than in Kansas, Gibbons (1972) found that it takes six years for females to mature (with a somewhat larger size at maturity than our Kansas snakes).

In New York, hibernacula are in the mountains on talus slopes. The heavily wooded slopes with dense shade may limit availability of suitable hibernacula. The snakes make long migrations, concentrating at hibernacula in the fall and dispersing in the spring. On our study site in Kansas, no such extensive migration occurred. The snakes emerged singly or in twos or threes from many different hibernacula along the hillside. Scent trailing in this species is well-known (Weldon et al. 1992; Brown and MacLean 1983; Seigel et al. 1987), and it may play a role in guiding several snakes to a common shelter. Also, these snakes may use airborne pheromones, as suggested by the sudden, long, up-wind movement of the telemetered adult male in May to join female No. 96.

The movements of individuals do not correspond well with the concept of "home range." The use of "minimum convex polygon" models gives a highly distorted view of their actual behavior which tended to be restricted to narrow bands of habitat. These factors have conservation implications for the species in areas of human development which may create significant barriers to dispersal and/or return to dens. Although our study included only one telemetered adult male, we found no discernible difference between the extent of his movements and those of the adult females (Table 1). In a four-year telemetry study in North Carolina that included six female and four male Timber Rattlesnakes, Sealy (2002) found that males had larger home ranges and on average moved both greater distances and more frequently than the females. Both of our immatures ranged mainly on the edges of open brome fields or into a terraced old-field tract, and they had ranges separate from those of the adults during the entire 2003 season.

Table 1. Comparison of average daily movements in male, female, and immature Timber Rattlesnakes. Numbers for distances moved are given as percentages for each category.

Age/Sex	Sample Size		Distance moved per day				
	Snakes	Records	0 m	1-10m	11-20m	21-30m	30+m
Adult Male	1	62	85.5	1.6	—	5.6	8.1
Adult Female (nongravid)	1	80	91.0	3.7	1.3	—	3.7
Adult female (gravid)	3	154	69.0	6.5	1.2	7.8	15.6
Immature	2	160	41.2	30.0	7.5	8.8	12.5

Since Audubon's time it has been well known that Timber Rattlesnakes occasionally climb trees, and various reasons (thermoregulation, hunting, escaping flood waters) have been postulated. In Nebraska, Fogell (2002) observed four instances of arboreality, including one of a gravid female. Of our seven snakes, four adults and two immatures, only the supposed two-year old was observed to climb, but she was in trees on many occasions. It is still unclear whether arboreality is correlated with either age of the snake, or with geographic distribution.

A surprising aspect of behavior was the rarity of feeding in our telemetered snakes. During the unusually long and hot dry spell of the summer, we recorded no food records, but in that time, the snakes tended to stay out of sight under shelter. The two gravid females were not known to take food for the entire season. Some feeding incidents may have been missed, but apparently each of the snakes went for periods of weeks without a meal. The adult male did not feed until July, and then apparently ate a woodrat. He was missing from July 4 to August 12, and might have fed during that interval, and he might have eaten again in late August/early September. The immatures, Nos. 52 and 81, each took a meal in September.

When individual counts are not feasible the "Petersen Index," involving their ratio of recaptures after a preliminary period of capture and marking is usually utilized. In this case the telemetered snakes complicated computations. They cannot be counted for recaptures. From 18 to 26 April 18 rattlesnakes were captured, marked and released, and seven of these were equipped for radiotelemetry, leaving a group of eleven that could serve for the census. In a follow-up census period 27 April through 11 June, ten snakes were caught, of which three were recaptures from the 15 to 26 April group. The recaptured marked snakes were thus 30 per cent of the sample, and the number actually present should be shown by multiplying $3.33 \times 11 = 36.7$ (plus the seven telemetered snakes = 43.7).

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