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ARTICLES

The Timber Rattlesnake in Northeastern Kansas

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Introduction

The geographic range of the Timber Rattlesnake (*Crotalus horridus*) corresponds approximately with the Deciduous Forest Biome in the eastern half of the United States (Shelford, 1963). Because its range encompasses metropolitan centers, interactions with humans have been frequent, usually resulting in the killing of rattlesnakes and/or destruction (intentionally or otherwise) of den sites. Consequently, over most of its range its numbers are diminishing, and in many areas it exists as disjunct populations. While public prejudice persists to some degree, and many people will kill a rattlesnake whenever and wherever they see one, change is underway. Public education campaigns, nature centers at public recreation areas, and a heightened awareness of natural fauna and resources have begun to shift public perception to admiration of this species as a symbol of our wild heritage and an appreciation of its role as a predator of rodents. A definite societal trend now favors preserving these animals, and many states have enacted laws (enforced to varying degree) protecting Timber Rattlesnakes from wanton collecting or killing (Brown 1983).

In recent decades, many field studies of Timber Rattlesnakes have been initiated in different parts of its range, especially in eastern states. The growing body of knowledge about the species has gradually clarified that its habits and seasonal habitats vary across the great expanse of its range, and this has added incentive to conduct studies in new localities with investigators pooling findings on a regular basis.

In 1948, when herpetological studies began on the University of Kansas Natural History Reservation, Timber Rattlesnakes were moderately common on the property and were given top priority as a species to be studied (Fitch 1999). An important finding was that these snakes require extensive open areas for basking. The University's management plan for the Reservation allowed unchecked succession, with the result that arborescent vegetation spread and the snakes dwindled correspondingly. In 1964, after 103 had been captured and marked, the last putative resident was captured. During the 1950s and early 60s the records were indicative of a resident population on the Reservation, but it was gradually dwindling— apparently due to the extension of forest and concomitant shading of the sunny places that the snakes seemed to require. The decrease was gradual. Although wandering snakes from relatively remote dens could not be distinguished with certainty from the remaining population, it seemed that the resident population had disappeared after 1964. During the late 60s and the decades of the 70s and 80s, thirty more snakes were captured and marked. These were mainly wanderers from various adjacent properties, and most often were encountered on county roads.

In the 1990s it became evident that there was a colony on University of Kansas land near the newly constructed (completed June 1991; Pittman, pers. comm.) Frank B. Cross Reservoir (FBCR). The locality is ca 1 mile N of the northeastern corner of the Natural History Reservation. This and other tracts referenced herein are managed by the Kansas Biological Survey and Ecological Reserves (KBS/KSR). From then on, GRP was an active participant in the capture and processing of rattlesnakes, especially from 2003 onward; as a consequence, our sample size has greatly increased. During the construction of FBCR, several rattlesnakes were killed by workers in the area, but the population survived. Habitat consisted of much more open terrain than the Reservation had provided. It was mainly grassland except along the hillside rock outcrops. Trees up to a foot in diameter were limited to a 50-ft wide band along the ledge outcrops, and smaller woody plants— mainly Rough-leaved Dogwood (*Cornus drummondii*), Smooth Sumac (*Rhus glabra*), Coralberry (*Symphoricarpos orbiculatus*) and Blackberry (*Rubus ostryiafolius*)— grew between the trees. Debris from bulldozing (boulders, logs, etc.) was scattered along the FBCR shoreline, interspersed with tall grasses and forbs. Woodrats (*Neotoma floridana*) were numerous, and their dome-shaped nest mounds were a prominent feature of the landscape along the ledge outcrop. The nearly 15m depth of the impoundment required close to 2 years to completely fill, and the surface presently is ca 4m below the hibernacula, which are at the top of an outcrop of the Toronto Limestone member of the Oread Limestone (generally on the 1010-1020ft elevation contours on the N shore of FBCR). The area lies in a zone characterized by Whittemore (1991) as "although lying in the glaciated region of Kansas is essentially characterized as Osage Cuestas affected by glaciation and glacial deposits of loess and till."

Movements and Demography

In the 2003 season (discussed in greater detail by Fitch et al., 2004), six Timber Rattlesnakes (one adult male, three adult females, two first-year young— both females) were captured on April 18th as they emerged from their hibernacula. These six snakes were equipped with Holohil radiotelemetry transmitters on April 24, 2003 and were monitored daily through the 2003 season. An additional 15 rattlesnakes were captured, processed and released as they emerged from these same hibernacula through the last 2 weeks of April 2003.

Compared with *C. horridus* from other parts of the species' range, the telemetered snakes were notable for their sedentary behavior and lack of any long movements, always within 1km of the den ledge. In the following few weeks, the four adults moved independently generally eastward along the ledge, and then SE, downslope through a field of mixed pasture grasses and Yellow Sweetclover (*Melilotus officinalis*) to (on private land) a degraded, grazed, rocky pasture along a generally NW-facing slope that is crossed by two limestone ledges, one at its upper border with a field of mowed brome grass (*Bromus*) and the other ca. 50m downslope. The upper ledge is lightly wooded, predominantly with Osage Orange (*Maclura pomifera*) and Honey Locust (*Gleditsia triacanthos*). The lower ledge is more sparsely wooded with the same prevailing species. Many Honey Locust saplings occur through the pasture. The entire pasture area is within 1km of the den ledge. Summer of 2003 was exceptionally hot and dry, with many July-August days close to or above 38°C; no measurable precipitation fell through June, July and August. Telemetered adults during July and August daylight hours frequently were within woodrat (*Neotoma floridana*) nest mounds.

The two telemetered immature females, both of similar size, departed the den ledge by moving to the top of the ledge and then generally in a NW direction along the wooded den ledge's border with an open brome field N of it. Both immatures travelled ca 0.8km NW to two neighboring tracts. Female-52 (numbers correspond to transmitter frequencies) moved about through an old-field tract overgrown with forbs and several species of trees, mainly Red Cedar (*Juniperus virginiana*) and Rough-leaved Dogwood (*Cornus drummondii*). Female-81 primarily utilized habitat along a fenceline between that area and a more open brome field to the north. Female-81 displayed distinct climbing tendencies, and readily ascended trees (mainly Honey Locust or species harboring ascending vines like Poison Ivy). It is likely the locust thorns and ascending vines provided access to the upper branches of these trees. On several occasions she climbed 6m or more above ground level as judged from angle of signal reception to a highly directional accessory antenna. The thermoregulatory potential of this behavior was discussed by Fitch and Pisani 2004. Female-52 never climbed. These two snakes on occasion used the same Dogwood clones along the fenceline, though they never were recorded in a clone together. When farthest from the den ledge, they were less than 10m apart; it is not known whether they associated with each other.

With the onset of cool weather in mid-September, all four of the adults and one of the immature females independently began to move toward the den ledge. Female-52, the adult male, and one of the adult females re-entered the same den openings from which they were captured in April. The remaining adults had already emerged from the ledge when captured, making it impossible to ascertain if they also returned to the same crevice from which they had emerged in April. The adults essentially backtracked their dispersal routes, whereas Female-52 at first moved S to the edge of the tract she had utilized all summer, then turned E moving towards FBCR, and finally NE where she crossed a nearly dry creek and moved to the N margin of the ledge; from there she moved ca 300yds E to her den crevice. The other immature female began to return to the ledge as well, essentially backtracking her dispersal route. However, her signal was lost overnight ca 0.2km from the den ledge. It is unknown whether she entered hibernation there, was killed and removed by a predator, or whether her transmitter failed.

The telemetered adult male utilized a somewhat larger home range (Fitch et al. 2004) than the adult females, a pattern that also was evident during the 2004 field season. Adult males in general have been shown to follow this pattern in other parts of the species' extensive range (see Brown 1993, Martin 2002). Miscellaneous captures of other snakes through May-August 2003-2006 would seem to corroborate this behavior in this population. At various times, we have been called to remove rattlesnakes from the yards of residents up to 0.5 mile from the den ledge; all these snakes were adult males, nearly all found in the vicinity of buildings. We also have responded to contacts from residents of neighboring counties regarding Timber Rattlesnake sightings near buildings, and again, nearly all snakes were adult males.

On 11 June 2006, two gravid females were recaptured. One (910mm SVL, 8 embryos) had moved 200yds E along the den ledge since 22 April; the other 900mm SVL, 6 embryos) had since 31 March moved a total of 300yds (100yds E, and 200yds S across the FBCR dam). Both were captured in late afternoon as they basked in partial shade. The latter female appeared to contain a partly-digested meal. It had gained 36g since 31 March, whereas the other snake had lost 44g.

Other than the 6 telemetered snakes, recaptures from the 2003 sample and from snakes marked at this location from 1990-2002 have been very few. Noteworthy among these is the 27 April 2003 recapture at a location ca 0.6 mile S of the den ledge of an adult male marked on 14 September 1995 (SVL gain 116 mm; weight gain 380 g). In 2003, in large part due to monitoring telemetered snakes, there were 52 captures (35 recaptures— largely of telemetered snakes for weighing) of snakes from this population.

Table 1. Captures and recaptures of Timber Rattlesnakes.

Year	Total Captures	Recaptures	% recaptures
2004	18	4	22.2 %
2005	22	5	22.7 %
2006 (Spr)	29	17	58.6 %
MEAN	23.0	8.7	37.7 %

Table 2. Age cohort and sex by year (1990-2006) of Timber Rattlesnakes captured and recaptured in vicinity of FBCR.

Year	Adult male	Adult female	Neonate	Immatures	Recaptures
1990	-	2	1	1	-
1991	3	1	-	5	-
1992	-	-	-	-	-
1993	3	1	1	-	-
1994	4	2	-	-	-
1995	6	2	-	-	-
1996	1	2	1	1	-
1997	8	3	1	-	-
1998	1	2	-	-	-
1999	3	2	1	3	-
2000	1	1	-	-	-
2001	3	2	-	4	2
2002	2	1	-	-	-
2003	7	2	-	-	-
2004	3	1	-	6	4
2005	2	7	2	7	10
2006	2	4	2	7	16

Numbers for subsequent years are:

In 2005 and 2006, substantial samples were obtained. From the mean numbers of captures vs recaptures, we can begin to estimate the total number of snakes in this local population. Using the simple arithmetic ratio: (Mean Total Capture ÷ Mean Number Recaptured) X Mean Total Capture = N (Total Population) yields an estimate of 61 snakes. That number seems plausible, but it assumes that all snakes taken within a half-mile radius were members of this local population, and that catchability was the same for all of them (an assumption to which we shall return below). Sundry other ways of estimating the population can of course be used, but the reality is that censuses based upon these relatively small samples have a fairly wide margin of error. Performing a similar calculation on the Spring 2006 data and arbitrarily dividing the capture period in two (March 31-April 16 vs. April 17-June 11) provides an estimate of 34.5 (rounded to 35) snakes— also within the realm of possibility.

With regard to catchability, we suspect, but cannot yet prove that there is an "investigator effect," with snakes altering their seasonal and daily movements to avoid capture, either by people or anthropogenic devices such as traps and drift fences. Adult snakes which have experienced trapping, handling and human interference with their normal activities may be more wary and elusive than snakes lacking these experiences. The single telemetered adult male (Male-99) of 2003, after being located and disturbed for observation on several occasions that year, became highly elusive in 2004. In Summer 2004, a drift fence was installed perpendicular to the long axis of the den ledge to intercept snakes returning to their hibernacula in September and October. Funnel traps installed in openings in the fence captured 6 rattlesnakes in September 2004. In the entire field season of 2005, with funnel traps installed to intercept snakes moving east in Spring and west in Fall, just two snakes were caught. Two were trapped in Spring 2006 (one recapture from 2005; one new), and both were caught (14 April, 16 May) in the trap at the north end of the drift fence. It is possible that some snakes, perhaps ones that emerged in early April, modified their dispersal route to avoid the fence, with others scent-trailing them later in the emergence and dispersal of 2006.

Table 2 shows numbers of snakes caught each year from 1990-2006 near FBCR, and their sex plus estimated age categories. Young are born in September with only the natal "button." Some young shed (gaining a new rattle segment) before hibernation, but most do not and young with only the button may be found as late as June. By the time they are a year old, most have gained four rattle segments in addition to the button. Two-year olds have mostly passed

Table 3. Rattle segments and SVL in mm for male and female *C. horridus*. Numbers are: mean (range; s.e., N)

Rattle segments	SVL(mm) Males	SVL(mm) Females
Button only	384.1 (298-482; 14.29; 18)	381.3 (311-470; 8.04; 21)
Button + 1	492.3 (464-531; 20.01; 3)	405.7 (348-495; 45.29; 3)
Button + 2	592.3 (525-678; 12.02; 12)	562.1 (540-580; 5.26; 7)
Button + 3	675.2 (628-720; 17.98; 5)	609.8 (582-652; 14.9; 4)
Button + 4	781.9 (682-915; 38.34; 7)	720.6 (504-807; 54.99; 5)
Button + 5	748.3 (658-814; 46.69; 3)	No Data
Button + 6	799.0 (716-870; 36.57; 5)	778.2 (644-900; 27.48; 9)
Button + 7	994.5 (994-995; 0.5; 2)	920.8 (883-960; 21.80; 4)
Button + 8	923.0 (893-955; 17.93; 3)	830.5 (700-961; 130.5; 2)
Incomplete, 4-5 segments	979.9 (825-1270; 45.98; 9)	989.3 (930-1038; 31.63; 3)
Incomplete, 6-12 segments	1055.7 (816-1196; 37.27; 10)	982.8 (950-1031; 19.94; 4)

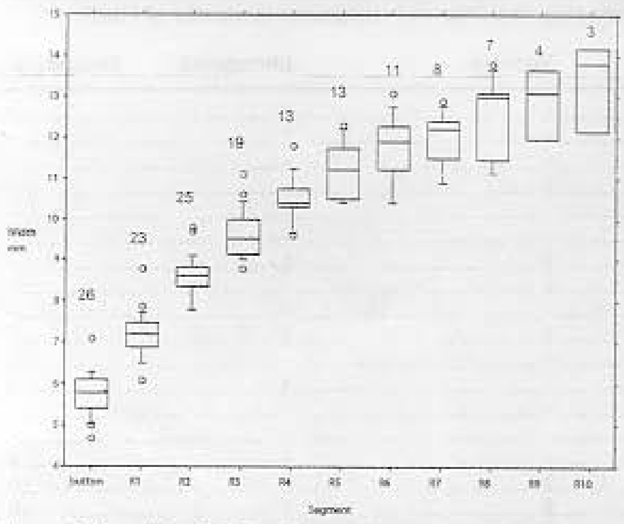

Figure 1. Boxplots of *C. horridus* rattle segments, FBCR sample, 2004-2006.

600 mm SVL and have at least six rattle segments. Some may breed in their third year.

Table 3 shows size (SVL) plus number of rattle segments for males and females over the 17 years 1990-2006. It shows that growth is erratic, and is correlated only in a general way with number of rattle segments. Young of the year, still having only the natal button, are most evident in October. Some gain an additional segment in that month but most enter hibernation without shedding. Some still have only the button the following May or even June. It is remarkable that snakes with one rattle segment plus the button are rarely seen. Those with only a button were seen 6.5 times as often, and those with a button plus two segments were seen nearly 3 times as often. A possible explanation is that young snakes grow very rapidly and spend less time in the button-plus-one stage.

Figure 1 lends support to this possibility. In 1993, summarizing their work with *Crotalus atrox* in Oklahoma, Fitch and Pisani examined the correlation of SVL with base rattle segment width (BSW) in 1,418

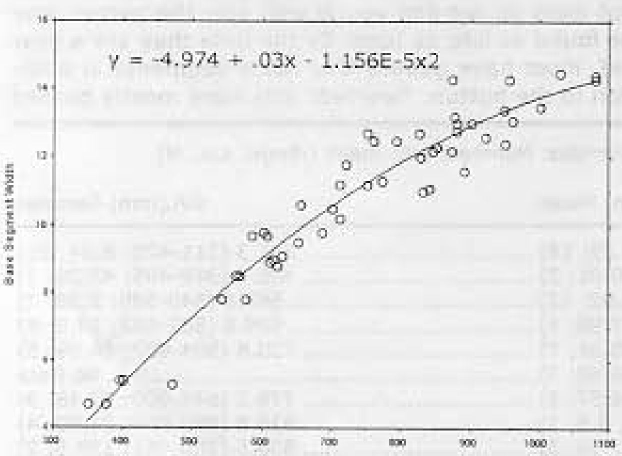

Figure-2. Second-order polynomial regression of BSW on SVL.

snakes and found it to be very high at all sizes ($r = 0.94$). This, coupled with the fact that every segment was once a base segment, means that each rattle with distinct taper reflects growth of that animal. To apply this information to our study of *C. horridus*, we first derived mean segment-size classes from complete strings (those with button present), and then incorporated less complete ones by statistically matching the terminal several segments to existing classes (rather like looking at forest growth by matching patterns in tree rings). Klauber (1956:313) introduced the "tree ring" approach and briefly described the relationship between BSW and SVL for *C. lucasensis*.

In this study, of 127 snakes 18 (14.2%) had lost the button, and usually other segments as well; 76 (60%) were first-year young having 1-4 rattles including the button, 36 (27.4%) were second-year young. Those that had lost rattles were the oldest and their ages could not be accurately estimated.

Young *C. horridus* from the FBCR population (2004-2006 data) make significant ($p=0.95$) gains in SVL through their 4th shed, after which increases are steady but of lesser magnitude (Figure 1). Log-transformed data for SVL (X) and BSW (Y) were compared (linear regression) for sexes separately; no significant ($p=0.95$) differences were noted in slope or Y-intercept. Data for sexes were therefore pooled; a 2nd-order polynomial regression of SVL vs BSW yields an approximation of the growth of snakes in this population (Figure 2).

Timber Rattlesnakes are long-lived, and our recapture (Fitch and Pisani, 2002) of an adult male nearly 24 years after marking— at an apparent age of 28 years— gives some perspective. While large snakes with incomplete strings of uniformly-sized rattle segments cannot be aged accurately, they can be estimated to be at least 10 years old (5 years to grow the tapered string that was lost, and perhaps 5 years more to produce their incomplete string of uniform-width segments).

Feeding

Over a 58 year period, 17 instances of predation by Timber Rattlesnakes were obtained (Table 4).

As a result of their larger size, males took (at the upper limit of size) larger prey than did females, including both cottontails and the Gray Squirrel. Males took two of the 5 voles, the bog lemming, and 3 of the 4 White-footed Mice. The Least Shrew was eaten by a neonate. A larger sample might have shown neonates to take small lizards and snakes as they are known to do elsewhere in the range (Reinert et al., 1984).

Table 4. Prey obtained from Timber Rattlesnakes.

Species	Number of instances
Prairie Vole (*Microtus ochrogaster*)	6
White-footed Mouse (*Peromyscus leucopus*)	4
Eastern Cottontail (*Sylvilagus floridanus*)	2
Hispid Cottonrat (*Sigmodon hispidus*)	2
Gray Squirrel (*Sciurus carolinensis*) adult	1
Southern Bog Lemming (*Synaptomys cooperi*)	1
Least Shrew (*Cryptotus parva*)	1

Table 5. Enlarged follicles from female *C. horridus*.

# of Enlarged Follicles	Number of snakes
4	1
5	1
6	6
7	3
8	4
9	3
10, 13, 14	1 each

Reproduction

Reproductive habits are known to vary geographically under the influence of climate. Reproductive females that emerge from hibernation already have enlarging follicles that can be detected and counted by palpation of the abdomen. Twenty-one females that we examined were reproductive; see Table 5 for numbers of enlarged follicles palped.

Twenty-seven females were not noticeably gravid; however, nine of them were captured in late August, September or October, and might have already given birth. Excluding these 9 leaves 18 non-reproductive adult females, a number closely approximating the 21 that were reproductive. We conclude tentatively that our female snakes are on a 2 year cycle, breeding in alternate years. Twenty-one gravid females averaged 898.4mm SVL (range 803-1038mm). Table 6 shows data from four litters born in captivity between 1994-2002.

Discussion

Crotalus horridus occurs across one of the largest and most ecologically diverse geographic areas of the species in this genus; the species shows considerable plasticity in habitat use and life history parameters. Eastern Kansas, at the extreme west limit of this range, provides opportunity to contrast and compare parameters with populations elsewhere in the country. Given this species' longevity, and also the increasing probability of a social structure within local populations (see Greene et al., 2002), our work is best categorized as in its early stages, with much yet to learn. Females in Kansas mature and become reproductive far earlier than in eastern populations; neonates of both sexes increase in mass and SVL faster than in eastern populations (Martin, pers. comm.); home ranges of adult females and subadults of both sexes are not only smaller than in many other areas of the species' occurrence, but also involve open fields of mixed forbs and grasses rather than woodland or woodland edge habitat typical elsewhere. This habitat usage may reflect an abundant food source of voles (*Microtus*) in these habitats, perhaps greater abundance than prey utilized elsewhere, especially by smaller snakes. It is our goal to more closely examine the questions raised by these and other observations over coming years.

Table 6. SVL and weight of captive born *C. horridus*.

Number in litter	SVL range	Weight range (g)
7	318-403	19-28
4	302-336	13-25
6	303-323	30-39
6	283-310	23-34

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