Short-distance translocations of timber rattlesnakes in a North Carolina state park A successful conservation and management program

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John B. Sealy
1158 Piedmont Springs Rd. Danbury, NC 27016
jbsealy@crotalushorridus.org

Introduction

In 1992, I began a mark-recapture study of a disjunct population of timber rattlesnakes (*Crotalus horridus*) at Hanging Rock State Park, a 6,192 acre wooded, upland area in north-central North Carolina. In 1993 I began using radiotelemetry to collect life history data, locate critical habitats, and determine the range and status of the population. The population is over-represented by females due to road and incidental kills of more vagile males and evidence suggests the population is experiencing a decline (Sealy 1997).

Hanging Rock State Park represents a rattlesnake-hostile habitat intersected with trails, campsites, and roads. The park receives >400,000 visitors borne by >100,000 vehicles annually, providing numerous opportunities for the public to encounter rattlesnakes. During the course of this study I have become involved in assisting the Park's personnel in managing rattlesnakes discovered in areas of human activity.

Prior to my study, the resolution of these encounters would take the form of distant translocations of the offending snake by park personnel. These translocations often exceeded two miles in length. The distant translocation of nuisance rattlesnakes is a common practice in North Carolina's state parks. I conducted a survey and found that parks reporting a nuisance problem (n=10) moved snakes an average of 2.5 miles from the capture site (range 0.5 to 5 miles). The goals of this well-intentioned practice are three-fold: to remove the perceived threat to the public's safety, to insure the survival of the animal, and to prevent the animal's recurrence as a nuisance. By all indications, long-distance translocations (LDTs) appeared to be a successful management practice. The perceived threat to park visitors was removed, it was assumed that the snakes were thriving in their new locations, and it was unknown, but also assumed, that the offending snakes were not recurring.

My observations of telemetered snakes over several years indicated that their movements in this population were not random. With few exceptions, telemetered snakes chose specific denning sites repeatedly, using nearly identical pathways and specific shelter rocks during movements into and out of their dens. Throughout the active season snakes were often found within a few meters of marked locations for the same snake in previous seasons. Snakes showed a marked familiarity with specific natural structures throughout their ranges in successive years. It became possible to make accurate predictions as to the general area an individual snake would inhabit at different times throughout the season. Mean maximum distances snakes traveled from their dens were 0.68 miles for males (n=2) and 0.4 miles for females (n=4). These observations suggested to me that the snakes' normal activity patterns may be disrupted as snakes were being translocated outside of their familiar ranges.

In this study I was unable to assess the effects of LDTs on the behaviors or survival of snakes. The two telemetered LDT snakes were not monitored for a time sufficient to draw any conclusions, however, there is a growing body of research documenting the negative effects and lack of biological success of LDTs. When moved outside their familiar home ranges, snakes cease normal behaviors and begin aberrant movements, presumably in search of familiar range (Fitch and Shirer 1971, Galligan and Dunson 1979, Hare and McNally 1997, Nowak 1996, Landreth 1973, Reinert 1995). In Reinert's (1995) study, translocated snakes experienced a mortality rate greater than three times that of the native population.

When tracking rattlesnakes in habitat so imbued with human structures and activity it is interesting to find that at times the animals are quite close to people. Undiscovered rattlesnakes are not a nuisance. Several telemetered individuals were adept at avoiding roads, parking lots, trails, and campsites by either stopping within a few meters of these structures and reversing their direction, or by changing their movements to parallel these areas. These snakes otherwise behaved quite normally in these situations, conducting their normal activities undetected as close as 6 m from areas used by people. I hypothesized that short-distance translocations (SDTs), at distances surely within the snakes' familiar ranges, might achieve the goals of long-distance translocations.

Methods

From July 1992 to August 1996 I compared the success of short and long-distance translocations. I defined a short-distance translocation as a distance <200 and long-distance translocations as >300 m. Translocations were deemed a success if individuals did not recur as nuisance snakes in the same season.

All snakes were uniquely marked with indelible ink by writing a number on both sides of the base rattle segment (Martin 1993). Juveniles <2 years-of-age, too small to mark by this method, were excluded from the study.

I performed implantation surgeries using methods described by Reinert (1992). Snakes were confined for two days prior to release to insure that healing had begun.

I used SM-1 transmitters manufactured by AVM Instruments LTD, Livermore, CA. Transmitter/battery configurations were wired in parallel. This package yields a life expectancy exceeding 10 months. Transmitting antennas were 40.5 cm in length. Implant subjects were chosen so the 10-12 g package did not exceed 5% of body weight. Snakes were located using a TRX-1000s receiver manufactured by Wildlife Materials Inc., Carbondale, IL. The receiver and transmitters were specified to operate on a frequency of 150 MHz and have a potential range of 500 m.

When collecting data using radiotelemetry, field locations were identified with surveyor flagging marked with the snakes rattle number and the date. Snake locations near human activity were flagged after the snake had moved to a new location. Movements and translocation distances were usually made with a Walktax Distance Measurer. Some translocation distances (<100 m) were paced off and considered to be accurate within a few meters. When these methods proved impractical, capture and release locations were plotted on USGS 7.5 min. topographical maps using a Peet 20' interval altimeter and distances were then calculated from the maps.

Nuisance snakes were captured by park personnel using tongs or hooks and held in a "snake" box until I could arrive. Holding times ranged from 1 to 24 h. Release locations for snakes moved a short distance were chosen by considering the animals direction of travel and the location of human structures and use areas nearby. All translocated snakes were released to some form of cover such as dense thickets of fallen limbs or trees, stump holes, or rock slabs. Snakes found near areas used extensively by visitors were usually released near dusk on Sundays. The park has the fewest number of visitors at this time; giving the animal its best chance to reorient itself and move away. Snakes found on trails and roads were processed for physical data, marked, and released as soon as possible.

Results

I recorded 19 short (<200 m) and 12 long (>300 m) translocations (Table 1) from July 1992 to August 1996. Of 31 total translocations, 96.8% were successful regardless of distance. All snakes monitored until the end of their season over-wintered successfully. The only recurrence in the same season was a snake moved 700 m. There have been 3 recurrences of SDT snakes in subsequent seasons during the period.

Table 1. Summary of translocation distances of nuisance timber rattlesnakes at Hanging Rock State Park.

	n	mean	range (m)	recurrences
Short Distance	19	90.25 m	(40-200)	0
Long Distance	12	721.0 m	(300-1600)	1

I have monitored 7 translocated individuals after release. Five of these were short-distance translocations. These five soon resumed normal behaviors of foraging, mate searching, and mating. The behaviors after release of the seven snakes are summarized below.

Snake No. 8, a female, was captured as a nuisance on the most heavily used trail in the park. Released on 12 July, 50 m from the trail, she moved an additional 100 m from the trail continuing in the direction of her translocation where she resumed typical foraging behaviors of nongravid females. On 28 July, during mating season, I discovered a male 6 m from the female. I monitored her for two additional seasons and determined that the area where she moved upon her translocation was within 100 meters of her den. During this period she was found to forage within 80 m of the trail. After these two seasons, I removed her transmitter. The following year No. 8 was discovered consuming a chipmunk on a different section of the trail by a park visitor. The visitor called the ranger office by cell phone and asked that someone come kill the rattlesnake. No. 8 was rescued by a park ranger and translocated again 80 meters from the trail.

No. 25, a male, was discovered in sparse vegetation between two campsites. I released this snake 100 m away in the adjacent woodlands. His initial movement was 450 m where he was found in a hollow log. The next day he had returned to within 100 m of his release site and 30 m from a different campsite where he resumed typical behaviors of foraging and then mate searching. Monitored for two seasons, No. 25 could often be found 30 m from the campground; an area marking the northern limit of his home range.

No. 23, a female, was captured on the campground road where it is bordered on both sides by campsites. Released 100 m distant, she moved 300 m, continuing in the direction of her translocation to a large, rock slab. Seventeen days later I observed No. 23 accompanied by a male and two days later copulating (Sealy, 1996). The initial movements of this female had taken her deeper into the area I determined in subsequent years to be her home range. In the three seasons monitored, this female never again approached the campground.

No. 20, a female, was discovered by park employees while cleaning debris from a drain culvert adjacent to the main park road. Translocated 60 m, snake No. 20 moved 1000 m in 17 days to an adjacent mountain top. Once there she settled into the normal movements and foraging behaviors of nongravid females for the remaining three months of the season. Such a distant "one way" movement was perplexing until she revealed that her den was close by on top of the mountain. Her transmitter was removed upon successful emergence from her den the following spring.

No. 9, a female, was captured in 1993 just after dark on the campground road where she was exiting a wooded area between two campsites. She was discovered by a camper returning to the campground by automobile, an occurrence few snakes survive. I translocated this snake 200 m from her point of capture and 200 m east of a row of vacation cabins. Upon release, the snake crossed a gorge north of the cabins and moved to an area 500 m in straight-line distance from her release location. She remained in this area for five days. I then found that she had returned to within 4 m of the cabin road and approximately 20 m from a vacation cabin. Although not a nuisance, since not discovered, I translocated her again to the previous release point (see Liability Issues below). Once again she crossed the gorge, and made her way back to the same distant site. The lure of this site was revealed when in October she entered her den a few meters away. Her transmitter failed during the winter. No. 9's whereabouts were unknown until 1996 when she was captured on the campground road <50 m from her 1993 capture site. I translocated her to the same release site used twice in 1993. This year (1997), No. 9 was again captured <50 m from the previous years capture site. The campground is evidently within the home range of No. 9 and the campground road is an obstacle with which she must frequently contend. I have reimplanted No. 9, and as this is written, she is located <90 m from several campsites and a trail, and is accompanied by a nontelemetered male.

No. 21, an immature male, was captured by a landowner residing adjacent to park property. I translocated No. 21 a long distance (500 m) in a direction that my knowledge of the habitat suggested was probably away from his home range. He moved 2130 m in 73 days, relentlessly on the move and never settling into the typical behaviors observed in the other snakes. However, these observations are not conclusive due to early transmitter failure.

No. 19, a male, was captured outside the park boundary near a house on a gravel road that runs between two large, tobacco fields. No. 19 was released 300 m distant onto park property due to farming activity in the fields and the public roads and private homes nearby. Evaluation of the available habitat in the area indicated the translocation was in the direction of the origin of his movements. Upon release he made several excursions into a field where he could be found concealed in the high grass of erosion control strips intersecting plots of tobacco. No. 19 soon returned to deep woods and resumed typical movements and behaviors; once found in ambush posture (Reinert 1984). One month after his release, his partial remains were located with the transmitter. Circumstantial evidence at the site indicated that No. 19 had been preyed upon by a Great Horned Owl (*Bubo virginianus*) (Sealy 1997). No. 19 consistently moved away from his capture location and was displaying normal behaviors when preyed upon. I do not think that his translocation and subsequent demise are in any way related.

Discussion

Nonrecurrence

Why might snakes tend not to recur as nuisances? If translocated snakes were moving away from translocation release sites randomly I would expect more recurrences. My observations of telemetered nuisance snakes indicate that avoidance of their capture site is not random happenstance and may be a tactic consistent with predator avoidance behaviors. Having made hundreds of field observations, it is clear that when in cover, *Crotalus horridus* relies primarily on its natural coloration and secretive behaviors (procrypsis) as protection from predators. These behavioral characteristics are thoroughly documented in *C. viridis viridis* as well (Duvall *et al.* 1985). The combination of coloration and cryptic behavior is so effective that even telemetered snakes are often difficult to see when coiled on the surface of the forest floor. When approached in woodlands, timber rattlesnakes do not move or rattle, and rarely flick their tongues until disturbed. If stretched out while basking or moving, they do not coil, but lay motionless (Duvall *et al.* 1985) The snakes, usually found in a resting coil, may be visited repeatedly to within a few feet and yet remain at that spot, sometimes for many days. This behavior is consistent even in snakes that are located when coiled in cover a few meters from roads, trails, and campsites. It is necessary at times to physically examine telemetered snakes. When disturbed in this manner the snakes rarely demonstrate overt defensive behaviors, however, no matter how briefly or gently examined, the snakes will move some meters away after handling. Galligan and Dunson (1979) noted identical behavior in a Pennsylvania population. This unfailing response may indicate an association with the site and the disturbance (Brown 1993).

Open areas may represent an increased vulnerability to predators and are actively avoided by rattlesnakes in this population. Nuisance snakes are usually discovered when exposed away from cover. These snakes, in contrast to those in cover, invariably exhibit behaviors of flight, defensive coiling, and/or rattling. In a very few instances, the snakes strike in the direction of human captors. I hypothesize that snakes may experience nuisance captures as an encounter with a large predator when they are most vulnerable; creating a memorable, negative association to the capture location. Upon release in familiar surroundings, the snakes move away from the offensive location and seek to avoid the site.

Avoidance of open areas

Observations of the behaviors of several individuals suggest that there is active avoidance of open areas (Fitch and Shirer 1971). These snakes, monitored using radiotelemetry, traveled to areas near people, but remained undetected. No. 15, a 1921 g, 138 cm, telemetered male, dens on the park periphery >800 m from the center of human activity in the park. Migration within the 160 acre home range of No. 15 necessitates his negotiating many human areas and structures. In a two month period No. 15 crossed the park's most heavily traveled trail four times. On three of these occasions he sat coiled from 10 to 20 m of the trail for periods of up to 10 days. In one instance, knowing his precise location, I could see him from the trail. When approaching a large picnic shelter surrounded by tables scattered in open woodlands, he stopped within 100 m of the shelter. Turning 90°, he moved parallel to the area and a parking lot. During this movement he coiled <50 m from the 400 space lot during a weekend when it was filled to capacity. Continuing parallel to the lot he encountered a road and reversed his heading, moving back 100 m. Altering this heading 90° again, he encountered the curved road once more. Here he stopped for part of a day <15 m from the road edge. In the only daytime movement recorded for this snake, he moved back from the road 200 m and eventually made his way back towards his den and to areas free of human obstacles. I consider No. 15 to be a revealing example of nonrandom, deterministic behavior in habitat where human structures are routinely encountered. During the period, undetected, he exhibited typical behaviors of mate searching and foraging while negotiating a maze of human structures, trails, and roads.

No. 9, a female, has occurred as a nuisance three times in separate years (1993-96-97) on a 100 m stretch of the campground road. First captured and implanted in 1993 (see Results above), her transmitter failed during hibernation. I reimplanted her this year (1997) and am monitoring her movements. I released No. 9 at the same location of her previous three translocations. On two occasions she has been located 6 and 20 m from the campground road, once in ambush posture. She has spent weeks during this season <30 m from campsites and was often 6 to 10 m from a frequently traveled campground trail. When leaving the campground area and then returning, No.9 has each time crossed two campground roads and threaded her way between two rows of campsites separated by <12 m wide patches of woodland. On one of these campground traversals I found her <5 m from a tent. No. 9 crosses the campground at two separate sites 300 m apart. When moving between these two sites she travels close to (<30 m) and parallel to the rows of campsites. Throughout this season her behaviors have been typical of nongravid females. Several inferences can be made from this snakes behavior. No. 9 frequently contends with humans in her range. If roads were not a factor, her movements through the campground would rarely be detected. Her movements paralleling the campsites indicate she is aware of and seeks to avoid open areas frequented by humans. When crossing the campground she travels between the campsites where cover is available, but can not avoid traversing the open area of roads. First captured in 1993, and again in 1996 and 1997, my data concerning home range fidelity would indicate a high probability that in the 1994-95 seasons No. 9 was present, yet undetected, in the campground.

Occurrence in open areas

If rattlesnakes are adept at avoiding open areas, why might snakes enter areas where they are exposed? Clearly there are obstacles/open areas that snakes must traverse, such as trails and roads. Large open areas seem to be completely detoured. Hanging Rock rattlesnakes have never been found in parking lots, but snakes do enter open areas where they become exposed, and thus, discovered. Some of these occurrences seem based upon adherence to higher needs of reproduction and prey capture.

When premolt, reproductively receptive females are using the edges of open areas to bask, the searching behaviors of males may increase their chances of discovery. The capture of nuisance males and females in close proximity during mating season is not uncommon and it seems that little will deter males when scent trailing receptive females. Over a period of 4 days following the capture of a recently shed, nuisance female in a northeastern New York yard, three males were found at her exact capture site (Brown 1995). In Pennsylvania, Carl Hess (pers. comm.) was called to capture a nuisance male found in a yard. The next day he was called to the residence again and captured a premolt female. Having placed both snakes in the same container for transport and eventual release, they mated after the female shed. The next day another rattlesnake was found in the yard by the homeowners. Its sex was not determined, but I presume it was another male in search of the female. The one same-season recurrence in a LDT Hanging Rock snake seems related to reproductive behaviors as well. Early in mating season, No.2, a male, was captured near a parking lot on a park road. The next day, a premolt female was captured <3 m from the males capture location indicating that the captures had interrupted the male's scent trailing the female. Both of these animals were moved 700 m. Two months later, now quite thin, the male recurred as a nuisance on the road <50 m from his initial point of capture.

I have recorded numerous examples of snakes foraging near open areas. Most notable were two snakes captured in separate years in ambush posture adjacent to the same log. The log was 1.5 m from a trail, <20 m from the park's lake bathhouse and <8 m from picnic tables; completely surrounded by open areas and human activity. One of these snakes was discovered when park visitors noticed a chipmunk running atop the log. It seems likely in these situations that upon envenomation, their prey would scurry away and may be scent trailed into an open area. My hypothesis is supported by the following observations: A homeowner residing adjacent to the park captured a young-of-year (born the previous fall) rattlesnake found eating a mouse on the walkway just outside her door (Reneé Henry, pers. comm.). Upon finding a young-of-year a few feet from a picnic shelter, park personnel noticed a freshly killed mouse in the shelter. Snake No. 8 (see Results above) was discovered on a park trail consuming a chipmunk. I conclude that the imperatives of reproduction and prey capture may be greater needs than avoidance of open areas.

Liability Issues

The context in which I address liability issues concerning public safety is different from those that may arise on private lands. All animals occurring in the parks are protected by state statute from "molestation, collecting or killing." The park system's Resource Management policy states in part: "Intervention with natural processes may occur to compensate for disruption of natural processes caused by human activities and to prevent danger to human health and safety."

Hanging Rock State Park personnel warn visitors of the inherent dangers associated with its natural areas such as cliffs and waterfalls. Brochures available at the park visitor center and signs on information boards inform visitors that venomous snakes are present in the park and encourages, but does not require, patrons to remain on park trails. The occasional snakebites are from copperheads (*Agkistrodon contortrix*) and usually result from visitors molesting the snakes. I am not aware of any documented cases of rattlesnake bite in North Carolina's state parks.

Removing snakes found where they are perceived as imminent danger to humans and releasing them to an area where the snake is safe, and its chance of continued survival increased, is consistent with the statute and the policies of the park system. The snakes are there (as naturally occurring as the rock cliffs) and the parks are charged with protecting their fauna and flora. Rattlesnakes are found regularly in human use areas and the evidence indicates that many are nearby yet undetected. Once when transporting a nuisance snake for release, I encountered another snake approx. 60 m from a campsite, crossing an adjacent service road. Through July of this season (1997), 5 rattlesnakes, and 8 copperheads have been found in Hanging Rock's campground. Surely there were others undetected. Only one of these rattlesnakes was marked, having been released the previous season. Short-distance translocations are not increasing human/rattlesnake encounters. I feel certain that if rattlesnake bites were common, or if the snakes frequently recurred as nuisance snakes in the same season, that SDTs would be viewed differently by the park system's Resource Management Program and Hanging Rock's superintendent. At present, SDTs are not considered to be a liability issue. However, if one argues that SDTs are an issue, at what translocation distance does liability cease to be an issue? How long after a translocation would a snakebite by a animal moved a short distance be a negligence issue? In any case, a charge of negligence for a snakebite would seem unlikely unless research methods such as marking and radio implants would reveal the individual identity of the snake. Therein is the only liability issue with which I must contend.

While conducting this research I often know when snakes are near people. At times, ethical considerations and liability concerns require that I move snakes. If snakes are close (<20 m) from people and in areas where there is a reasonable expectation that people may tread, the snakes are moved. Three times this season, No. 9 has been in the campground and undetected by visitors, but was moved for these reasons. Snakes outside this radius rarely need to be moved. In situations where movements of snakes indicate that their traveling into campsites is imminent, they are moved. Whenever snakes are close by, they are monitored more frequently, often several times each day. In contrast to No. 9, No. 15 (see Avoidance of open areas above) never required that he be moved. When close to trails, inside the 20 m radius, he was thoroughly concealed and not in places where children may play or hikers walk. An entirely different situation than that of the campground.

Public reaction

The reactions to this research and to snakes encountered by the public and adjacent landowners/residents are mixed. Occasionally park visitors have killed snakes they encounter. Most kills are on park roads and I feel certain that many of these are intentional. It is encouraging, however, that park visitors often inform park rangers when rattlesnakes are found. Invariably visitors inquire as to what will be done with the snakes and are told of the ongoing research. The response from this group is favorable. If monitored snakes move close to a campsite and must be moved, I explain the situation to the campers. The most frequent response is fascination and some relief that I am monitoring the snakes movements. These discussions invariably lead to many questions about the life history of rattlesnakes and their conservation. The study is also thoroughly explained in several talks presented in the park each summer.

Two landowners residing adjacent to the park have captured snakes for the study and another has allowed me to track a snake to within 120 m of their home. However, this group as a whole does kill most rattlesnakes found in their fields and yards.

Summary and Conclusions

Short-distance translocations have proven to be a successful management practice at Hanging Rock State Park. The fears of the public are allayed when the perceived threat is removed, the animals soon resume normal behaviors, and there have been no same-season recurrences in snakes translocated a short distance. The three recurrences in subsequent years are evidence of SDT success and a confirmation that these animals are continuing to thrive within their familiar home ranges. The SDT snakes that moved relatively large distances prior to resumption of normal behaviors were evidently discovered on the periphery of their ranges. These snakes immediately moved back into the heart of their ranges, evidenced by my discovering their dens near these distant destinations. Three of the five monitored SDT snakes remained close to areas frequented by humans after release. These snakes, and monitored non-translocated snakes that frequented areas near humans, exhibited normal behaviors of foraging, mate searching, and mating; carrying out these essential behaviors of survival undiscovered scant distances from open areas frequented by humans. My observations suggest that snakes deemed a nuisance are discovered when traversing unnatural, open areas encountered during their migrations or when the imperatives of prey capture and reproduction suppress their inherent reluctance to enter open areas.

On average, 6 rattlesnakes are translocated from human use areas each year in the park; exclusive of juveniles <2 years-of-age and road kills in the same areas. It is unreasonable to believe that all snakes in these areas are found. Rattlesnakes are ubiquitous in Hanging Rock and there seems to be a significant degree of serendipity associated with their discovery. The snakes are there and seem to expend some effort to avoid human use/open areas. SDTs are not increasing human/rattlesnake encounters at Hanging Rock State Park, however, by allowing snakes to remain in their chosen habitats, managers may encounter some individuals again over the years. SDTs are not a perfect remedy, but more a compensation and compromise to address the intrusion of man into rattlesnake habitat. Snakes moved a short distance are in effect being escorted safely out of what is often a maze of human structures in hostile territory. SDTs do disrupt the activity of snakes, but the evidence indicates that the disruption is brief and creates no discernible, lasting affect on the animals.

In a discussion of conservation programs, Dodd (1993) makes two assertions: 1) that the first question to ask when developing conservation programs is, "What do we know about the species' biology?", and 2) that programs should begin with a goal in mind, and clearly defined objectives to achieve those goals. SDT is a practice based upon the biological needs of the species and therefore successfully attains the stated goals of LDT. SDTs render moot the host of biological, habitat, genetic, and disease transmission concerns associated with the various forms of moving reptiles or amphibians into novel habitats (Dodd and Seigel 1991, Reinert 1991). Rattlesnakes are not random wanderers (Reinert and Zappalorti 1988, Landreth 1973) and satisfy needs of survival by making functionally dedicated movements within their familiar ranges (King and Duvall 1990, Reinert 1984), visiting specific sites repeatedly (Brown 1992, 1993; Martin 1988, 1992; Sealy 1995, 1997; Reinert and Zappalorti 1988). In short, rattlesnakes know where they are, and their survival is dependent upon knowing.

The results of this study suggest that if rattlesnakes are provided a small measure of assistance, combined with a willingness of communities and the public to attempt some degree of coexistence, rattlesnake populations can continue to survive and thrive safely in close proximity to man.

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