Initial Den Location Behavior in a Litter of Neonate *Crotalus horridus* (Timber Rattlesnakes)

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Abstract - In September 2003, we monitored the movements of a postpartum *Crotalus horridus* (Timber Rattlesnake) and her four neonates via radiotelemetry. Upon dispersal, two neonates maintained a close association with the mother, but within one week they were making independent movements. Total movement distance by all five snakes during the first 10 days varied considerably (mother: 22 m; neonates: 3, 21, 49, and 154 m). Continued movements by neonates were independent and sporadic, with individuals staying several days in single locations. Excluding one neonate, all individuals converged to a single wooded, rocky hillside for hibernation (320 m from birth site). During their movements to the hibernaculum, one neonate was found with a subadult female and another neonate was found again with its mother. Our observations support the hypothesis that conspecific trails may be used by neonates during their initial den location.

Introduction

Behaviors associated with the dispersal of neonates remain unknown for most snake species. The primary reason for this is the general inability to telemeter neonates due to size constraints. Therefore, basic natural history data such as movement patterns, habitat utilization, and daily activity have not been documented for the neonates of most snake species.

Recent observations of crotalids (Butler et al. 1995, Greene et al. 2002, Holycross and Fawcett 2002, Price 1988) indicate that maternal attendance is common, typically persisting for a week to ten days, until the neonates' first ecdysis. Both the mother and neonates disperse after this period. Questions remain concerning the mother-young association once dispersion begins. Are behaviors from this point on independent of each other? Limited evidence in the field and laboratory indicates that neonatal rattlesnakes have the ability to trail conspecifics (Brown and McLean 1983, Graves et al. 1986, Reinert and Zappalorti 1988). Reinert and Zappalorti (1988) suggest that conspecific trailing may play a role in neonate snakes locating overwintering sites. However, it is unknown how independent the movements of sibling neonates are from those of their mother or each other.

This study was a preliminary investigation of the extent of conspecific trailing employed by *Crotalus horridus* L. (Timber Rattlesnake) in locating hibernacula. The study examines the independence of neonate movements and offers detailed insight into early movement patterns and

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hibernaculum location by neonatal snakes. We also tested a novel technique for using external radio transmitters to track small snakes.

Materials and Methods

Study species and field site

Crotalus horridus is widely distributed in forested regions throughout much of the eastern United States. However, relatively little is documented about its distribution and abundance in the southern US. Most of what is known about the ecology and behavior of *C. horridus* has resulted from long-term field studies in the northern portion of its range (Beaupre 2002, Brown 1991, Martin 1992, Reinert and Zappalorti 1988).

The study site for this project was a 340-ha state-owned tract comprised of a mixture of hardwood forest, cedar forest, cedar glades, cedar barrens, and field habitats located in Rutherford County, TN. The cedar glades and barrens are a unique feature of middle Tennessee (Quarterman 1950), and the adjacent forested elevations provide considerable limestone outcrops that appear to serve as gestation sites and hibernacula for a small population of *C. horridus*. The site is bordered by private property with abundant and increasing residential development.

Telemetry

In June of 2003, we captured and released two adult female *C. horridus* (one gravid, one non-gravid) surgically implanted with radio transmitters (Holohil SB-2, 5.2 g) following modified procedures of Reinert and Cundall (1982). On 1 September, we observed one female to be newly postpartum beneath a 0.8 m^2 rock. On 2 September, under the same rock, we captured this snake along with four neonates (two undeveloped embryos were also found) and transported them to the laboratory at Middle Tennessee State University. To minimize the effect of capture on potential maternal attendance behavior, we housed the female together with her litter in minimal disturbance until the neonates had undergone their first ecdysis. Three neonates shed on 7 September and one on 8 September. On 8 September, radio transmitters (Holohil BD-2HX, 1.65 g) were applied externally to the dorsum (Fig. 1) of the neonates using cyanoacrylate glue (i.e., gel Super Glue). Transmitter attachment was dorsolateral and approximately 70% of SVL in the caudal direction. This location corresponded well to being just posterior to the maximum body diameter. Transmitters ranged from 5.8 to 6.8% of neonate body mass. We released all snakes under the birthing rock on the morning of 9 September. Each snake was located twice per day (morning and evening) for the first ten days and once per day thereafter. However, for movement and substrate analyses, we only used one location per day. We recorded all movements for the mother and neonates using a compass and measuring tape.

Results

Within five hours of releasing the snakes on 9 September, the mother moved 21 m to a small rock ledge. The next morning we observed two

neonates ([#]2 and [#]4) within 1 m of their mother. These two neonates re-
mained within 1.5 m of the mother for five and eight days, respectively.
Neonate [#]2 was frequently located within 10 cm of the mother or in retreat
under the same rock ledge. Neonate [#]4 mostly remained arboreal in a sapling
within 1 m of the rock ledge. On 11 September, neonate [#]1 moved 18 m away
from the birthing site to a mossy/herbaceous area near a foot trail, in a
direction different from that of the mother. On 13 September, the fourth
neonate ([#]3) moved 2 m from the birthing rock in a different direction.

Over the next two weeks, the neonates made movements of varied
distances, few of which exceeded 3 m. While neonates [#]2 and [#]4 began
making movements independent of their mother, the two other neonates ([#]1
and [#]3) remained relatively stationary. During this time, the mother began
making lengthy movements, essentially ending any associations with neo-
nates, and spent much of her time in an old field habitat (Fig. 2).

Locations selected by the neonates during the first 19 days exhibit
considerable variation (Table 1). Neonates selected terrestrial locations (i.e.,
ground surface) and fossorial locations (i.e., burrows or under rocks) more
frequently than arboreal locations ($\chi^2 = 64.75$, df = 2, p < 0.001). However,
three neonates exhibited arboreal behavior at least once. Between 9–26
September, neonate [#]4 was observed arboreal on 14 days. On at least some
nights this neonate remained arboreal, even through thunderstorms. Mean
height above ground for this neonate was 1.7 m, but ranged up to 4 m. This
neonate was never observed in trees again after 26 September.

Figure 1. Neonate *Crotalus horridus* illustrating external transmitter placement.

Table 1. Location of occurrence in a single litter of neonate *C. horridus* during the postpartum
period. Only one snake location per day was used.

Neonate #	Days tracked	Terrestrial	Fossorial	Arboreal
1	41	39	2	0
2	39	20	17	2
3	39	30	8	1
4	42	10	18	14
Total	161	99	45	17

Neonates generally remained stationary and did not make daily movements to new locations (Fig. 3). We found that, on average, neonates moved further per day in October (14.8 m) than in September (4.8 m) (t = -1.71, 36.8, n = 52, p = 0.028). The longest movements were made between 19 – 26 October. During this time, three of the four neonates successfully located a rocky hillside that we later found to contain overwintering sites (Fig. 2). However, neonate [#]2 moved (> 300 m) in a nearly opposite direction. This individual lost its transmitter on 1 November and it is not known if it eventually located the same hibernation site as the others. Movements toward the hillside all occurred within a one week period and untelemetered conspecifics were located during this time. On 19 October, neonate [#]1 was with a subadult female under a piece of tin roofing. The next day, neonate [#]1 had moved 51 m to another piece of tin within 15 cm of its mother. The two remained together for the next four days. Neonate [#]4 was found within 2 m of another conspecific as it moved toward the rocky hillside. We observed three more conspecific associations involving neonates; how-ever, by this time, snakes were within 10 m of their hibernacula. All conspecific associations occurred during movements to the hillside where hibernation occurred. Neonate [#]4 lost its transmitter on 2 November, but the remaining two neonates entered hibernation with their transmitters attached and functioning. During the spring of 2004, neonate #3 emerged from hibernation with the transmitter still attached (albeit the battery was dead). In addition to the mother and her litter, we captured 22 additional *C. horridus* of various ages emerging from this communal overwintering site.
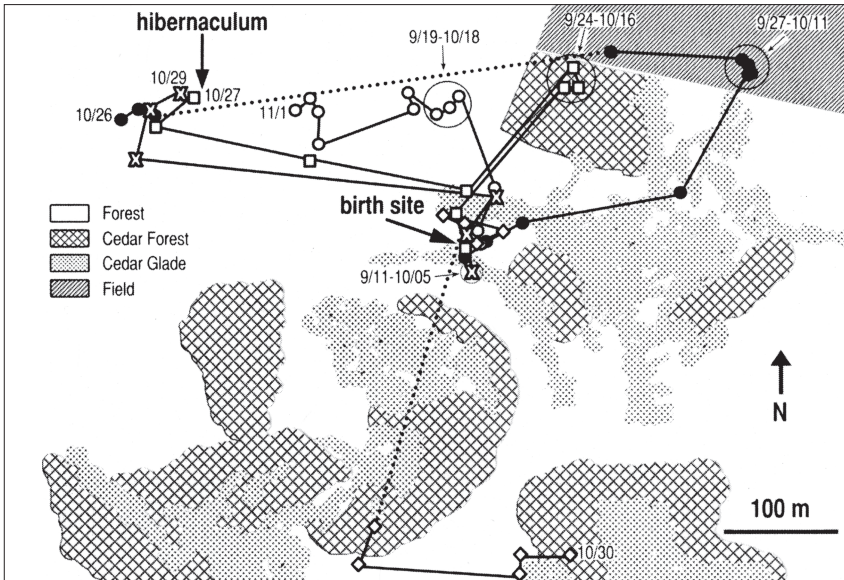

Figure 2. Movement patterns of a postpartum female (solid circles) *Crotalus horridus* and four of her offspring from birth location to hibernaculum. Individual neonates are [#]1 (x), [#]2 (open diamond), [#]3 (open square), and [#]4 (open cirlce). The two dotted lines for the mother and neonate [#]2 indicate short periods when transmitter signals were lost. Neonates [#]2 and [#]4 lost transmitters at their last indicated location.
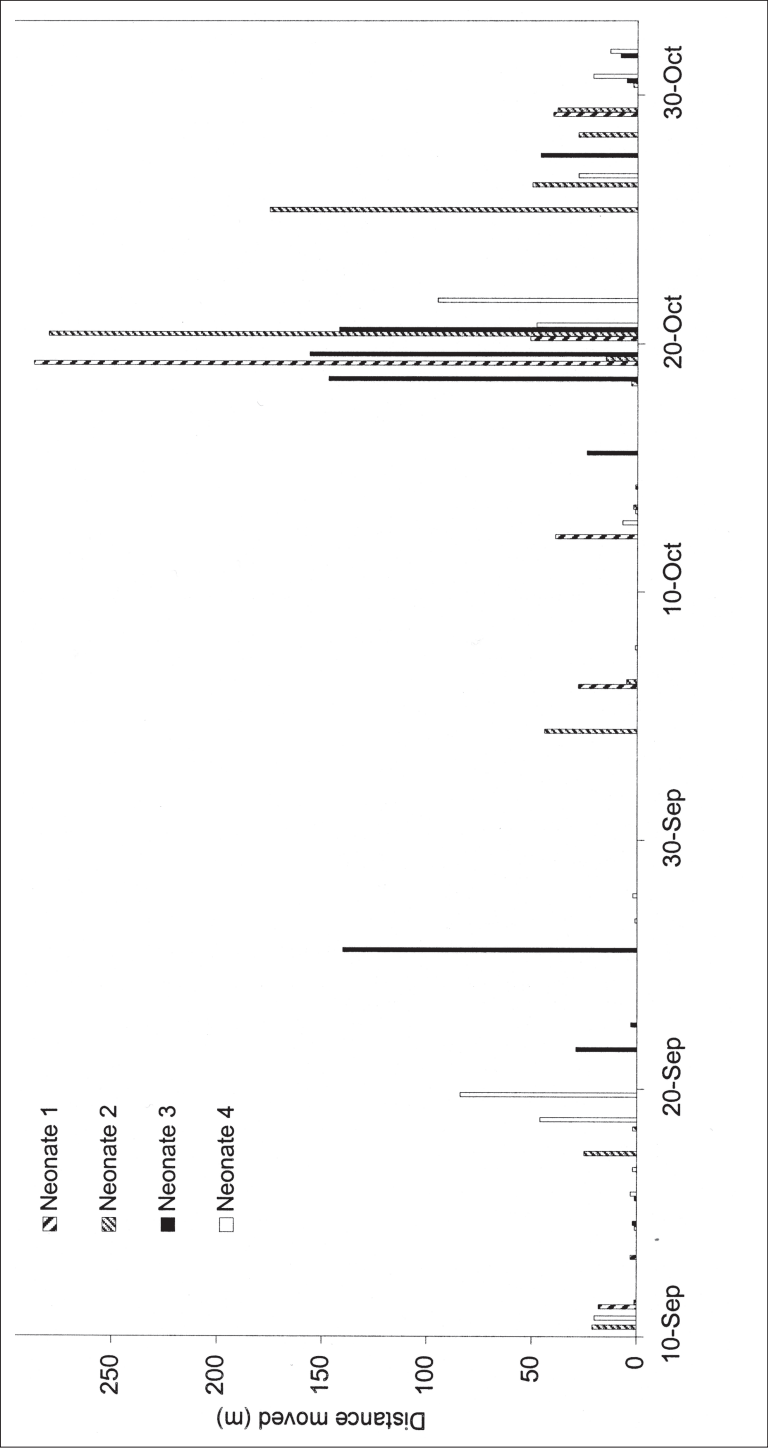
Figure 3. Movements of neonate *Crotalus horridus* between birth location and hibernaculum. Increased movement in late October is associated with movement to an overwintering site and indicates suspected conspecific trailing.

Discussion

Neonate behavior

Our study suggests that mother/neonate association may persist for short periods of time ($\approx$ 1 week) following initial dispersion from the parturition site and first neonate ecdysis. In this study, this association was from neonates trailing the mother and not the mother remaining with the neonates. Not all neonates trailed the mother, suggesting that this behavioral association may be weak and only exhibited by some individuals.

During the majority of the fall, we never observed neonates near conspecifics, nor was there any indication of conspecific trailing. Movements and trailing behavior toward a common hibernaculum began abruptly in late October. During this time we made multiple observations of neonates in the immediate vicinity (< 2 m) of conspecifics, including one with the mother. It is also interesting to point out that the neonate with its mother did not show any association with her during the initial movements from the birth site. Our observations support the conspecific trailing hypothesis regarding neonate location of a common hibernaculum. However, we still were not able to observe the mechanism by which neonates find conspecific trails. Unless they are making exploratory ventures while returning to the exact same location, we cannot explain how they are initially finding the pheromone trails of conspecifics.

Another noticeable movement trend was that the neonates did not disperse far from the birth site for several days. Once neonates did disperse, they had few movements to new locations, remaining relatively stationary at these sites for days. Movements of this nature are typical of many viperids and sit-and-wait predators (Greene 1997); however, little has been documented on the movement patterns of neonate snakes. When neonates did move, they were variable in the type of location they selected, indicating much individual variation. As is common in adult snakes, individual variation in behavior sometimes appears to be the rule rather than the exception.

We cannot discern why one neonate traveled in the opposite direction from the mother. We can only assume that this individual: 1) did not find any conspecific trails, 2) found conspecific trails going in another direction (perhaps to a different hibernaculum), 3) wrongly trailed a conspecific trail, or 4) experienced a disturbance event, potentially by a predator.

Although these data are quite preliminary, we believe our findings to be important in better understanding the role of trailing behavior in dispersal and refugia location as well as general neonate snake natural history. Besides naturally high mortality on neonatal snakes due to predation or overwintering (Greene 1997), dispersal into novel areas can be risky (Bonnet et al. 1999).

Transmitter attachment

Few field studies of snakes have incorporated the use of externally-attached transmitters (Újvári and Korsós 2000). It is typically thought that the movements and microhabitat selection of snakes would make most external attachments obstructive and would be limited to larger species. However, animal use regulation in some countries or the endangered or

threatened status of some species has led researchers to attempt less invasive transmitter attachment techniques than the classical surgical implantation (Reinert and Cundall 1982). Using glue and tape to attach transmitters to the tail base of *Coronella austriaca* Laurenti, Gent and Spellerberg (1993) had only short-term success (less than 10 d). Ciofi and Chelazzi (1991) used a more permanent attachment by using subcutaneous nylon thread to tie a molded transmitter package on the tail dorsum of *Coluber viridiflavus* Lacépède. This technique was more long-term and did allow for external transmitter battery change. They suggested that their technique could be used on small snake species; however, we do not know of more recent studies that have used this technique. Although surgical implantation can be done on large neonate snakes (H. Reinert, The College of New Jersey, pers. comm.), we wanted to test the usefulness of a less invasive approach. We found that the small size and shape of our transmitters allowed for a relatively close attachment and could be done on small snakes. Although telemetry reception range was reduced to approximately 100 m because of the coiled antenna design, we were easily able to locate individuals on most occasions.

Because few published studies have included telemetered neonate snakes, we believed our project would be successful if we were able to follow the snakes for two weeks. However, the transmitters remained attached for a minimum of 51 days, opening up the possibility to learn considerably more about the habits of neonatal snakes. Even though we had good success with *C. horridus*, there were features of that species that we feel led to relatively long transmitter attachments. Crotalids have relatively large body sizes at birth, allowing for a large area of contact with the transmitter. Crotalids also have keeled scales, prefer relatively dry habitats, and are more sedentary than many species of snake. With that said, the neonates we tracked never appeared inhibited by the transmitters regarding locomotion or microhabitat selection.

Acknowledgments

Literature Cited

Beaupre, S.J. 2002. Modeling time-energy allocation in vipers: Individual responses to environmental variation and implications for populations. Pp. 463–481, *In* G. Schuett, M. Höggren, M. Douglas, and H. Greene (Eds.). Biology of the Vipers. Eagle Mountain Publishers, Eagle Mountain, UT. 580 pp.

Bonnet, X., G. Naulleau, and R. Shine. 1999. The dangers of leaving home: Dispersal and mortality in snakes. Biological Conservation 89:39–50.

Brown, W.S. 1991. Female reproductive ecology in a northern population of Timber Rattlesnake, *Crotalus horridus*. Herpetologica 47:101–115.

Brown, W.S., and F.M. MacLean. 1983. Conspecific scent-trailing by newborn Timber Rattlesnakes, *Crotalus horridus*. Herpetologica 39:430–436.

Butler, J.A., T.W. Hull, and R. Franz. 1995. Neonate aggregations and maternal attendance of young in the Eastern Diamondback Rattlesnake, *Crotalus adamanteus*. Copeia 1995:196–198.

Ciofi, C., and G. Chelazzi. 1991. Radiotracking of *Coluber viridiflavus* using external transmitters. Journal of Herpetology 25:37–40.

Gent, A.H., and I.F. Spellerberg. 1993. Movement rates of the Smooth Snake *Coronella austriaca* (Colubridae): A radiotelemetric study. Herpetological Journal 3:140–146.

Graves, B.M., D. Duvall, M.B. King, S.L. Lindstedt, and W.A. Gern. 1986. Initial den location by neonatal Prairie Rattlesnakes: Functions, causes, and natural history in chemical ecology. Pp. 285–304, *In* D. Duvall, D. Müller-Schwarze, and R. Silverstein (Eds.). Chemical Signals in Vertebrates. Vol. 4. Plenum Press, New York, NY. 742 pp.

Greene, H.W. 1997. Snakes: The Evolution of Mystery in Nature. University of California Press, Berkeley, CA. 351 pp.

Greene, H.W., P.G. May, D.L. Hardy, Sr., J.M. Sciturro, and T.M. Farrell. 2002. Parental behavior by vipers. Pp. 179–206, *In* G. Schuett, M. Höggren, M. Douglas, and H. Greene (Eds.). Biology of the Vipers. Eagle Mountain Publishers, Eagle Mountain, UT. 580 pp.

Holycross, A.T., and J.D. Fawcett. 2002. Observations on neonatal aggregations and associated behaviors in the Prairie Rattlesnake, *Crotalus viridis viridis*. American Midland Naturalist 148:181–184.

Martin, W.H. 1992. Phenology of the Timber Rattlesnake (*Crotalus horridus*) in an unglaciated section of the Appalachian Mountains. Pp. 259–278, *In* J.A. Campbell and E.D. Brodie, Jr. (Eds.). Biology of the Pitvipers. Selva, Tyler, TX. 467 pp.

Price, A.H. 1988. Observations on maternal behavior and neonate aggregation in the Western Diamondback Rattlesnake, *Crotalus atrox* (Crotalidae). Southwestern Naturalist 33:370–373.

Quarterman, E. 1950. Major plant communities of Tennessee cedar glades. Ecology 31:234–254.

Reinert, H.K., and D. Cundall. 1982. An improved surgical implantation method for radio-tracking snakes. Copeia 1982:702–705.

Reinert, H.K., and R.T. Zappalorti. 1988. Field observations of the association of adult and neonatal Timber Rattlesnakes, *Crotalus horridus*, with possible evidence for conspecific trailing. Copeia 1988:1057–1059.

Újvári, B., and Z. Korsós. 2000. Use of radiotelemetry on snakes: A review. Acta Zoologica Academiae Scientiarum Hungaricae 46:115–146.