Ecology of the Desert Massasauga Rattlesnake in Colorado: Habitat and Resource Utilization

A report to the CDOW and USFWS for the Colorado Wildlife Conservation Grant Program

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Desert Massasauga (*Sistrurus catenatus edwardsii*) from Lincoln County, Colorado

ABSTRACT

We conducted a radiotelemetric study on a population of Desert Massasaugas (*Sistrurus catenatus edwardsii*) in Lincoln County, SE Colorado. Massasaugas were most active between 14 and 30 °C, with an average ambient temperature during activity of 22.1°C. In the spring, snakes make long distance movements (up to 2 km) from the hibernaculum (shortgrass, compacted clay soils) to summer foraging areas (mixed grass/sandsage, sand hills). Summer activity is characterized by short distance movements, and snakes are most often observed at the base of sandsage in ambush or resting coils. Massasaugas gave birth to 5-7 young in late August, and reproduction appears to be biennial. Observations on three radioed gravid females indicated that Desert Massasaugas show maternal attendance for at least five days post-parturition. Snakes returned to the hibernaculum area in October and appear to hibernate individually in rodent burrows most commonly. However, the immediate region is utilized by several other species of snakes, particularly Prairie Rattlesnakes (*Crotalus viridis viridis*), and Massasaugas were also observed at the entrance to these den sites, suggesting that they are used by the Massasaugas as well. We believe this hibernacular area is exceptionally important as a winter refuge for numerous snake species. The size of this population of *S. c. edwardsii* appears to be quite large (perhaps 5,000-10,000 individuals) based on total number of captures and low recapture rates. The population rediscovered in Baca County in 1997 is still present, but habitat fragmentation and conversion to tilled fields may be negatively affecting the species in this southeastern county. At present, the main metapopulations occur far from developing regions in the state, and they appear to be stable. However, due to habitat loss and fragmentation resulting from agricultural expansion and urbanization, these populations will become increasingly threatened in the future.

INTRODUCTION

The Massasauga Rattlesnake, *Sistrurus catenatus*, is a diminutive species with a distribution in the United States which largely tracks the retreat of Pleistocene glaciation and the spread of grasslands. The Desert Massasauga, *Sistrurus catenatus edwardsii*, inhabits xeric grasslands from western Texas to southeastern Arizona and occurs in disjunct populations in Colorado and Mexico (Fig. 1). Populations in Colorado are the largest known (Mackessy 1998) and appear to be stable in several areas (Mackessy, 2005). As such, they are of particular conservation value and concern. In Colorado, Desert Massasaugas are associated with xeric grasslands in the southeastern portion of the state (Hobart et al., 2004; Mackessy, 2005). In light of the status of the Desert Massasauga as a state species of special concern (CDOW designation), a radiotelemetric study of a metapopulation of Desert Massasaugas in south Lincoln County was conducted in the spring of 2005 in order to monitor the status of the population and to obtain more detailed ecology and life history data. We also conducted extensive road surveys at the Lincoln County site in order to PIT-tag as many snakes as possible in the study area.

MATERIALS AND METHODS

Study site - The study area comprises approximately 12,000 acres on a private ranch (1380 m to 1470 m elevation) in southeast Lincoln County, Colorado, divided along a north/south axis by a dirt road. East of the road, the area is characterized by gently sloping grass-stabilized sandhills and loose sandy soils. The dominant vegetation in the sandhills consists of gramma grass (*Bouteloua sp.*) and buffalo grass (*Boucloe sp.*), sandsage (*Artemesia sp.*), and dense stands of bluestem grass (*Andropogon sp.*), a typical mixed-grass prairie association. West of the road, the area slopes downward to the drainage of the site, which roughly parallels the dirt road in a N-NW to S-SE direction. Immediately east and west of this drainage, the soil is loamy/dense and the vegetation is dominated by gramma grasses, buffalo grasses, and prickly pear (*Opuntia sp.*), a typical short-grass prairie habitat (also called hard-pan).

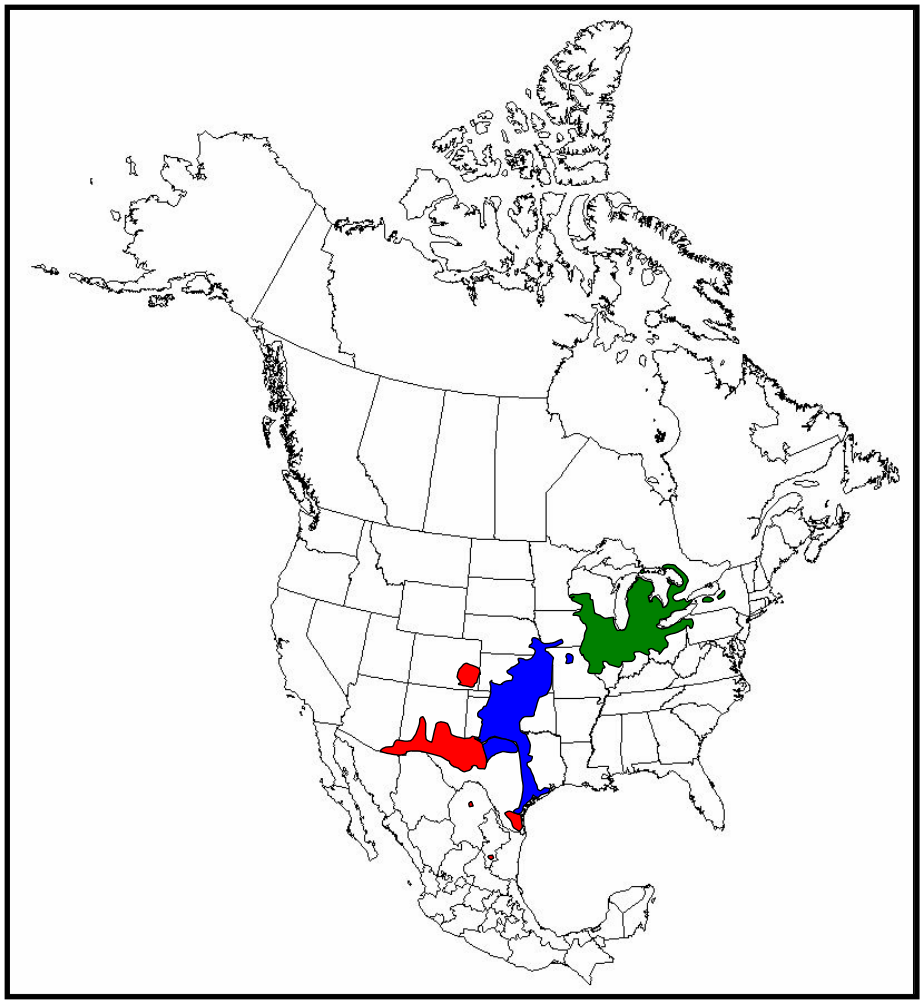

Figure 1. Massasauga distribution in North America (from Mackessy, 2005). Desert Massasauga distribution is indicated in red.

Abundance surveys - Road surveys were conducted from the spring of 2005 through the spring of 2007. At each encounter, locality was taken with a GPS unit, and temperature and general weather conditions were recorded. Other methods of collection include drift-fence/funnel traps and habitat searches. All Desert Massasaugas were brought to UNC for processing, consisting of morphological measurements (weight, snout to vent and tail lengths), sex determination, venom extraction, insertion of a PIT-tag (Avid Inc., Norco, CA), and possible radio implantation. Surveys of relative prey abundance between the two habitat types were also conducted. For small mammal surveys, Sherman traps were baited with oatmeal and set at 10 m intervals, and 500 m continuous line transects with visual observation were conducted for lizard surveys.

Radiotelemetry - Radiotelemetry of 22 Desert Massasaugas was conducted from May through October in 1997-1998 and in 2005 using radios obtained from Holohil Inc., AVM Co., and Advanced Telemetry Systems (ATS). Radios were implanted using well-established procedures (Reinert and Cundall, 1982) approved by the UNC-IACUC (protocol #0503). Radio-tagged snakes were released at the site of capture and tracked daily when possible. At each location, the following parameters were noted: behavior (moving, shading, basking, subterranean, mating, etc.), habitat cover, and climatic and thermal conditions. Analysis of telemetry data from 1997 through 1998 was conducted using SAS software and with significance set at the 0.05 level. All telemetry data from 2005 through 2006 are being analyzed using the Animal Movement extension to ArcView ver. 1.1 (P. N. Hooge and B. Eichenlaub, 1997).

RESULTS

Snake daily movements varied from <1m to as great as >350m (Figure 2). In the spring, snakes made long distance movements to the east (up to 2k) from the hibernaculum shortgrass prairie/compact clay soils) to summer foraging areas (mixed grass/sandsage and sand hills). Summer activity was characterized by short distance movements, and snakes were most often observed at the base of sandsage in ambush or resting coils. Colorado Vegetation Classification Project maps (CDOW) indicate there is an obvious vegetative compositional difference between the shortgrass habitat at the hibernacula and the mixed-grass habitat of the summer foraging grounds (Figure 3). Areas favored by the snakes in the spring and summer are typified by valent/sandy soils, in contrast to areas of fall and winter preference which are alkaline/loamy type (compacted clay) soils. In late summer/early fall, snakes made long distance movements back to the hibernaculum. In fall of 2005 and 2006, four radioed snakes were tracked to hibernacula in the short grass prairie. The hibernaculum area is situated in the drainage of the area and appears to be utilized by numerous snake species (based on encounters and sheds, 2005). For example, in early October we encountered nearly sixty Prairie Rattlesnakes (*Crotalus viridis viridis*) in approximately two hours. Prairie Rattlesnakes were most commonly observed, and Glossy Snakes (*Arizona elegans*),Racers (*Coluber constrictor*), Plains Milksnakes (*Lampropeltis triangulum,* Bullsnakes (*Pituophis catenifer*), Coachwhips (*Masticophis flagellum*) and *S. c. edwardsii* were also found in the same holes and in the immediate vicinity. Based on the observed Desert Massasauga

density at the hibernaculum area, it seems likely that Desert Massasaugas hibernate communally. Additionally, in 2005 and 2006 we obtained evidence that Desert Massasaugas are sharing a hibernaculum with Prairie Rattlesnakes and several other species of colubrid snakes; several Desert Massasaugas were found basking with prairie rattlesnakes at the entrance to this den site.

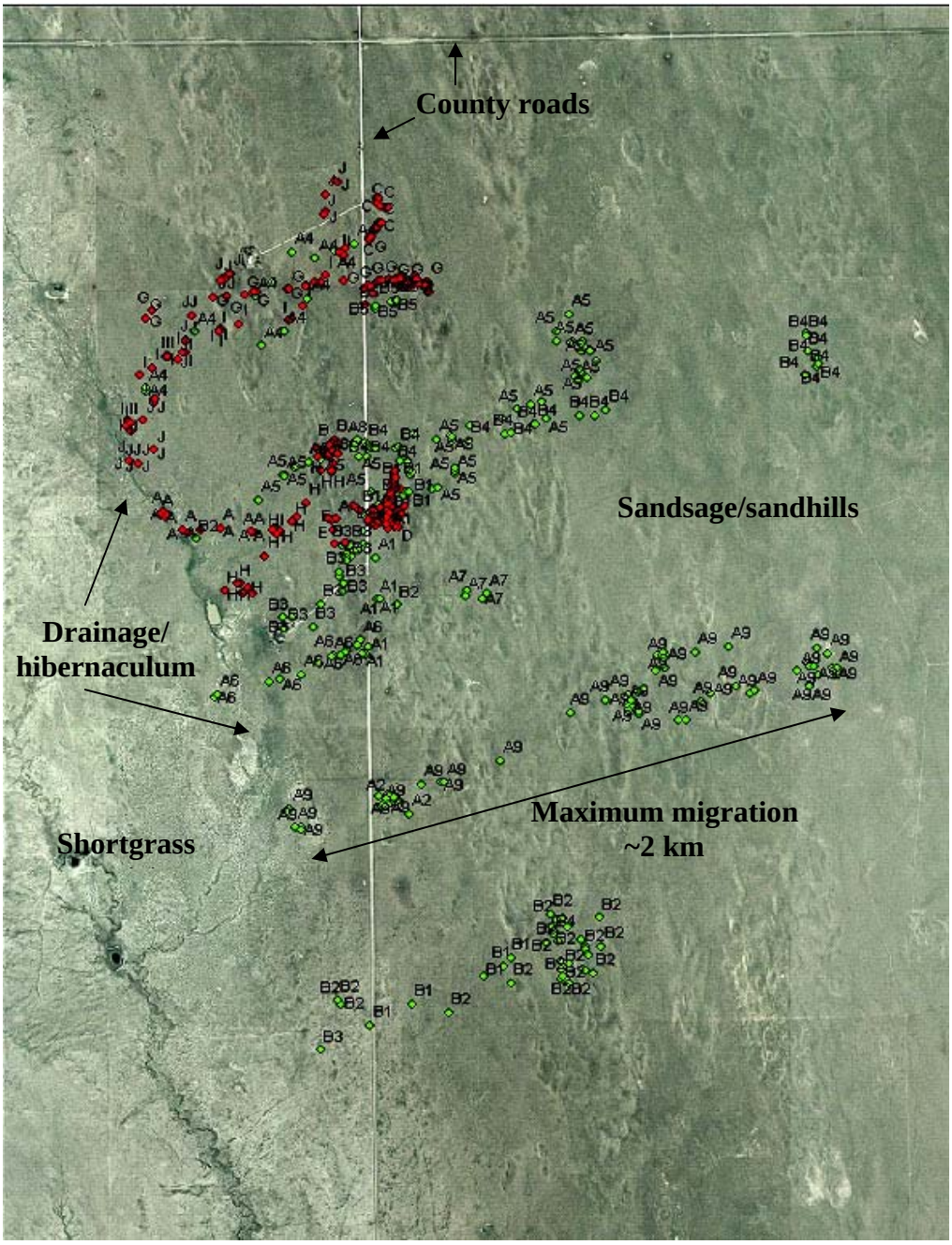

Figure 2. Massasauga movements on the study site. In the spring, Massasaugas move from the hibernaculum area in shortgrass prairie to sandsage/sandhills for the summer; in fall, movements reverse. Snakes tracked in 2005-2006 are shown in red; green dots are from a previous study on the site (Manzer and Mackessy, 1998).

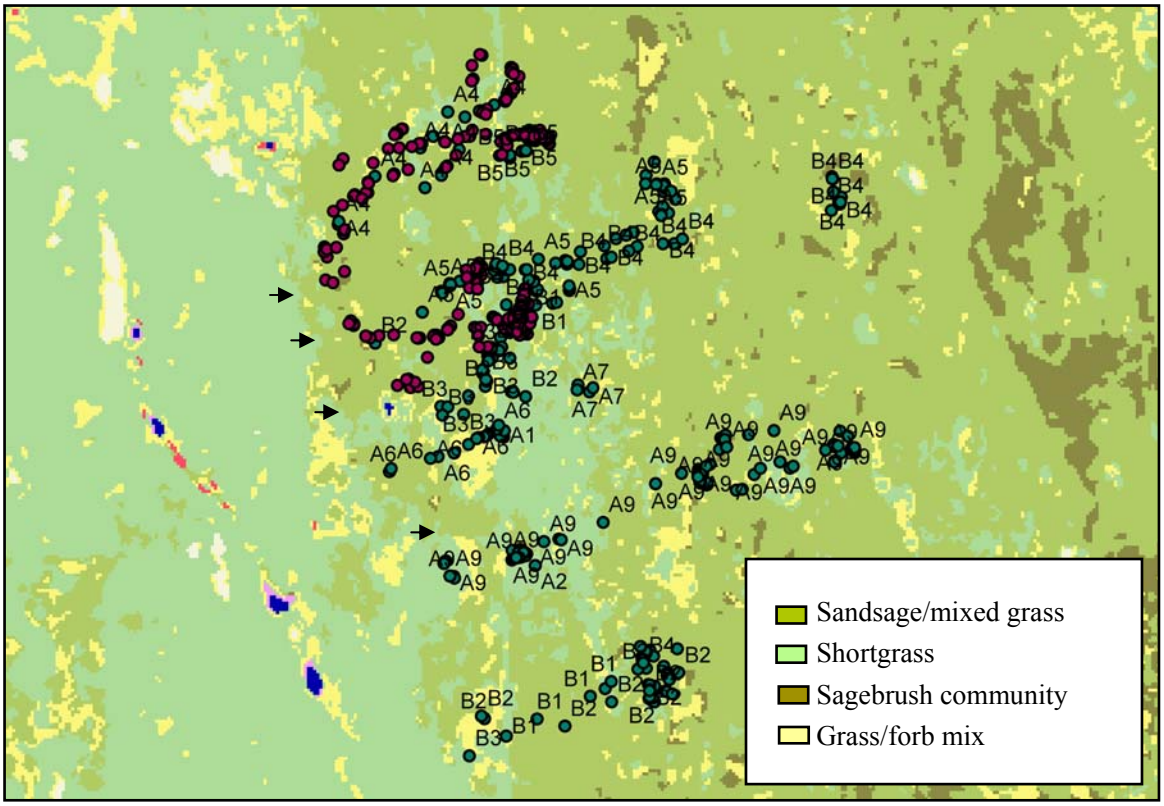

Figure 3. Colorado Vegetation Classification Project map of the study site. Note the abrupt transition from sandsage to shortgrass, which coincides with the hibernaculum area (arrowheads). Snake movement data points are the same as in Fig. 2.

Size class distribution and monthly activity patterns are presented in Figures 4 and 5, respectively. Snakes were active above ground from 12-44ºC; Average above ground temperature was 26.1ºC. Snakes retreated to subterranean refugia when ambient temperatures were in excess of 32.4ºC (n=86, SE: 0.35). On average, snakes moved at lower ambient temperatures during migratory movements (21.3ºC, n=109, SE: 0.27) than movements in the summer foraging grounds (26.6ºC, n=22, SE: 0.60).

Surveys to determine differences in prey abundance between the two habitat types showed a substantially higher abundance of both small mammals (Table 1) and lizards (Table 2) in the mixed grass/sandsage habitat. Species diversity is also apparently greater in the mixed grass/sandsage habitat compared to the shortgrass (hardpan) habitat.

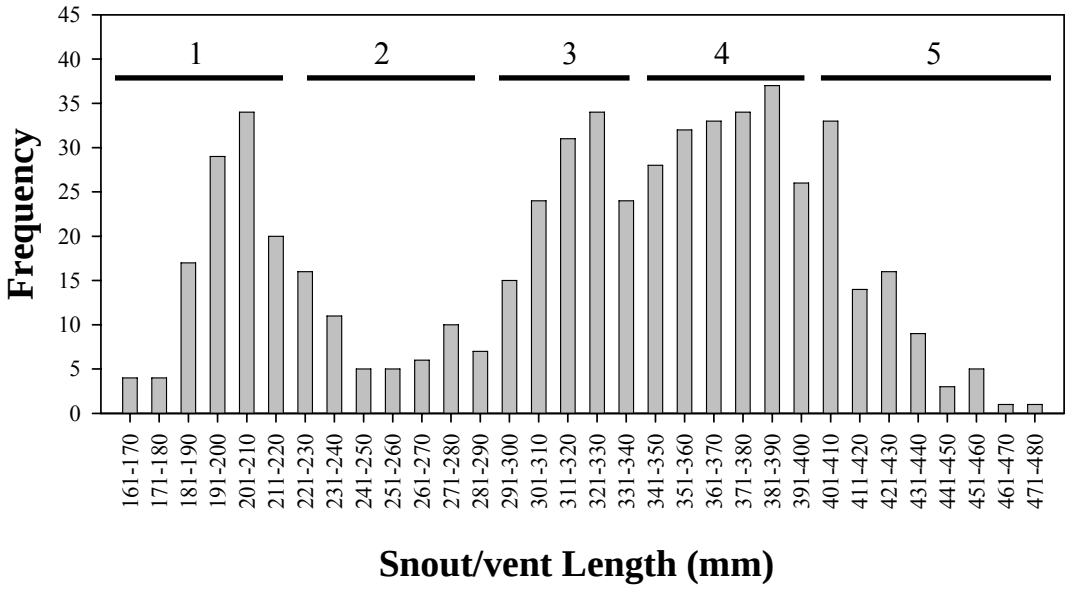

Figure 4. Size class distribution of Desert Massasaugas captured in Lincoln Co., Colorado between May 2005 and May 2007 (n=567). Bars above the histograms are approximate age classes (in years).

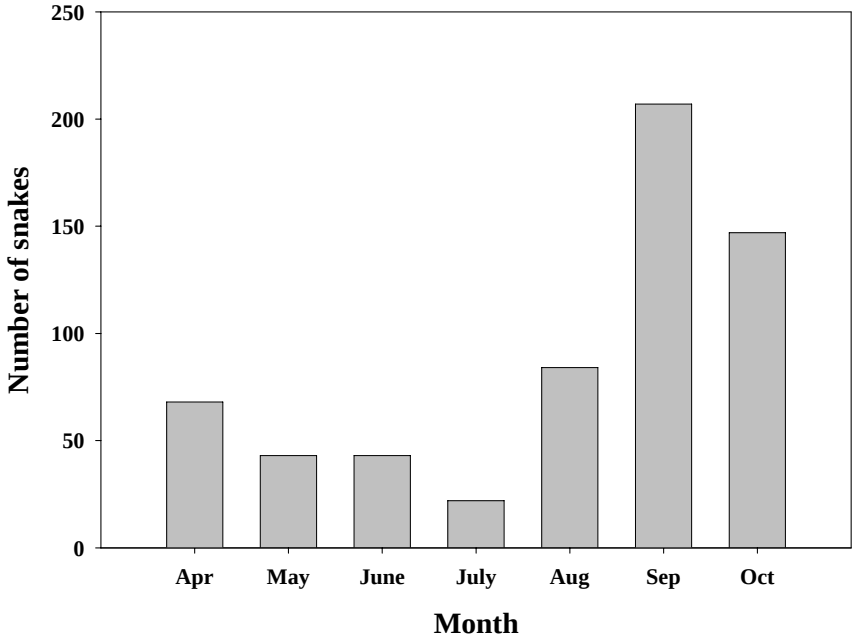

Figure 5. Number of Desert Massasauga encounters per month (1995-2005). In the spring (April-May) and in the fall ((September-October), snakes were encountered primarily during migration from and to the hibernacular area.

Table 1. Small Mammals: Relative Abundance by Habitat Type

Species	Sandsage	Hardpan
Peromyscus maniculatus	2	46
Perognathus flavescens	20	0
Perognathus flavus	0	2
Dipodomys ordii	64	1
Onychomys leucogaster	20	6
Spermophilus spilosoma	4	0
Spermophilus tridecemlineatus	0	3
Neotoma cinerea	1	0

Total trap nights = 1170 per habitat type; numbers include only unique individuals.

Table 2. Lizards: Relative Abundance by Habitat Type

Species	Sandsage	Hardpan
Holbrookia maculata	18	0
Cnemidophorus sexlineatus	18	0
Sceloporus undulatus	14	2

Abundance based on fourteen 500 m line transects/habitat type.

In 2005, three radioed gravid female Desert Massasaugas were tracked from spring migration through birthing and attendance of neonates. Females gave birth to four to seven young in late August and early September (4-7 young, two on 22 August, one on 25 August (captive birth, 1998), and one on 3 September). For approximately three weeks prior to giving birth, females became highly stationary, basking near (or inside of) a rodent burrow, appearing to take up "long-term residency" at birthing sites. All birthing sites were small rodent burrows in somewhat exposed areas of mixed grass/sandsage habitat. For five days, neonates were frequently observed basking at the burrow entrance (or just inside the burrow) both on top of or near their mother (Fig. 6). In all three cases, the female left the birth site after five days. The females then appeared to forage for a few days before making long distance movements generally in the direction of the hibernacula. One of these females was observed in copulation immediately after leaving the birth site. The neonates remained at the birthing site until their first shed (~8 days). A large proportion of neonates and adults were encountered crossing the county road (heading west toward hibernacula) in mid-August through early October, suggesting that neonates follow conspecific scent trails of adults (cf. Reinert and Rupert, 1999).

Figure 6. Female Desert Massasauga with neonates at rodent burrow entrance. This female gave birth to five young in this burrow and then remained associated with them until the first shed, approximately five days after parturition. Arrowhead indicates female snake's head, and two neonates are visible to her right.

DISCUSSION

The migratory patterns observed by Desert Massasaugas in Lincoln County appear to be influenced by seasonal differences/constraints in resource utilization. The wide range of air temperatures (12-44◦C) during which massasaugas are above ground is notable. Summer habitat is exclusively sandsage/mixed-grass/sandy soils dominant, and appears to provide an adequate temperature gradient for thermoregulation (cover/shade). Winter habitat, being exclusively short grass/clay soils, likely lacks the temperature gradient of the summer habitat, being devoid of cover. Inversely, winter hibernation in the shortgrass prairie (compacted clay soils) likely provides a more adequate hibernacula, containing burrows with better insulative and structural qualities than burrows in the sandy soils of the mixed-grass/sandsage habitat; this hypothesis is currently being tested. Huey (1989) noted that *Thamnophis elegans* in temperate Northern California selectively selected summer refugia that provided a variety of thermal gradients for thermoregulation. Similar habitat shifts have been reported in the eastern subspecies of Massasauga, *S. c. catenatus*. Reinert and Kodrich (1982) found a population of eastern Massasaugas in western Pennsylvania hibernating in low-lying wet areas and preferring high-dry areas throughout the summer and fall. Seigel (1986) reported a population of eastern Massasaugas in

northwest Missouri that utilized low-lying wet areas (crayfish burrows) for hibernation and moved to dry upland areas in the summer and fall, and then returned to low-lying wet areas before hibernating. Additionally, there appears to be greater prey availability in the sandsage habitat than in the short grass habitat, particularly of lizards, which make up ~59.4% of their diet (Holycross and Mackessy, 2002). Desert Massasauga births appear to coincide closely with that of emerging neonate lizards. Considering the relatively small size of neonate Desert Massasaugas (average SVL = 148 mm), neonate lizards are likely a primary food item. Similarly, when taking into account appropriate mammal prey size for adult Desert Massasaugas, the mixed grass/sandsage habitat has a higher abundance of appropriately sized mammal species, most notably that of *Perognathus flavescens*, which constitutes approximately 5% of their diet (Holycross and Mackessy, 2002).

Since 1995, we have documented approximately 950 Desert Massasauga locality records, PIT-tagged approximately 800 snakes and shown that several metapopulations in Colorado appear to be relatively large and stable. Because Desert Massasauga populations elsewhere are either poorly known (Texas, New Mexico and Mexico) or in decline (Arizona), the Colorado populations are particularly important to the continued persistence of this diminutive species. The greatest constraint in conservation planning for snakes is the fundamental lack of basic biological information for most species (Dodd, 1987, 1993; Reinert, 1993), and implementing a conservation program without regard to or in ignorance of the specific biological constraints on a given species has little chance of success (Dodd and Seigel, 1991; Scott and Seigal, 1992). By extensively monitoring this well-documented population of Desert Massasaugas in Lincoln County, we have begun to address many aspects of basic biology/ecology for this species which are fundamental for future conservation approaches.

ACKNOWLEDGEMENTS

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PRODUCTS RESULTING FROM THIS PROJECT

1. Master's thesis, Andrew Wastell. "Ecology of the Desert Massasauga Rattlesnake (*Sistrurus catenatus edwardsii*) in Colorado: habitat and resource utilization", Biological Sciences, UNC. Expected date of completion: December 2007.

2. Manuscripts (in preparation): "Ecology of the Desert Massasauga Rattlesnake (*Sistrurus catenatus edwardsii*) in Colorado: habitat and resource utilization" – *Conservation Biology*. "Shared hibernaculum area usage by a broad assemblage of amphibians and reptiles in southeastern Colorado" – *Journal of Herpetology*.

3. Other projects indirectly benefiting from this study: Susanta Pahari, Stephen P. Mackessy, R. Manjunatha Kini - "The Venom Gland Transcriptome of the Desert Massasauga Rattlesnake (*Sistrurus catenatus edwardsii*): Towards an Understanding of Venom Composition Among Advanced Snakes (Superfamily Colubroidea)" – in review, *BMC Molecular Biology*. Published: Sanz, L., H.L.Gibbs, Stephen P. Mackessy and J.J. Calvete. 2006. Venom proteomes of closely related *Sistrurus* rattlesnakes with divergent diets. *Journal of Proteome Research* 5: 2098-2112.

References

Butler, J.A., T.W. Hull, and R. Franz. 1995. *Copeia.* 1995:196-198.
Dodd, C.K., Jr. 1987. In R.A. Seigel, J.T. Collins, and S.S. Novak (eds.), *Snakes, Ecology and Evolutionary Biology*, pp. 478-513. Macmillan Publ. Co. New York.
Dodd, C.K., Jr.. 1993. In R.A. Seigel, J.T. Collins (eds.), *Snakes, Ecology and Evolutionary Biology*, pp. 478-513. Macmillan Publ. Co. New York.
Dodd, C.K., Jr., and R. A. Seigel. 1991. *Herpetologica*. 47:336-350
Hobert, J. P. 1997. M.S. thesis, University of Northern Colorado, Greeley.
Hobert, J.P., C.M. Montgomery, and S.P. Mackessy. 2004. *Southwest. Nat*. 49: 321-326.
Holycross, A.T., and M.E. Douglas. 1996. Unpubl. report to the Arizona Game and Fish Department, IIPAM I93004, Phoenix, Arizona.
Holycross, A.T., and S.P. Mackessy. 2002. *J. Herpetol*. 36:454-464.
Huey, R.B., Peterson, C.R., Arnold, S.J., and Porter, W.P. 1989. *Ecology*. 4:931-944.
Mackessy, S.P. 1998a. Final report to the Colorado Division of Wildlife. 418 pp.
Mackessy, S.P. 2005. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/massasauga.pdf
Reinert, H.K. and W.R. Kodrich. 1982. J. *Herpetol*. 16:162-171.
Reinert, H.K. and R.R. Rupert, Jr. 1999. J. *Herpetol*. 33:45-61.
Reinert, H.K. and Cundall, D. 1982. *Copeia* 1982:702-705
Scott, N.J., Jr., and R.A. Seigel. 1992. In D. R. McCullough and R. H. Barrett (eds.), Wildlife 2001: Populations, pp. 343-368. *Elsevier Applied Sci*., London.
Seigel, R. A. 1986. *Biological Conservation* 35:333-346.