

particularmente para especies que pueden estar amenazadas o en peligro de extinción. Colectamos 254 (141 machos:94 hembras:19 desconocidos) de massasauga del desierto, *Sistrurus catenatus edwardsii*, entre mayo de 1995 y octubre de 1996. El promedio de longitud hocico-cloaca (LHC) para machos adultos (355

♂ 45 mm) no fue significativamente diferente al de las hembras (364 ♂ 24 mm). Las descripciones del hábitat indican que la massasauga en Colorado es una especie de pastizales semiáridos que habita áreas de praderas de pasto corto relativamente abiertas. Massasaugas estuvieron activas entre 14 y 30°C, con un promedio de temperatura ambiente durante la actividad de 22.1 ♂ 2.5°C. La época de la actividad observada cambió con la estación del año, con actividad diurna durante los meses más frescos (abril y finales de septiembre a octubre) y con actividad crepuscular durante los meses más calientes (mayo a agosto). Massasaugas en Colorado dieron a luz a camadas de 5 a 7 crías entre fines de agosto y fines de septiembre, y la reproducción pareció ser bianual. Las poblaciones de *S. c. edwardsii* en Colorado están dispersas pero el tamaño poblacional pareció ser relativamente grande basado en el número de capturas y las tasas bajas de recaptura, especialmente en el condado de Lincoln. Sin embargo, debido a la fragmentación y la pérdida de hábitat resultado de la expansión agrícola, estas poblaciones pueden ser amenazadas en el futuro.

The massasauga, *Sistrurus catenatus*, is a small rattlesnake broadly distributed across North American prairies from Ontario, Canada and New York to extreme southeastern Arizona, with an apparently disjunct population in northern Chihuahua, Mexico (Stebbins, 1985). It is listed as endangered or threatened across much of its range by several state and provin-

cial agencies based largely on distribution and natural history reports and numerous surveys of historic populations funded by state agencies (Reinert, 1978; Seigel, 1986; Allen, 1988; Weatherhead and Prior, 1992). Distribution and life history studies conducted in eastern and central portions of the range of the massasauga supplied critical information about

population status and viability. The Colorado Division of Wildlife (CDOW) currently lists the massasauga as a species of special concern, which indicates that the status of *S. catenatus* in Colorado is uncertain, but populations are likely declining due to habitat loss and human encroachment.

In Colorado, there is a paucity of data pertaining to the biology and ecology of *S. catenatus* (Hammerson, 1999). Data concerning massasauga in Colorado are limited to diet (Smith et al., 1965; Holycross and Mackessy, 2002), distribution (Hammerson et al., 1991; Pegler et al., 1995; Mackessy et al., 1996; Hobert et al., 1997; Montgomery et al., 1998), taxonomy (Maslin, 1965; Hobert, 1997), and reproduction (Goldberg and Holycross, 1999). Many of these studies originated from or included specimens from the survey summarized here. Recent morphological analysis indicated that *S. catenatus* in Colorado is the desert subspecies, *S. c. edwardsii* (Hobert, 1997), rather than an intergrade between the western and desert subspecies, *S. c. tergeminus* and *S. c. edwardsii*, respectively, as reported by Maslin (1965). Geographically, Colorado populations of massasauga apparently are disjunct from neighboring races but are west of an area in Kansas inhabited by an assumed intergrade form of the western and desert subspecies (Maslin, 1965; Conant and Collins, 1991).

Additional information on the biology and ecology of the massasauga was necessary to provide baseline information to ensure adequate protection of *S. catenatus* in Colorado. Specifically data on basic demographic parameters, such as habitat, life history characteristics, and distribution are lacking. Objectives of this study were to determine distribution and population parameters of *S. catenatus edwardsii* and to evaluate habitat characteristics in areas of known occurrence in southeastern Colorado.

METHODS—Study Site—A survey for massasauga was conducted in 12 southeastern Colorado counties, consisting broadly of the area south of Interstate Highway 70 and east of Interstate Highway 25. The

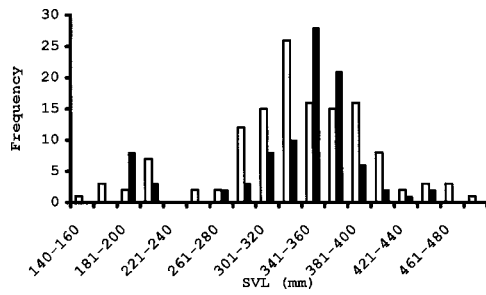


FIG. 1—Frequency distribution of snout-vent length (SVL) of male (open) and female (solid) *Sistrurus catenatus edwardsii* in southeastern Colorado.

equations of LogTL on LogSVL for both sexes. All statistics were performed using Jump 4.0 (SAS Institute, Cary, North Carolina).

RESULTS AND DISCUSSION—Body Size and Stage Class—We captured or recovered 254 *S. c. edwardsii* (141M:94F:19UNK) over the course of this study. Of the 141 males found, 80 were alive and 61 were dead; for females, 75 were alive and 19 were dead. We were unable to determine sex for 19 dead snakes. Of the 254 snakes recovered, 199 were adults (126M:69F:4UNK) and 55 were juveniles and YOY (15M:25F:15UNK). The average SVL (\bar{x} \pm SD) of adult males (355 \bar{x} 45 mm) was not significantly different than the average SVL of adult females (364 \bar{x} 24 mm) (ANOVA, F ratio 5

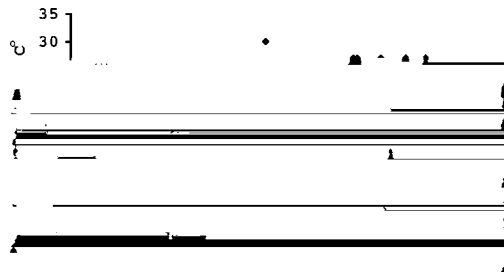


FIG. 2—Relationship of ambient temperature at time of capture and capture date of *Sistrurus catenatus edwardsii* in southeastern Colorado. Ambient temperature of activity remained relatively constant (22.1 \pm 2.58C) across the activity season.

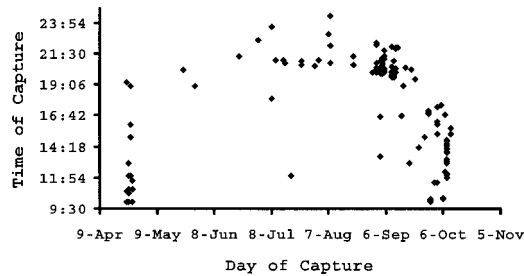


FIG. 3—Relationship of time of capture and capture date of *Sistrurus catenatus edwardsii* in southeastern Colorado. Snakes became increasingly nocturnal during warmer summer months.

range contraction. The Mesa de Maya and Raton Mesa regions in southeastern Colorado seem to represent a physical barrier between massasauga in Colorado and New Mexico.

Activity Patterns—We observed massasaugas as early as 13 April (1996) and as late as 15 October (1995). Because these snakes were observed on roads, it can be assumed that the active season was longer, because snakes need to move to and from suitable hibernacula. Snakes were found most commonly in April (38), September (106), and October (53) and were less commonly encountered from May through August. Increased capture success at the beginning and end of the active season probably was due to seasonal migrations to and from hibernation areas in several localities. Along a road at 1 site, all massasauga observed were moving from west to east in April (29 individuals) and from east to west in the September and October (85 individuals). In this area, habitat to the west was shortgrass prairie associated with loamy soil, while to the east the habitat was sandsage prairie associated with loose sandy soil. Radio-tagged massasauga spent the entire active season in sandsage prairie and hibernated in the shortgrass prairie habitat (Manzer and Mackessy, unpubl. data). Occurrence of an abundant prey base (harvest mice, *Reithrodontomys megalotis*) to the east and appropriate hibernacula to the west (Manzer and Mackessy, unpubl. data) might be a factor in this migration. A similar migration pattern from hibernacula to activity areas in the spring and back to hibernacula in fall has been shown for the western massasauga, *S. c. tergeminus*

(Siegel, 1986), and the eastern massasauga, *S. c. catenatus* (Johnson, 2000).

Based on 157 records of temperature data at capture, massasaugas were active between 14 and 30°C, with an average ambient temperature of activity of 22.18°C (\pm 2.58°C). Temperature when snakes were captured was relatively consistent throughout the season (Fig. 2). The time of observed activity shifted through the season (Fig. 3), with primarily diurnal activity during cooler periods (April and late September to October) and primarily evening and early night activity during warmer periods (May through mid-September; National Oceanic and Atmospheric Administration, 1994, 1995, 1996, 1997). In Arizona, massasaugas were described as a nocturnal species (Lowe et al., 1986).

Growth—Eight of the 143 (5M:3F) PIT-tagged rattlesnakes were recaptured (5.6%). Recapture rates in our study were too low to analyze growth or population size. However, 1 adult male snake captured on 24 April and recaptured on 21 September grew 56.0 mm (from 320 to 376 mm) and 27 g (24.2 to 51.2 g), which represented an increase in SVL of 117% and in body mass of 112% in 149 days. Using drift fences and road cruising, the recapture rate for *S. c. edwardsii* in Arizona (Hollycross and Douglas, 1996) was much higher (18%) than recapture rates in our study.

Reproduction—We collected 1 DOR adult female on 30 May 1996 that measured 380 mm SVL and contained 5 vascularized ova. A total of 23 YOY collected in the field averaged 191.4 mm (\pm 16.0 SD) SVL. The earliest YOY was observed on 3 September (1994) and the latest YOY was observed on 15 October (1995). Ob-

ervation of YOY during this period indicated massasaugas in Colorado probably birth between late August and late September, consistent with reports for Arizona and Colorado snakes (Goldberg and Holycross, 1999). One gravid female collected on 24 July and held in captivity until birth showed a weight loss of 26% (from 54.0 to 39.9 g) after parturition. The female gave birth on 24 August to 7 young that averaged 148 mm SVL and 3.46 g. Average SVL of YOY in Colorado from our study seem to be larger than the SVL for Arizona YOY (Goldberg and Holycross, 1999). Because birth date is unknown for all YOY in both studies, actual size at birth is unknown.

Information presented here on the massasauga reproduction in Colorado is based on data collected in 1992 and 1993. This study is one of the first to report on the natural history of massasauga reproduction in Colorado. The data presented here indicate that massasaugas in Colorado may have a single clutch of young during the late summer to early fall period. The young are born on 24 August and average 148 mm SVL and 3.46 g. The average SVL of YOY in Colorado from our study seem to be larger than the SVL for Arizona YOY (Goldberg and Holycross, 1999). Because birth date is unknown for all YOY in both studies, actual size at birth is unknown.

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