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REPRODUCTION AND SEASONAL ACTIVITY OF SILVER-HAIRED BATS (*LASIONYCTERIS NOCTIVAGANS*) IN WESTERN NEBRASKA

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ABSTRACT.—Silver-haired bats (*Lasionycteris noctivagans*) were thought only to migrate through Nebraska; however, recent surveys in eastern Nebraska report summer records of females and their young. Our study in western Nebraska also shows that silver-haired bats are summer residents. We discovered the 1st reproductively active *L. noctivagans* in this part of the state. We caught lactating females and volant young in riparian forests along the North Platte River and in forested areas of the Pine Ridge. Previously, adult males were not known from Nebraska in summer, and only 4 records of *L. noctivagans* were known from western Nebraska during migration. On 28 July we captured an adult male in a coniferous forest of the Wildcat Hills, and we have more than 100 records of migrating individuals. Lastly, an obese *L. noctivagans* captured on 4 November may represent an individual preparing to hibernate in the state.

Key words: *Lasionycteris noctivagans*, silver-haired bat, Nebraska, reproduction, seasonal activity, migration, hibernation, Great Plains.

The silver-haired bat (*Lasionycteris noctivagans*) occurs throughout the southern provinces of Canada and most of the United States (Hall 1981). Based on noticeable changes in seasonal abundance throughout its range, *L. noctivagans* has been considered migratory (Kunz 1999). Winter distributional records are concentrated in southern and eastern parts of the United States, but after spring migration most records appear in southern Canada and in northern and western United States (Cryan 2003). Although some *L. noctivagans* migrate southward in late summer and autumn, others hibernate at middle and northern latitudes in the United States (Izor 1979, Hoffmeister 1989, Sherwood and Kurta 1999, Twente and Maruniak 2002).

Czaplewski et al. (1979) and Jones (1964) reported that in Nebraska *L. noctivagans* may occur only during migration; however, both suggested that summer residents may exist in northern Nebraska on the Pine Ridge and along the Niobrara River. Recent studies of bats in eastern Nebraska report summer populations of lactating females and volant young (Sarpy County, Geluso et al. 2004; Lancaster County, Benedict 2004), but no documentation exists for summer populations in western Nebraska. Thus far, only 4 silver-haired bats from 3 localities have been reported in west-

ern Nebraska (Sioux and Morrill Counties, Czaplewski et al. 1979; Sheridan County, Benedict 2004). Herein, we report an additional 151 individuals from 21 new localities in western Nebraska, including information on reproduction and seasonal activity.

METHODS

Using mist nets we captured bats at several localities in western Nebraska from 1997 to 2002. We netted as early as May and as late as November; we did not net December–April. Nets were placed over metal stock tanks and ponds in the Wildcat Hills (Banner, Scotts Bluff, and Morrill Counties); over ponds, a stream, and a river at the North Platte National Wildlife Refuge (Scotts Bluff County); and over a stream at Fort Robinson State Park (Sioux County). We generally deployed mist nets before sunset and attended them continuously for at least 3 hours after darkness; occasionally we tended nets until dawn. For each bat captured we recorded time of capture, species, sex, reproductive condition, and age (Anthony 1988). All bats were released at the site of capture except for a few individuals that were kept as voucher specimens. These specimens were deposited in the U.S. Geological Survey, Biological Survey Collection, housed at the Museum of

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TABLE 1. Dates of capture of *Lasionycteris noctivagans* in western Nebraska, based on the present study (1997, 1998, 2000, 2001, and 2002), on museum specimens not previously published (1965, 1979, 1988, and 1994), and on previously published records (1966, 1976, and 2000). In column labeled *Number of individuals*, entries represent adult males, adult females, and volant young, respectively. For localities with voucher specimens, parentheses contain the number of specimens and the museum acronym. Due to epiphyseal ossification of joints of the wing (Anthony 1988), some bats classified as adults in August, September, and November may have been young of the year.

Date of capture	Number of individuals	Locality
1 May 1965	(-) (1 ^a) (-)	Garden Co., Crescent Lake National Wildlife Refuge (1, JMM).
8 May 2001	(1) (3 ^b) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21.
9 May 2001	(-) (4 ^b) (-)	Scotts Bluff Co., Wildcat Hills, Carter Canyon, T21N, R56W, NE1/4, Sec. 28.
11 May 1994	(-) (1 ^a) (-)	Sioux Co., Soldier Creek, T32N, R53W, NE1/4 of SW1/4, Sec. 32 (1, UNSM).
17 May 1988	(-) (1 ^a) (-)	Kimball Co., T16N, R56W, Sec. 26 (1, UNSM).
20 May 2002	(2) (1 ^c) (-)	Scotts Bluff Co., Wildcat Hills, Carter Canyon, T21N, R56W, NE1/4, Sec. 28 (1, USGS).
22 May 2002	(-) (1 ^d) (-)	Scotts Bluff Co., North Platte NWR, Stateline Island, 41°59.361'N, 104°03.169' W (1, USGS).
24 May 1994	(-) (1 ^a) (-)	Sioux Co., Gilbert-Baker Campground, T32N, R56W, Sec. 8 (1, UNSM).
25 May 1998	(1) (-) (-) (1, UNSM).	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21
30 May 2001	(1) (-) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1, USGS).
1 June 1994	(1) (4 ^a) (-)	Sioux Co., Squaw Creek, T33N, R57W, SE1/4 of NW1/4, Sec. 15 (5, UNSM).
8 June 1988	(1) (-) (-)	Sioux Co., Gilbert-Baker Wildlife Management Area, 5.25 mi N, 2.25 mi W Harrison, 42°46.03'N, 103°55.53'W (1, UNSM).
10 June 1994	(-) (1 ^a) (-)	Dawes Co., Bordeaux Creek, T32N, R48W, NW1/4 of NE1/4, Sec. 14 (1, UNSM).
17 June 1988	(1) (-) (-)	Sioux Co., Soldier Creek Wildlife Management Area, 1.0 mi N, 8.0 mi W Crawford, 42°42.13'N, 103°34.30'W (1, UNSM).
19 June 1966	(1) (-) (-)	Sioux Co., Lower Sowbelly Canyon, 3.0 mi N, 2.0 mi E Harrison (1, UNSM ^e).
24 June 1994	(1) (-) (-)	Sioux Co., Sowbelly Creek, T32N, R56W, SE1/4 of NE1/4, Sec. 24 (1, UNSM).
28 June 1994	(27) (-) (-)	Sioux Co., Wood Reserve, Trout Ponds, T32N, R53W, SE1/4 of NW1/4, Sec. 31 (27, UNSM).
30 June 1994	(1) (-) (-)	Dawes Co., Cliffs, Little Bordeaux Creek, 7.75 mi S, 3.5 mi E Chadron, T32N, R48W, NE1/4 of SE1/4, Sec. 27 (1, UNSM).
1 July 2002	(-) (1 ^f) (1)	Scotts Bluff Co., North Platte NWR, Stateline Island, 41°59.323'N, 104°02.954'W (2, USGS).
2 July 2002	(-) (1 ^f) (-)	Scotts Bluff Co., North Platte NWR, Stateline Island, 41°59.323'N, 104°02.954'W.

Southwestern Biology, University of New Mexico (USGS), or at the University of Nebraska State Museum, University of Nebraska-Lincoln (UNSM). In addition to our field surveys, we examined collections at the University of Nebraska State Museum and Joseph Moore Museum, Richmond, Indiana (JMM), for additional specimens of *L. noctivagans* from Nebraska that were deposited since or overlooked by Czaplewski et al. (1979).

RESULTS

During surveys in western Nebraska we captured 71 *L. noctivagans* (Table 1). In addition, we obtained another 80 unpublished records from this part of the state from specimens at UNSM and JMM (Table 1). Combining our records of *L. noctivagans* ($n = 151$) with previously published ones from western

Nebraska ($n = 4$), we obtained the following totals: 56 in spring-early summer (May and June), 17 in summer (July), 81 in midsummer-early autumn (August and September), and 1 in autumn (November).

Summer Populations

We documented summer residents of *L. noctivagans* at 4 localities in western Nebraska. Lactating females and volant young were captured at 3 of these localities and an adult male and volant young at the other locality (Table 1).

At North Platte National Wildlife Refuge, we captured a lactating female and a volant young on 1 July and another lactating female on 2 July (Table 1). Bats were netted over a stream (9.1 m wide) and nearby pond (21.3 m in diameter) in a riparian forest dominated by cottonwoods (*Populus deltoides*). The site is approximately 70 m from the North Platte

TABLE 1. Continued.

Date of capture	Number of individuals	Locality
4 July 2002	(-) (3 ^f) (-)	Scotts Bluff Co., North Platte NWR, Stateline Island, 41°59.199'N, 104°02.224'W (1, USGS).
5 July 2002	(-) (3 ^f) (1)	Scotts Bluff Co., North Platte NWR, Stateline Island, 41°59.199'N, 104°02.224'W (1, USGS).
19 July 2002	(-) (2 ^g) (3)	Sioux Co., Fort Robinson State Park, Soldier Creek, 42°41.827'N, 103°34.017'W.
27 July 2001	(-) (-) (1)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1 UNSM).
28 July 2000	(1) (-) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1, UNSM).
5 August 2000	(1) (1) (-)	Sheridan Co., Patton Creek, 17.2 mi N, 3.2 mi W Rushville (1, male RAB 4984 ^h).
17 August 1994	(5) (1) (-)	Dawes Co., West Ash Creek, T31N, R51W, SE1/4, Sec. 24 (6, UNSM).
28 August 1997	(1) (-) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1, USGS).
1 September 2000	(6) (5) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (2, USGS).
4 September 1994	(10) (2) (-)	Dawes Co., Stock Pond, 1 canyon E West Ash Creek, T31N, R51W, NW1/4, Sec. 13 (12, UNSM).
9 September 1994	(-) (7) (-)	Sioux Co., Wood Reserve, Trout Ponds, T32N, R53W, SE1/4 of NW1/4, Sec. 31 (7, UNSM).
18 September 1994	(6) (7) (-)	Dawes Co., Saw Log Creek, Pasture 31, T31N, R51W, SE1/4 of SW1/4, Sec. 32 (13, UNSM).
18 September 1998	(1) (-) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1, UNSM).
20 September 2002	(-) (1) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21 (1, UNSM).
22 September 2001	(2) (-) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21.
22 September 1979	(1) (-) (-)	Morrill Co., T19N, R48W, SW1/4, Sec. 28, (1, UNSM).
24 September 1976	(-) (1) (-)	Morrill Co., 8.0 mi S, 7.5 mi E Bridgeport, T18N, R49W, Sec. 15 (1, UNSM ^e).
29 September 2000	(7) (16) (-)	Banner Co., Wildcat Hills, Dooley Canyon, T20N, R55W, NW1/4, Sec. 21.
4 November 2001	(-) (1) (-)	Scotts Bluff Co., Wildcat Hills, Carter Canyon, T21N, R56W, NE1/4, Sec. 28 (1, USGS).

^aNo reproductive information reported by collector.

^bStatus of pregnancy unknown because female was released.

^cNo discernable embryos present.

^dIndividual was pregnant.

^eOriginally reported in Czaplewski et al. (1979).

^fIndividual was lactating.

^gOne adult female was lactating and the other was not.

^hOriginally reported by Benedict (2004).

River. At another site on the refuge, we captured 6 lactating females and 1 volant young on 4 and 5 July (Table 1). Bats were netted over a large pond (15 m × 47 m) in the riparian forest approximately 100 m from the river.

At Fort Robinson State Park, we captured 1 lactating female, 1 post-lactating female, and 3 volant young on 19 July (Table 1). Bats were netted over a small pool (9.1 m × 6.1 m) along a road where it crosses Soldier Creek. Various deciduous trees line the creek, and nearby buttes contain burned and unburned forests of ponderosa pine. Grasslands dominate the area between the buttes and Soldier Creek.

In the Wildcat Hills we captured an adult male (28 July) and a volant young (27 July) over ponds in Dooley Canyon (Table 1). The

grassy floor of this narrow canyon contains widely scattered deciduous trees, a few ponderosa pine (*Pinus ponderosa*), and some junipers (*Juniperus*), while surrounding hill-tops consist of open woodlands of ponderosa pine and juniper.

Migratory Individuals

Of the 56 *L. noctivagans* obtained in spring and early summer (May–June), 38 were adult males and 18 were adult females (Table 1). We captured 9 of the females and kept 2 as voucher specimens. One contained 2 fetuses (the largest measured 14 mm in crown-to-rump length), and the other had no discernable embryos. No reproductive information was provided for the 9 females collected by others. Of 81 *L.*

noctivagans obtained in midsummer and early autumn (August–September), 40 were males and 41 were females. Some may have been young-of-year that went undetected because of recent epiphyseal ossification (Anthony 1988).

A Potential Hibernator

On 4 November we captured an adult female flying over a pond (5.5 m × 9.1 m) in Carter Canyon of the Wildcat Hills (Table 1). The canyon contained many junipers as well as some ponderosa pine and cottonwoods. This individual contained large deposits of subcutaneous fat.

DISCUSSION

As winter approaches in temperate regions, insectivorous bats must cope with a decline in activity of night-flying insects. To compensate for this decline in food availability, bats respond by hibernating in the area, migrating to regions where suitable hibernacula exist, or migrating to regions where insects are still available. *Lasionycteris noctivagans* was thought only to occur in western Nebraska during spring and autumn migration. However, we documented summer residents in western Nebraska as well as an individual that likely was preparing for hibernation. We also documented large numbers of migrants in this part of the state.

Summer Populations

Until recently, female silver-haired bats were thought only to migrate through Nebraska (Czaplewski et al. 1979), but now females and their young are known from both eastern and western parts of the state (Geluso et al. 2004, Benedict 2004, this study). Lactating females are known in Nebraska from 16 June to 19 July (Geluso et al. 2004, this study). In addition, 1 of our volant young represents the earliest capture in Nebraska (1 July; Table 1).

The nearest records of lactating *L. noctivagans* to populations in Nebraska are in central and southern Iowa (Easterla and Watkins 1970, Kunz 1971, Clark et al. 1987) and the Black Hills of South Dakota (Mattson et al. 1996, Cryan et al. 2000). No records of lactating females are known from Colorado or Kansas (Armstrong 1972, Sparks et al. 1999, Sparks and Choate 2000). Our captures of lactating

females and volant young in Nebraska represent 1 of the southernmost records of *L. noctivagans* raising its young in North America.

Although Czaplewski et al. (1979) suspected that an adult male *L. noctivagans* captured on 19 June 1966 was a summer resident in Nebraska, no clear records of males exist from the state. Our capture of an adult male on 28 July in the Wildcat Hills provides evidence that some males may reside in Nebraska during summer, although this male might represent an early migrant (Table 1). For this study we were conservative with respect to dates for potential summer residents; we considered individuals as residents only if they were captured in July. By examining distributions of *L. noctivagans* on a month-to-month basis (Cryan 2003), we conclude that *L. noctivagans* is relatively stationary from June to August. Thus, if we expand dates for residency to include the last half of June and the first half of August, an additional 32 summer records exist for adult males in Nebraska. Lack of summer records of males from central and eastern Nebraska suggests that males only migrate through these parts of the state. Summer records of male *L. noctivagans* are not known from Kansas and the eastern plains of Colorado (Armstrong 1972, Sparks and Choate 2000), but adult males are known from Iowa, South Dakota, and Wyoming in summer (Turner 1974, Clark et al. 1987, Cryan et al. 2000).

Migratory Individuals

Although silver-haired bats have been documented in Nebraska during migration at least since 1908 (Swenk 1908), only 15 apparent migrants have been reported from April–June (adult males and nonlactating females) and August–October (Czaplewski et al. 1979, Manning and Geluso 1989, Benedict 2004, Geluso et al. 2004). With this study an additional 133 individuals are known from western parts of the state during these time periods (Table 1). All capture dates reported herein lie within previously reported dates of migratory activity in Nebraska (21 April–2 October; Geluso et al. 2004).

Dates of seasonal activity in adjacent states are similar to those in Nebraska (Bowles 1975, Bogan and Cryan 2000, Sparks and Choate 2000). In Nebraska and Kansas, migratory activity peaks in May and September (Sparks

and Choate 2000, this study). These peaks correspond well with data presented in Cryan (2003) for *L. noctivagans*.

Autumn migrants of *L. noctivagans* in western Kansas may move in sexually segregated groups (Sparks and Choate 2000); however, we saw little evidence of this type of movement in western Nebraska. Of 6 nights with multiple captures in September, 4 contained individuals of both sexes (Table 1).

Potential Hibernators

Although records are scarce, silver-haired bats are known to hibernate at middle and northern latitudes in the United States (Izor 1979, Hoffmeister 1989, Sherwood and Kurta 1999, Twente and Maruniak 2002). Two Nebraska records suggest that *L. noctivagans* may hibernate in the state (26 November, Benedict 2004; 4 November, this study). However, because 1 individual was captured on the wing (4 November) and the other did not appear to be hibernating (Benedict in litt.), each may represent a late migrant. The individual captured on 4 November from western Nebraska was extremely fat and had a mass of 12.5 g. The individual discovered on 26 November from eastern Nebraska was removed by hand from under a bale of hay in a barn and was held in captivity before it died (Benedict in litt.); therefore, we do not report its mass.

Twente and Maruniak (2002) report that an *L. noctivagans* lost 1.4 g of body mass in 52 days of hibernation in a controlled environmental chamber. If the 12.5-g individual we captured lost mass at a similar rate, it would have a mass of 8.5 g after 150 days of hibernation (November–March). This mass (8.5 g) is in the normal range for this species; for example, 8.5–12.5 g (Jones et al. 1983) and 8.1–11.0 g (Kunz 1982). Thus, this individual probably possessed adequate fat reserves to hibernate through winter in Nebraska. Thus far, *L. noctivagans* has not been found to hibernate in Iowa or Kansas (Bowles 1975, Sparks and Choate 2000), but it has been documented in a torpid condition in South Dakota (Turner and Jones 1968). Individuals captured from November to March in Nebraska likely represent winter residents.

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