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EXTRALIMITAL RECORDS OF THE MEXICAN FREE-TAILED BAT (*TADARIDA BRASILIENSIS MEXICANA*) IN THE CENTRAL UNITED STATES AND THEIR BIOLOGICAL SIGNIFICANCE

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ABSTRACT

Two new records of *Tadarida brasiliensis mexicana* are reported from Nebraska. The literature records of this taxon from the central United States are summarized. In this region of North America, these bats occupy a "natal range" where the species carries on regular reproductive activities and the populations are relatively stable, including California, Arizona, New Mexico, Texas, and Oklahoma. To the north of the natal range of *T. b. mexicana* is a "pioneering zone" where, under favorable conditions, the species is capable of reproducing and conducting its normal activities. The pioneering zone of the Mexican free-tailed bat includes Barber and Comanche counties in Kansas and as far north as Mesa and Saguache counties in southwestern Colorado. Finally, to the north of the pioneering zone, there is a much larger area that is proposed as the "exploring zone" in which only a few individuals of the species are found. Reproductive activities do not occur on any regular basis in the exploring zone, which encompasses the remainder of Colorado and Kansas as well as the states of Wyoming, Nebraska, Iowa, Illinois, Missouri, and southeastern South Dakota.

† † †

The Mexican free-tailed bat, *Tadarida brasiliensis mexicana*, occurs throughout the western and southwestern United States, and Mexico. Some populations of the subspecies are known to be highly migratory (Cockrum 1969). Cockrum (1969) demonstrated that there are four populations within this area, including one population that is resident in California and southern Oregon and three that migrate from Mexico into the southwestern United States—one in western Arizona and adjacent California and Nevada; a second in eastern Arizona and western New Mexico; and the third in eastern New Mexico, Texas, and Oklahoma. These migratory populations form maternity colonies dominated by pregnant females in Arizona, New Mexico, Oklahoma, and Texas. Individuals from these colonies have been recovered during the winter months in the northern Mexican states of Sonora, Sinaloa, Coahuila, Nuevo Leon, and Tamaulipas and as far south at least to Jalisco in west-central Mexico (Cockrum 1969, Glass 1958, 1959, 1982, Villa and Cockrum 1962).

The northernmost of the nursery colonies in the Great Plains is in northern Oklahoma, at Merrihew Cave about 2 kilometers south of the Kansas stateline in Woods County (Twente 1956). To the west, in Arizona and New Mexico *T. b. mexicana* is found statewide (Findley et al. 1975, Hoffmeister 1986). Breeding begins in February and ends before the northward migration. The northern caves are occupied from April to October (Cockrum 1969, Glass 1982, Twente 1956). Newborns have been observed as early in the year as June 5 and occur until mid-July, with a peak in births in the first week of July (Caire et al. 1989, Twente 1956). Flying young have been seen as early as July 17, and many are flying by the first week of August. Data indicate that maturation of the young requires about six weeks (Caire et al. 1989, Kunz and Robson 1995, Twente 1956).

To the north of the major maternity colonies in Arizona, New Mexico, and Oklahoma, some temporary or unusual maternity colonies have been reported from southern Kansas and western Colorado. Hibbard (1936) was the first to report maternity colonies of the Mexican free-tailed bat in Kansas when he documented four

colonies living in buildings in Medicine Lodge, Barber Co. Hall (1955) believed that the species was "regularly resident in only the extreme southern part of the State [= Kansas]," but by 1967, Jones et al. (1967) stated "We know of no permanent colonies in Kansas, although several formerly inhabited buildings in Medicine Lodge." Kunz et al. (1980) again confirmed that a colony occupied the Masonic Hall in Medicine Lodge, but no colonies could be found in a survey in 1995 (Sparks and Choate 2000). Kunz et al. (1980) also reported a potential colony in an old building in Protection, Comanche Co.

Hibbard (1934) reported an interesting phenomenon that still may occur in southern Kansas when he observed "large clouds" of *T. b. mexicana* leaving Merrihew Cave at sundown and flying northeast over Kansas. Hibbard (1934) shot one of these bats as it flew near the Salt Fork of the Arkansas River in Aetna, Barber Co. Residents of the Merrihew Ranch believed that the bats were foraging in Kansas as far north as the Arkansas River. This seems to document that even though the bats in Merrihew Cave are day residents of Oklahoma at least a portion of the population includes Kansas in its foraging range at night.

In Colorado, a major colony of Mexican free-tailed bats occupies the Orient Mine in Saguache Co. It reaches a maximum number of over 100,000 individuals of which as many as 98% are males. It is unusual that there is evidence that a small number of pregnant females also occupy this mine because the sexes are generally segregated during the summer months. The Orient Mine was worked for limonitic iron ore from 1881 until 1932 and presumably the bat colony has developed since that time (Armstrong et al. 1994, Fitzgerald et al. 1994, Svoboda and Choate 1987). Only recently has another maternity colony been reported from Grand Junction, Mesa Co. (Adams and Thibault 1999, Hall 1997). This colony was believed to consist of approximately 200 individuals and was located in the "old St. Regis Hotel in downtown Grand Junction." Because the building was renovated shortly after the colony had left for the winter in 1997, its current status is unknown.

Further to the north in Kansas and Colorado and into Wyoming, Nebraska, South Dakota, Iowa, Missouri, and Illinois scattered records of individual or small groups of Mexican free-tailed bat have been documented since at least 1875. In general, these records based on specimens have been treated as extralimital in nature and the result of some unusual or accidental circumstance. These records have been described in the literature in various terms such as "accidental visitor" (Hibbard 1936), "stragglers" (Hall 1955; Walley 1970), "general scattering" (Glass 1959), "wandering individuals" (Armstrong 1972, Barbour and Davis 1969, Bee et al. 1981, Birney and Rising 1968, Bogan and Cryan 2000, Czaplewski et al. 1979, Jones 1964, Jones et al. 1967, Walley 1970), "great dispersion by winds" (Long and Long 1965), "some kind of navigational failure" (Glass 1982, Jones et al. 1967), "may have 'overshot' its intended destination in spring migration" (Czaplewski et al. 1979, Jones et al. 1967), "waif" (Glass 1982), "extralimital occurrences by migrants" (Feldhamer 1985), and "accidental migrant" (Hoffmeister 1989).

Only a few authors have attributed these northern records to natural phenomena such as when Long and Long (1965) stated "that these rare northern records result mainly from a natural mechanism of dispersal in this species seems plausible to us." Birney and Rising (1968) provided a possible reason for this dispersal when they wondered if these individuals were moving "away from crowded conditions characteristic of maternity colonies." This would allow them to reduce intraspecific competition for food and space and to search for appropriate sites for new colonies.

In recent years the University of Nebraska State Museum has received two additional specimens of *Tadarida brasiliensis mexicana* from the state. As we prepared to document these specimens, we took the opportunity to review other northern records of this taxon in the central United States. Our objective has been to discover if any natural phenomena were at work that would be of biological significance within the species.

METHODS AND MATERIALS

All measurements were taken with digital calipers, with readings rounded to the nearest 0.1. All measurements are presented in millimeters.

Records of *Tadarida brasiliensis* from the central United States were gathered from the published literature. New specimens from Nebraska are housed in the collections of the Division of Zoology, University of Nebraska State Museum, University of Nebraska–Lincoln (USNM). Jerry R. Choate provided information on specimens housed in collections of the Sternberg Museum of Natural History, Fort Hays State University, Hays, KS (MHP). Robert M. Timm provided information on specimens housed in the collection of the Natural History Museum of the University of Kansas, Lawrence (KU). David M. Armstrong, University of Colorado; Rick A. Adams, University of Wisconsin at Whitewater; Joseph J. Allen III, Western State College, Gunnison, CO; Joseph C. Ortega, Fort Lewis College, Durango, CO; Fred Bunch, Great Sand Dunes National Monument, CO (GRSA), provided data on *Tadarida brasiliensis*

from their files and collections. We thank Angie Fox, Technical Artist, University of Nebraska State Museum, for preparation of the final copy of Figure 1.

RESULTS

New Nebraska records

Two specimens of *Tadarida brasiliensis mexicana*, not previously reported in the literature, have been obtained by the University of Nebraska State Museum in recent years. A male (UNSM 15390) from the headquarters of the Crescent Lake National Wildlife Refuge, Garden Co., Nebraska, is the first specimen of the species from the western panhandle of the state. A female (UNSM 16017) from Lincoln, Lancaster Co., Nebraska, is the fourth specimen of the species recorded from the city of Lincoln. These are only the seventh and eighth specimens of *Tadarida brasiliensis* recorded from Nebraska (Table 1).

Crescent Lake National Wildlife Refuge lies along the southwestern edge of the Nebraska Sandhills (an area of 50,000 square kilometers), has few trees and widely scattered buildings, and is approximately 25 kilometers north of the North Platte River near Oshkosh. The bat, which was taken on August 22, 1978, was a young-of-the-year, but no information is available on its capture. The female from Lincoln was recovered after it hit the window of a home at 621 W Beal Street. This bat, which was obtained on August 28, 1983, also was a young-of-the-year, but it was more mature than the specimen from Garden County. Microscopic examination of the prepared skeleton of one side of the individual was required to observe the nearly closed phalangeal epiphyses.

External and cranial measurements of the male and female, respectively, were as follows: total length, 100, 92; length of tail, 38, 31; length of hind foot, 9, 10; length of ear, 18.5, 17; length of forearm, [43, field measured], 41.9; greatest length of skull, 16.5, 17.1; condylobasal length, –, 15.9; zygomatic breadth, –, 9.6; postorbital constriction, 3.7, 4.0; breadth of braincase, 8.1, 8.0; mastoid breadth, –, 9.4; breadth across upper molars, 6.6, 7.2; length of the maxillary toothrow, 5.9, 5.8. The female weighed 7.7 grams.

Specimen-based records

Specimen-based records from the central United States for *Tadarida brasiliensis mexicana* are listed in Table 1. Specimens have been reported from 65 localities, including 23 localities from 11 counties in Colorado, two localities from separate counties in Illinois, 31 localities from 20 counties in Kansas, two localities from separate counties in Missouri, four localities from four counties in Nebraska, and three localities from three counties in Wyoming.

Multiple numbers of individuals taken on the same date were recorded from 18 localities—eight from Colorado and 10 from Kansas. Of these 18 localities, six have been identified as at least temporary colonies. Three colonies have been recorded in buildings in Medicine Lodge, Barber Co., in 1936 (Hibbard 1936) and 1980 (Kunz et al. 1980), but they were said not to be present by Jones et al. (1967) and were not found during a search in 1995 (Sparks and Choate 2000). Kunz et al. (1980) reported a possible colony in a building in Protection, Comanche Co., Kansas. The largest of the colonies in the central United States is located in the Orient Mine, Saguache Co., Colorado. The second colony in Colorado was located in a building in Grand Junction, Mesa County and may have been destroyed shortly after its discovery. Seven other multiple captures on the same date were recorded from the four counties in which the colonies were located—Barber and Comanche counties, Kansas, and Mesa and Saguache counties, Colorado. The five remaining multiple captures on the same dates were recorded in Garfield and Montezuma counties in Colorado and Finney, Gray, and Meade counties in Kansas.

Banding records

During the 1950s and 1960s, thousands of free-tailed bats were fitted with numbered forearm bands as the migratory habits and routes of the species were being studied. Many of the band recoveries were not fully documented in the literature, but several records of considerable interest from the central United States were published. Apparently the first banded bat that was recovered from the central United States was a young-of-the-year female banded at Selman's Cave in northern Oklahoma on July 5 (Glass 1959). It was recovered 8 miles [= 13 km] S Emporia, Lyon Co., Kansas, on September 16 (Glass 1959, Jones et al. 1967). The distance covered was 306 kilometers to the northeast.

The most extensive documentation of recovered banded bats in Kansas was presented by Jones et al. (1967) when they recorded 14 recoveries. All bats had been banded at maternity colonies in northern Oklahoma, either Selman's Cave 34 kilometers south of Comanche Co., Kansas, or Connor's Cave 72.5 kilometers south of Barber Co., Kansas. Four of the recoveries were adult females born the previous summer and recovered in June or early July from the following locations in Kansas: 10 mi. [= 16 km] N Greensburg, Edwards Co.; 15 mi. [= 24 km] NW Dodge City, Ford Co.; Fort Dodge, Ford Co.; Kismet, Seward Co. The remaining individuals were recovered in the year of their birth between August 10 and October 12 at the following locations in Kansas: Ashland, Clarke Co.; 6 mi. [= 9.5 km] NW Coldwater, Comanche Co.; 25 mi. [= 40 km] NW Colby, Rawlins Co.; 4 mi. [= 6.5 km] S, 2.75

Table 1. Specimen-based records of *Tadarida brasiliensis mexicana* in the central United States. GRSA = Great Sand Dunes National Monument, Colorado; KU = Natural History Museum, University of Kansas, Lawrence; MHP = Sternberg Museum of Natural History, Ft. Hays State University, Hays, Kansas; UNSM = University of Nebraska State Museum, University of Nebraska–Lincoln.

Locality	Specimens	Date captured	Status	References
COLORADO				
Baca Co.: Walsh	1?	–	–	Armstrong et al. 1994
Boulder Co.: Shanahan Hill (NW ¼ sec. 18, T1S, R70W)	1M	5 Jul 1998	adult	Adams and Thibault 1999
Douglas Co.: no specific locality	1?	12 Jun 1985	–	Armstrong et al. 1994, Armstrong pers. comm.
Garfield Co.: New Castle	4M, 1?	24 Jul 1907	–	Armstrong 1972, Armstrong et al. 1994
Gunnerson Co.: Western State College Campus	1?	1971	–	Armstrong et al. 1994, J. Allen pers. comm.
Gunnerson Co.: Wildwood Trailer Park	1M	16 Jul 1973	adult	Armstrong et al. 1994, J. Allen pers. comm.
La Plata Co.: Fort Lewis College	1M	1 Oct 1967	–	Armstrong et al. 1994, Fort Lewis College collection, J. Ortega pers. comm.
Las Animas Co.: Pinon Canyon Maneuver Site (37°31'36"N, 103°49'06"W)	1F	4 Aug 1989	adult	Armstrong et al. 1994, MHP 25550
Las Animas Co.: Pinon Canyon Maneuver Site (37°29'31"N, 103°50'31"W)	1M	14 Jun 1990	adult	Armstrong et al. 1994, MHP 25977
Las Animas Co.: Trinidad	1?		–	Armstrong et al. 1994
Mesa Co.: Grand Junction	≈ 200	observed 16 Sep 1997	presumed maternity colony	Armstrong et al. 1994, Hall 1997, Adams and Thibault 1999
Mesa Co.: Lower Car Tunnel, 2.2 mi SE W Entrance Gate, Colorado National Monument, sec. 32, T1S, R2W	1M, 3F	2 Aug 1989	3 females post-lactating; male young-of-the-year	Armstrong et al. 1994, R. Adams pers. comm.
Mesa Co.: no specific locality	1?	17 Sep 1984	–	Armstrong pers. comm.
	4?	9 Oct 1984	"from colony"	Armstrong pers. comm.
	3?	12 Oct 1984	–	Armstrong pers. comm.
Montezuma Co.: Cliff Palace, Mesa Verde National Park	2M	23 Aug 1936	–	Anderson 1961, Armstrong 1972
Montezuma Co.: near Cortez	–	–	–	Armstrong et al. 1994
Otero Co.: no specific locality	1?	25 Sep 1984	–	Armstrong et al. 1994, Armstrong pers. comm.
Saguache Co.: 3 ½ mi N, 2 ½ mi E Hooper	1F	1 Sep 1983	young-of-the-year	Armstrong et al. 1994, MHP 21826

Table 1. Continued.

Locality	Specimens	Date captured	Status	References
COLORADO, continued				
Saguache Co.: near Mineral Hot Springs	1M	29 Jun 1965	adult	Armstrong 1972, Armstrong et al. 1994, F. Bunch pers. comm., GRSA 346
Saguache Co.: 3 ¼ mi S, 4 ½ mi W Moffat	1M	31 Aug 1983	adult	Armstrong et al. 1994, MHP 21839
Saguache Co.: Orient Mine, 32 km SE Poncha Pass (38°13'N, 105°48'W)	> 100,000	studied 1978–83	male dominated maternity colony	Svoboda and Choate 1987, Freeman and Wunder 1988, Armstrong et al. 1994, Fitzgerald et al. 1994
	1M	17 Jul 1978	–	Fort Lewis College collection, J. Ortega pers. comm.
Saguache Co.: Valley View Hot Springs	11M	15–21 Jul 1982	adults	Armstrong et al. 1994, MHP 21340-50
Saguache Co.: ½ mi S, 1 ½ mi W Villa Grove	1M	1 Aug 1982	adult	Armstrong et al. 1994, MHP 21352
Saguache Co.: 1 ½ mi S, 2 ½ mi E Villa Grove	1M	1 Aug 1982	adult	Armstrong et al. 1994, MHP 21351
ILLINOIS				
DeKalb Co.: DeKalb	1M	17 Oct 1969	young-of-the-year	Walley 1979, Hoffmeister 1989
Jackson Co.: Carbondale	1F	18 Oct 1984	young-of-the-year	Feldhamer 1985, Hoffmeister 1989
KANSAS				
Barber Co.: Aetna Post Office	1M	6 Sep 1933	adult	Hibbard 1934, Cockrum 1952, KU 9315
Barber Co.: 3 mi N, 2 mi E Sharon	5?	26 Jul 1952	found roosting in barn	Loomis 1956
Barber Co.: Medicine Lodge	5M, 13F	1 Sep 1935	maternity colony	Hibbard 1936, Cockrum 1952, Sparks and Choate 2000, KU 11120-34, 11883-85
	2M, 1F	31 Mar 1969	maternity colony	Kunz et al. 1980, KU 120216-18
Barber Co.: Masonic Lodge, Medicine Lodge	2F, ≈2000	9 Jun 1969	maternity colony	Kunz et al. 1980, KU 120219-20
Barber Co.: Harvard Cave, 4.5 mi SW Sun City	4F	4, 8 Sep 1933	–	Cockrum 1952, KU 10899, 10909, 128059-60
Barber Co.: National Gypsum Mine, 1.5 mi S, 1.5 mi W Sun City	1F	9 Jun 1969	adult	Sparks and Choate 2000, KU 120215
Barber Co.: T34S, R15W, SW ½ sec 16	1M	24 May 1964	adult	Sparks and Choate 2000, MHP 3515
Cherokee Co.: Galena	1F	28 Mar 1951	adult	Cockrum 1952, Jones et al. 1967, Sparks and Choate 2000, KU 41374
Cheyenne Co.: T01S, R41W, sec 35 SE ¼	1M	18 Sep 1969	–	Sparks and Choate 2000, KU 121363
Comanche Co.: 1 mi S, 4 mi E Wilmore	1M	18 Oct 1969	–	Sparks and Choate 2000, KU 121549
Comanche Co.: Protection	numerous mummies	24 Nov 1971	possible colony	Kunz et al. 1980

Table 1. Continued.

Locality	Specimens	Date captured	Status	References
KANSAS, continued.				
Comanche Co.: 1.5 mi S, 16.25 mi E Buttermilk	2M, 4F	21–22 Sep 1991	adults	Sparks and Choate 2000, MHP 28606-07, 27748-51
Douglas Co.: Lawrence	1?	5 Sep 1936	worn teeth	Cockrum 1952, Long and Long 1965, Sparks and Choate 2000, KU 11597
Ellis Co.: Hays	1F	27 Jun 1971	adult	Choate and Fleharty 1975, Sparks and Choate 2000, MHP 11125
	1F	7 Sep 1976	young-of-the-year	Sparks and Choate 2000, MHP 14586
	1M	10 Sep 1982	young-of-the-year	Sparks and Choate 2000, MHP 21478
	1F	16 Aug 1983	young-of-the-year	Sparks and Choate 2000, MHP 24934
Ellis Co.: 12 mi N, 2 mi E Ellis	1M	12 Sep 1973	adult	Choate and Fleharty 1975, Sparks and Choate 2000, MHP 11124
Finney Co.: 6.5 mi N, 10 mi E Garden City	1M, 1F	15 Sep 1989	young-of-the-year	Sparks and Choate 2000, MHP 26715-16
Gove Co.: Castle Rock	1F	8 Oct 1934	adult	Black 1935, Cockrum 1952, Jones et al. 1967, Sparks and Choate 2000, KU 10119
Grant Co.: Ulysses	1F	unknown	–	Sparks and Choate 1995, 2000, MHP 31983
Gray Co.: T29S, R27W	1M, 1F	30 Mar 1955	adults; found in building	Anderson and Nelson 1958, Jones et al. 1967, Sparks and Choate 2000, KU 64464-65
Harper Co.: vicinity of Bluff City	1F	31 Aug 1983	–	Sparks and Choate 2000, KU 139182
Kiowa Co.: Greensberg	1M	21 Aug 1976	young-of-the-year	Hays et al. 1978, Sparks and Choate 2000
Lane Co.: 3.5 mi N, 2 mi W Alamato	1F	11 Apr 1995	adult, apparently not pregnant	Sparks and Choate 1995, 2000, MHP 32206
Logan Co.: 20 mi S, 8 mi W Oakley	1F	20 Jun 1967	adult	Birney and Rising 1968, Sparks and Choate 2000, KU 112698
Marion Co.: Lincolnville	1M	15 Aug 1936	adult	Cockrum 1952, Jones et al. 1967, Sparks and Choate 2000, KU 11882
Meade Co.: Meade County State Park	1F, 2-3?	19 Aug 1946	3 or 4 hanging on screen of office window	Getz 1961
Meade Co.: 2 mi N, 1 mi W Fowler	1M	31 Aug 1964	young-of-the-year	Jones et al. 1967, Sparks and Choate 2000, KU 98342
Morton Co.: Elkhart	1M	26 Oct 1953	young-of-the-year	Hall 1955, Jones et al. 1967, Sparks and Choate 2000, KU 57136
Riley Co.: Manhattan	1? 1?	before 1885 Nov 1980	– –	Cockrum 1952 Sparks and Choate 2000, KU 139029

Table 1. Continued.

Locality	Specimens	Date captured	Status	References
KANSAS, continued.				
Shawnee Co.: Tecumseh	1M	14 Sep 1961	young-of-the-year	Long and Long 1965, Jones et al. 1967, Sparks and Choate 2000, KU 100176
Stafford Co.: St. John	1?	7 Sep 1990	young-of-the-year	Sparks and Choate 2000, MHP 26807
Sumner Co.: Caldwell	1F	1979	–	Sparks and Choate 2000, KU 139183
MISSOURI				
Jackson Co.: Nashua Area, 10 mi E State Line	1?	–	–	Pitts et al. 1996
Phelps Co.	–	–	–	Schwartz and Schwartz 1981, Pitts et al. 1996
NEBRASKA				
Buffalo Co.: Kearney	1M	18 Sep 1973	young-of-the-year	Farney and Jones 1975, Czaplewski et al. 1979
	1M	4 Oct 1973	young-of-the-year; mummified	Farney and Jones 1975, Czaplewski et al. 1979
Garden Co.: headquarters of Crescent Lake National Wildlife Refuge	1M	22 Aug 1978	young-of-the-year	This paper, UNSM 15390
Keya Paha Co.: 1 mi S, 18 mi E Valentine	1M	17 Aug 1972	young-of-the-year; testes 3 × 2 mm	Farney and Jones 1975, Czaplewski et al. 1979
Lancaster Co.: Lincoln	1M	15 Aug 1913	young-of-the-year	Jones 1964, Czaplewski et al. 1979
	1F	27 Jun 1931	gave birth to young day following capture	Jones 1964, Czaplewski et al. 1979, UNSM 4136
	1M	27 Aug 1956	young-of-the-year	Jones 1964, Czaplewski et al. 1979, UNSM 12437
	1F	28 Aug 1983	young-of-the-year	This paper, UNSM 16017
WYOMING				
Laramie Co.: Cheyenne	1M	6 Jul 1981	adult	Stromberg 1982, Clark and Stromberg 1987, Bogan and Cryan 2000
Big Horn Co.: Cowley	1F	5 Aug 1985	–	Bogan and Cryan 2000
Sublette Co.: Pinedale	1F	16 Jun 1988	adult	Bogan and Cryan 2000

mi. [= 4.5 km] W Otis, Rush Co.; St. John, Stafford Co.; T12S, R23W, SW ¼ sec. 27, Trego Co. The female recovered in Rawlins Co. had been banded on July 9 and was recovered on September 4 after covering 370 kilometers to the northwest from Selman's Cave (Jones et al. 1967).

Cockrum (1969) reported a male Mexican free-tailed bat banded at Eagle Creek Cave, Greenlee Co., in eastern Arizona, that was recovered at Monte Vista, Rio Grande Co., in south-central Colorado (Armstrong et al. 1994).

Glass (1982) presented results from over 12 years of banding studies of the Mexican free-tailed bats from maternity colonies in northwestern Oklahoma. Of particular interest here are recoveries of banded bats to the north of these caves. Glass (1982, figures 1-3, 6-8) showed a total of 23 recoveries in Kansas. Of these recoveries, 13 were in August-September, two in October, one in November, one in April, one in May, and five in June-July. The recoveries in April and May were adult females from Lyons, Rice Co., and Lincoln, Lincoln Co, KS. None of the remaining 21 recovery sites was specifically identified.

Glass (1982) reported three additional individuals that were recovered to the north of Kansas in Nebraska, South Dakota, and Iowa. An adult female was recovered at Oxford, Harlan Co., Nebraska, in April. The first record of a Mexican free-tailed bat in South Dakota was a banded 3-year-old female recovered at Menno, Hutchinson Co., also in April. The first record of Mexican free-tailed bat in Iowa (Bowles 1975) was a banded adult male recovered at Massena, Cass Co., in October.

DISCUSSION

As postulated by Long and Long (1965), we believe that the majority of these extralimital records of *Tadarida brasiliensis mexicana* are the result of natural processes in a long-distance migratory species rather than the result of some "accident" or "malfunctioning" individuals. This species is capable of traveling more than 1800 kilometers in one-way seasonal migrations (Glass 1982), and individuals may forage as far as 80 kilometers per night from a roost cave (Caire et al. 1989). With such a highly mobile mammalian species, traditional geographic range maps do not provide meaningful representation of the distribution of *T. b. mexicana*; therefore, the question of the nature of these records as extralimital or some other designation needs to be explored.

To gain a better understanding of these records, we believe that it is necessary to divide them into several groups based upon the biology of the species. Because flying young-of-the-year are known only as early as July 17, records prior to this date should be adults that are at least approaching one year of age. Records from this period appear to be natural dispersal movements associated with the northward migration of Mexican free-tailed bats. In our specimen-based records, we are able to document three adult males and one of unknown sex from Colorado in addition to those at Orient Mine that fall into this group. In addition to the colonies in southern Kansas, six adult females and two adult males are recorded in Kansas before July 17 as are a female from Lincoln, Nebraska, and a male and a female from Wyoming (Table 1). Jones et al. (1967) added four adult females from Kansas based on banding records, and Glass (1982) added records of seven banded females from Kansas captured prior to July 17. Glass also recorded captures of banded females from Nebraska and South Dakota in April. Unfortunately, the reproductive data for these females is limited to three individuals—those from Lane and Logan counties in Kansas evidently were not pregnant. In contrast, a female from Lincoln, Nebraska, was pregnant and gave birth to a young on June 28 (Table 1). These meager data at least support the concept that some of these females are pregnant and capable of producing young at these northern locations.

We believe that this group of records is normal dispersal activity during northward migration by adult bats attempting, in the case of some of the females, to find new locations for maternity colonies. These movements would be those responsible for the founding of several maternity colonies in Medicine Lodge, Kansas, and in Orient Mine and a building in Grand Junction, Colorado. Clearly, these locations only became available to Mexican free-tailed bats in the twentieth century; therefore, there must be a constant exploration for potential colony sites to be discovered and colonized.

The geographic limits of all biological species are dynamic zones of expansion and contraction. A species will continue to expand its distribution as its populations build, while climatic and other environmental forces will impose limits. For most species of mammals, this dynamic situation occurs in an area of a few meters to a kilometer or two. Distributional dynamics are more readily apparent in Mexican free-tailed bats because their high mobility and migratory habits play out in a much larger area that covers several states. Clearly for Mexican free-tailed bats, one of the limiting factors to their distribution is appropriate roost and maternity sites. As appropriate sites in southern Kansas and western Colorado become available, Mexican free-tailed bats have established pioneering colonies.

The second group of records is those from July 17 to September 15—from the time that young-of-the-year individuals are beginning to fly until the beginning of the southward migration. This is the largest group of records for Mexican free-tailed bats from the central United States north of maternity colonies (Table 1). As predicted, these records are a mixture of adults and young-of-the-year. In the specimen-based records, we are able to document the following individuals: Colorado—14 adult males and four adult females, one young-of-the-year male and one female, and seven males and one unknown sex individual of unknown age; Kansas—three adult males, five young-of-the-year males and three females, one adult and one young-of-the-year of unknown sex, and six females and seven unknown sex individuals of unknown age; Nebraska—four young-of-the-year males and one female; Wyoming—one female of unknown age. Glass (1982) reported 13 records of Mexican free-tailed bats in Kansas in August-September based on banding data. Some of the records given by Jones et al. (1967) for Kansas based on banding records would also fall into this category, but the exact number can not be determined based on published information.

We agree with the hypothesis of Birney and Rising (1968) that these records represent individuals moving

away from the crowded conditions characteristic of maternity colonies at this time of summer. Glass (1959) believed that these individuals resulted from "a general scattering in late summer when numbers were at a maximum." Glass (1982) recorded individuals dispersing as far as 640 kilometers north in Kansas during this time. As Birney and Rising (1968) have pointed out, these movements reduce intraspecific competition for food and space. These movements also would afford individuals the opportunity to explore potential maternity sites. Homing experiments conducted in Arizona support the concept that Mexican free-tailed bats have no sense of "home" but are able to orient to a migratory pattern of wide geographical range (Davis and Cockrum 1963). It could be expected that sites "discovered" during this exploratory time during late summer could be relocated the following spring.

The final group of records, those after September 15, would be individuals preparing for or in the midst of southward migration for the winter. We are able to document 23 specimen-based records from this time period of which 10 are from Colorado and 10 are from Kansas and certainly well within a southward migratory pattern that would carry them into New Mexico-Arizona and Oklahoma, respectively. The remaining three individuals for which we have definitive data are from Kearney in central Nebraska taken on September 18 (Farney and Jones 1975) and two from Illinois taken on October 17 at DeKalb in the north-central part of state (Walley 1970) and October 18 at Carbondale in the extreme southwestern part of state (Feldhamer 1985). These latter three records are young-of-the-year and would be our candidates for "accidental" records or "lost" individuals. This is especially true for the two records from Illinois taken as late in the season as mid-October. These simply may represent young individuals that during the late summer general dispersion have wandered too far and become separated from migratory routes of the species.

Documented band recoveries show much the same pattern as the records based on specimens. Glass (1982) showed two records in south-central Kansas in October. These two individuals are a young-of-the-year female and a female of unknown age. The bats appear to be lined up with the caves and migrating individuals in central Oklahoma. The November-taken individual reported by Glass (1982) is an adult female from south-central Kansas. The recovery appears to have come from near caves in north-central Oklahoma, but Glass (1982) showed no recoveries of banded bats in Oklahoma from November. An enigmatic banding record is the adult male recovered in southwestern Iowa in October (Glass 1982). It would be interesting to know if this had been a mild autumn and this was an individual lingering behind to feed before starting southward or if is another disoriented individual "lost" from the southward migratory route of the Mexican free-tailed bat.

We conclude that the distributional patterns of *T. b. mexicana* are far more complex than can be represented by standard geographic range maps. We believe that the distribution would be best represented by recognizing three regions within the overall distribution of the subspecies (Fig. 1). We name the first region the "natal range." In this region individuals carry on regular reproductive activities and the populations are relatively stable. In this subspecies, the natal range in the United States would include California, Arizona, New Mexico, Texas, and Oklahoma.

To the north of the natal range of *T. b. mexicana*, we would recognize a second region—the "pioneering zone." The pioneering zone would be the area where, under favorable conditions, the species is capable of reproducing and conducting its normal activities (Fig. 1). The pioneering zone of the Mexican free-tailed bat would include Barber and Comanche counties in Kansas and as far north as Mesa and Saguache counties in southwestern Colorado. A case could be made for including the Orient Mine (in Saguache Co.) in the natal range of *T. b. mexicana*, but we have chosen to exclude it because of the unusual nature of the colony. It is a large colony dominated by males. Males generally form colonies segregated from pregnant females; they are found more in the southern part of the geographic range of the species; and they normally form small colonies.

Finally, to the north of the pioneering zone of *T. b. mexicana*, there is a much larger area that we term the "exploring zone" in which only a few individuals of the species are found (Fig. 1). Reproductive activities do not occur on any regular basis in the exploring zone. Individuals are primarily foraging and "exploring" for appropriate habitats in which to establish permanent populations in this zone. Occasionally, "accidental" or "lost" individuals are discovered in this zone.

It is our contention that the distributions of most mammals follow this same dynamic pattern, but it is only in highly mobile species that the pattern becomes evident because it is on a scale that can be readily observed. A similar pattern of distribution has been documented for the expanding populations of the nine-banded armadillo, *Dasypus novemcinctus* (Freeman and Genoways 1998, Humphrey 1974). We believe that similar distributional patterns can be found and documented in expanding populations of carnivores and artiodactyls, such as the least weasel, *Mustela nivalis*, which is expanding south and west; white-tailed deer, *Odocoileus virginiana*, which is expanding westward; and moose, *Alces alces*, which is expanding southward.

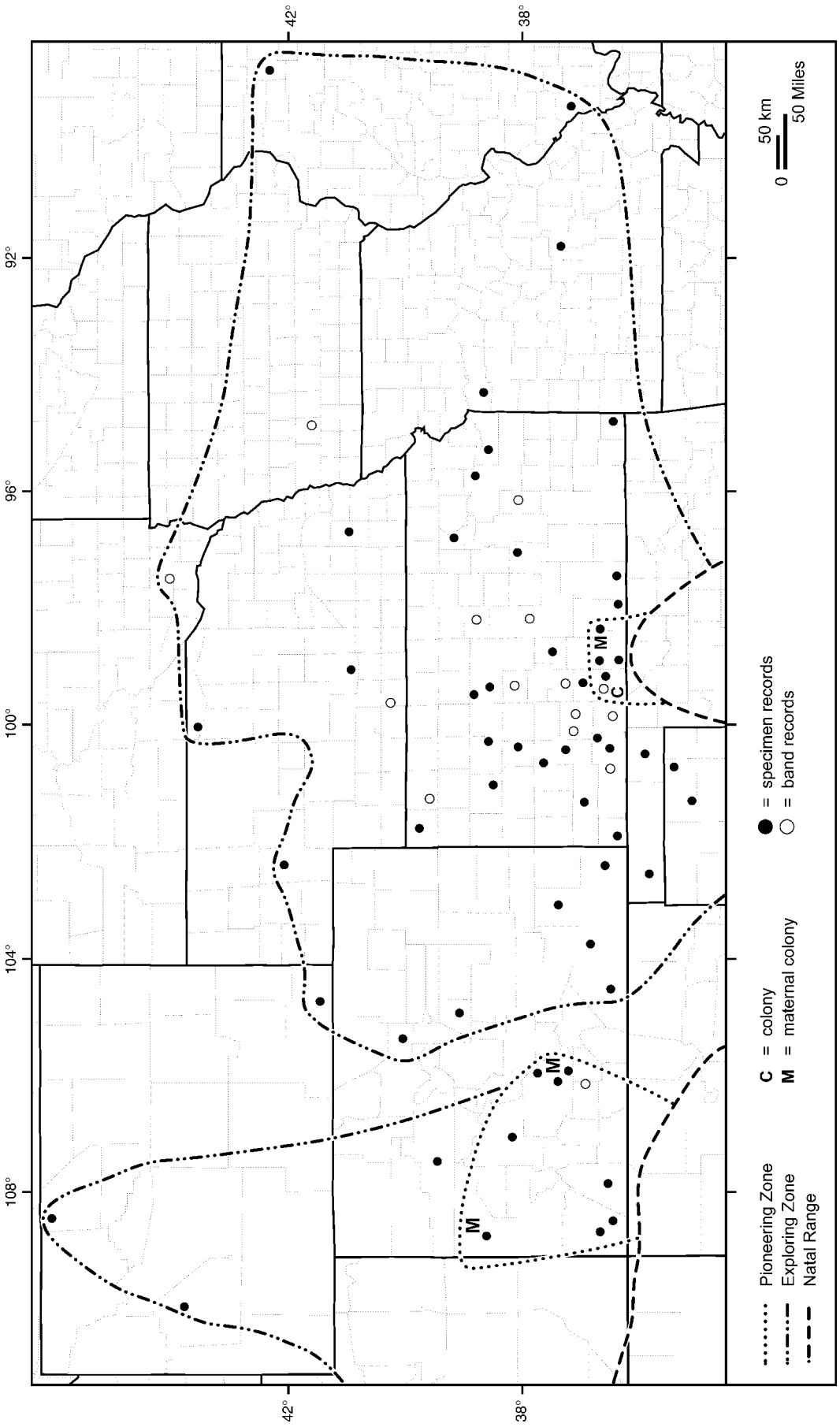

Figure 1. Geographic distribution of the Mexican free-tailed bat, *Tadarida brasiliensis mexicana*, in the central Great Plains. Records from the Oklahoma Panhandle are from Caire et al. (1989) and from the Texas Panhandle from Schmidly (1991). See text for description of Natal Range, Pioneering Zone, and Exploring Zone.

Two additional observations can be made based upon the data compiled here. First, it appears that the "extralimital" records of *Tadarida brasiliensis mexicana* in the central United States originate from two of the behaviorally separate groups recognized by Cockrum (1969) in the southwestern United States. Certainly, the records in Kansas, Nebraska, Missouri, Iowa, South Dakota, and probably Illinois are originating from Cockrum's Group D centered in eastern New Mexico, Texas, and Oklahoma. The origin of records in Colorado and Wyoming are problematic, but the one banding record from this area is an individual from Cockrum's Group C banded at Eagle Creek Cave in Greenlee Co., Arizona, and recovered in Rio Grande Co., Colorado (Cockrum 1969). This county is immediately to the south of the county in which the Orient Mine colony is found. Although the evidence is not compelling, we postulate that records from west of the mountains in Colorado and Wyoming originate from Cockrum's Group C (centered in western New Mexico and eastern Arizona), whereas those from the western edge of the Great Plains in eastern Colorado and southeastern Wyoming have originated from Cockrum's Group D.

Finally, we would like to observe that many of the records on which this paper was based were reported in the literature as single observations. It has become increasingly difficult to find scientific journals to publish documentation of such information. It is our firm hope that there will be journals, either print or electronic, in the future that will publish single observations because as these data accumulate broader biological patterns will emerge over time.

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