

SUMMER FORAGING RANGE OF MEXICAN FREE-TAILED BATS (*TADARIDA BRASILIENSIS MEXICANA*) FROM CARLSBAD CAVERN, NEW MEXICO

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ABSTRACT—We determined the foraging range of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) that spend summer in Carlsbad Cavern, Carlsbad Caverns National Park, New Mexico. We captured bats at varying distances and directions from the cavern and attached a radiotransmitter to each. During daylight hours, we entered Carlsbad Cavern to determine if bats with radiotransmitters were present in the maternity roost. The distribution of localities where captured bats returned to Carlsbad Cavern indicated a nightly foraging range of at least 56 km from Carlsbad Cavern. Our data indicated that the colony eventually dispersed in every direction after leaving the cavern each evening and foraged in a space nearly 4,000 km². This study was the first to document use of water sources on property of Carlsbad Caverns and Guadalupe Mountains national parks, the Lincoln National Forest, and other sites in southeastern New Mexico and western Texas by members of the colony of *T. b. mexicana* that reside in Carlsbad Cavern.

RESUMEN—Determinamos la extensión de forrajear de los murciélagos mexicanos de colas libres (*Tadarida brasiliensis mexicana*) que pasan los veranos en la Caverna de Carlsbad en el Parque Nacional de Carlsbad Caverns, Nuevo México. Apresamos murciélagos a distancias variables y a sentidos variables de la caverna y les pusimos emisores de radio. Durante las horas de luz, entramos en la Caverna de Carlsbad para determinar si los murciélagos con emisores de radio estaban presentes en su percha de maternidad. La distribución de las localidades donde los murciélagos apresados regresaron a la Caverna de Carlsbad sugirió una extensión de forrajear cada noche de por lo menos 56 km de la Caverna de Carlsbad. Nuestros datos dieron a entender que la colonia se dispersó eventualmente en todos sentidos después de salir de la caverna cada noche y luego forrajeó en un espacio de casi 4.000 km². Esta investigación fue la primera que documentó el uso de fuentes de agua en la propiedad de los parques nacionales de Carlsbad Caverns y de Guadalupe Mountains, el Bosque Nacional de Lincoln y otros sitios en el sudeste de Nuevo México y en el oeste de Texas por residentes de la colonia de *T. b. mexicana* que residen en la Caverna de Carlsbad.

Groups of flying Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) sometimes are large and dense enough to be detected by weather radar (Westbrook et al., 1998) and by military radar (Williams et al., 1973). These groups of bats are known to be as large as 400 km², to move at speeds averaging 40 km/h, and to fly at altitudes greater than 3,000 m above ground level (Williams et al., 1973). Davis et al. (1962) noted that nocturnal foraging flights of Mexican free-tailed bats might cover no more than an 80-km radius per cave. Although it has been believed that most foraging is done at heights of 6 to 15 m above the

ground (Wilkins, 1989), there is now evidence that a significant amount of foraging can occur at altitudes greater than 400 m above the ground (McCracken, 1996; McCracken et al., 1999). Considering what is known about migration, homing ability, and foraging habits of the Mexican free-tailed bat, this species can fly significant distances and at great altitudes to visit foraging areas each night.

Among questions most frequently asked about bats at Carlsbad Caverns National Park is where do Mexican free-tailed bats that live in Carlsbad Cavern go at night? Studies by Geluso and Geluso (in press) verified that some

Mexican free-tailed bats use several nearby water sources in Carlsbad Caverns National Park. However, it is not known whether these bats are part of the colony that roosts in the cavern. Even if bats from Carlsbad Cavern visit these water sources, most of the bats must go elsewhere to forage and drink because there is no report of large numbers of bats at these sites.

It has long been assumed that most Mexican free-tailed bats residing at Carlsbad Cavern feed and drink along the Pecos and Black river valleys. The main line of evidence is based on the southeasterly direction that the bats usually fly after leaving Carlsbad Cavern each evening; this is toward the river valleys. Another line of evidence is that several individuals of *T. b. mexicana* that were banded at Carlsbad Cavern were recaptured at railroad bridges near the Pecos River (Constantine, 1967:71). Thus, there has been only speculation about where bats from Carlsbad Cavern forage. The purpose of the research reported herein was to determine where Mexican free-tailed bats living in Carlsbad Cavern forage and drink.

METHODS—We attempted to capture Mexican free-tailed bats at varying distances and directions from Carlsbad Cavern on 9 through 13 July 1997, 30 May through 1 June 1998, 4 through 9 July 1999, and 1 through 6 July 2000. With the exception of May and June 1998, research was conducted in July, which is during the time of parturition and lactation of the colony residing in Carlsbad Cavern (Altenbach et al., 1979). At the cavern, substantial numbers of adult males also are present in the maternity roost throughout summer (Geluso and Geluso, in press). Thus, our captures in July are resident, nonmigratory individuals. All radiotransmitters were attached to adult males or females that were lactating, except 1 female captured 1 June 1998 (reproductive condition not noted) and 1 female captured 1 July 2000 (pregnant).

At each locality where we captured *T. brasiliensis*, a radiotransmitter was attached to 1 or 2 individuals. Each radiotransmitter (Model BD-2A with reed switch, Holohil Systems, Ltd., Carp, Ontario, Canada), including whip antenna and battery, weighed 0.65 to 0.70 g. We applied a nontoxic adhesive (Skin-Bond Cement, Smith and Nephew United, Inc., Largo, Florida) to the fur between the scapulae of the bat and to the body of the radiotransmitter. We let the glue dry for 5 min and then gently pressed the radiotransmitter downward between the scapulae of the bat. After confirming a secure attachment and verifying the radiotransmitter was functioning properly, bats were released at place of capture.

Our radioreceiving systems consisted of a hand-held antenna (3-element Yagi style, Wildlife Materials, Inc., Carbondale, Illinois) and a multi-channel receiver (TRX-2000S and Falcon-five models, Wildlife Materials, Inc., Carbondale, Illinois). During daylight hours of 10 through 15 and 19 July 1997, 31 May through 1 June 1998, 6 through 10 July 1999, and 2 through 7 July 2000, we entered Carlsbad Cavern to determine if bats were present by monitoring signals from their radiotransmitters near the maternity roost in a section of Carlsbad Cavern named Bat Cave. In 1997, we also monitored radiosignals during and after evening outflights of *T. brasiliensis*; radioreceivers were positioned outside Carlsbad Cavern, near its large and small natural openings.

RESULTS—Throughout warm months of the year, a massive exodus of Mexican free-tailed bats occurs from Carlsbad Cavern each evening (Mulheisen, 1999). Both natural openings of Carlsbad Cavern are used by these bats (Geluso and Geluso, in press), but the majority use the large opening. Although the stream of exiting bats usually flows toward the southeast, their foraging area extends in every direction from Carlsbad Cavern (Fig. 1).

Localities where radiotransmitters were attached to *T. brasiliensis* are presented in Table 1 and Fig. 1, and localities where we were unsuccessful in capturing *T. brasiliensis* are shown on Fig. 1. During 1997 through 2000, Mexican free-tailed bats with radiotransmitters attached to them returned to Carlsbad Cavern from several localities in southeastern New Mexico and western Texas (Tables 1 and 2). Within Carlsbad Caverns National Park, we documented that *T. b. mexicana* from Carlsbad Cavern visit Rattlesnake Spring and Sewer Lagoon Tank; these are 8.0 and 2.2 km from Carlsbad Cavern, respectively. Geographic extremes of returns were from: Sitting Bull Falls in the Lincoln National Forest to the northwest (26 km); the dam at Lake McMillan (presently dry) along the Pecos River to the northeast (47 km); the Black River near Malaga to the east (35 km); Salt Creek, a tributary of the Pecos River, to the southeast (56 km); a ranch-house pond in Texas to the south (36 km); and Manzanita Spring in Guadalupe Mountains National Park to the southwest (46 km).

A female from Noye Tank was the only *T. b. mexicana* that we captured east of the Pecos River (Fig. 1 and Table 1). When released at the capture site, she flew directly west, but her

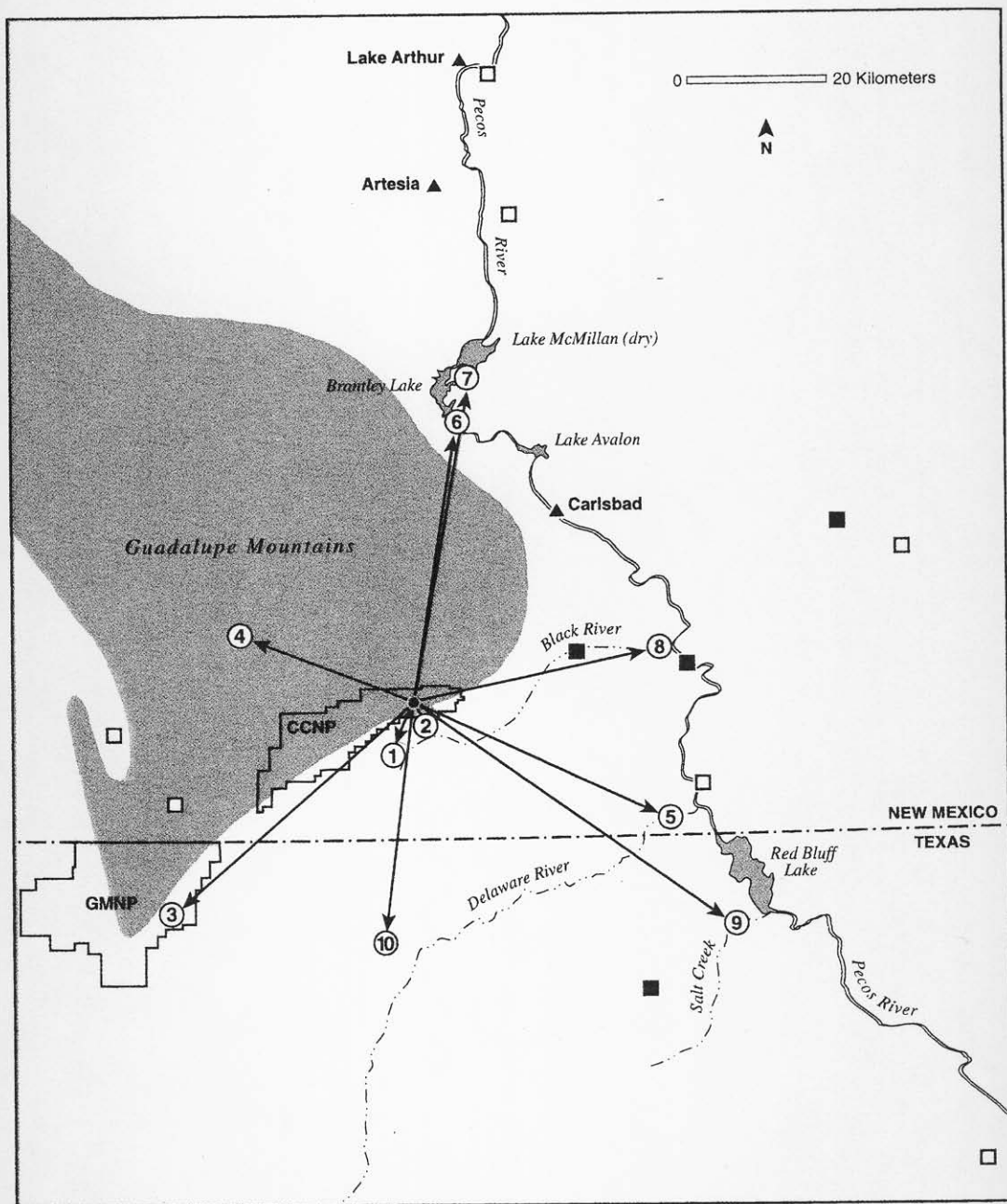


FIG. 1—Summer foraging range of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) from Carlsbad Cavern, New Mexico (NM). The black dot represents the large natural opening of Carlsbad Cavern. Circled numbers represent localities from which bats with radiotransmitters returned to Carlsbad Cavern (Table 1): 1) Rattlesnake Spring, a detached 0.32-km² parcel of land within Carlsbad Caverns National Park (CCNP); 2) Sewer Lagoon Tank, CCNP; 3) Manzanita Spring, Guadalupe Mountains National Park (GMNP); 4) Sitting Bull Falls, Lincoln National Forest; 5) Delaware River-US Highway (Hwy) 285; 6) Pecos River-Capitan Reef Road; 7) Lake McMillan Dam; 8) Black River near Malaga; 9) Salt Creek-US Hwy 285; and 10) ranch-house pond. Closed squares represent localities where we attached radiotransmitters to bats, but their radiosignals were not detected in Carlsbad Cavern (Table 1). Open squares represent localities where we were unsuccessful in capturing *T. brasiliensis* (distance from Carlsbad Cavern in km is in parentheses): Pecos

radiosignal was never detected in Carlsbad Cavern. It is possible that this was a migrating individual, because it was captured on 1 June. Two other attempts to capture *Tadarida* east of the Pecos River were unsuccessful (Red Tank and locality southeast of Artesia; Fig. 1); in addition, we were unable to capture *Tadarida* at Noye Tank 11 through 12 July 1997.

DISCUSSION—Although small colonies of *T. b. mexicana* are known to occur in railroad bridges near the Pecos River east of Carlsbad Cavern (Constantine, 1967:71) and in the city of Carlsbad (G. W. Vequist, pers. comm.), we know of no other large maternity colony of this species in the region. Lack of returns of 2 lactating females, which we captured and attached radiotransmitters to near Malaga in 1999 (Table 1), indicated that other small maternity colonies might exist in the region. On 1 July 2000, we also attached radiotransmitters to an adult male and a pregnant female on the Black River near Malaga; the radiosignal of the male was detected in Carlsbad Cavern the following day, but the radiosignal of the female was not detected there 2 through 7 July. Examination of the railroad bridge at our capture site near Malaga in 2000 yielded no evidence of a colony of *Tadarida*, but a maternity colony could have been present in another bridge or elsewhere in the region. On 3 July 2000, a similar scenario occurred when we captured, attached radiotransmitters, and released a male and a lactating female at the ranch-house pond in Culberson County, Texas, i.e., the radiosignal of the male was detected at Carlsbad Cavern, but the radiosignal of the female was not (Table 1). On 3 July 2000, we discovered a maternity colony of *T. brasiliensis* in a railroad bridge north of Freeport Sulphur Plant in Culberson County, Texas, 53 km southeast of Carlsbad Cavern. We attached radiotransmitters to 2 lac-

tating females at the bridge, and neither radiosignal was detected at Carlsbad Cavern 4 through 7 July (Table 1).

Radiosignals of 11 of 13 males with radiotransmitters were detected in Carlsbad Cavern, but only 4 of 12 females with radiotransmitters were detected there (Table 1). We have no reason to suspect that females were losing their radiotransmitters more often than males during their flight from time of their release to when they arrived at their roost. Even if radiotransmitters were dislodged from lactating females at Carlsbad Cavern (because of extra tugging from babies), we still were able to detect fallen radiotransmitters on the guano. Unless radiotransmitters altered the roosting behavior of females, it seems that males were more likely to reside in Carlsbad Cavern than females. Although there was a maternity colony present in the cavern in summers of 1997 through 2000, the majority of females in the region apparently inhabited other small maternity colonies elsewhere.

The distribution of localities where bats with radiotransmitters returned to Carlsbad Cavern indicated a nightly foraging range of at least 56 km from Carlsbad Cavern (Table 1). Our data also indicated that the colony eventually disperses in every direction after leaving Carlsbad Cavern each evening (Fig. 1). If the colony from Carlsbad Cavern forages at an altitude ≥ 750 m above ground level, as did bats observed in Texas by McCracken (1996), the colony that resides in Carlsbad Cavern has a huge foraging area. Using an average foraging radius of 41 km that we documented herein (our 6 geographic extremes) and a foraging altitude of 750 m, Mexican free-tailed bats from Carlsbad Cavern forage in a space nearly 4,000 km³.

This study was the first to document use of water sources in Carlsbad Caverns and Gualupe Mountains national parks, the Lincoln

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River-NM Hwy 507, 4.3 km ESE Lake Arthur, 32°59.340'N, 104°19.434'W, Chaves County, NM, 5–6 July 2000 (91); Red Tank, 32°22.759'N, 103°43.232'W, Lea County, NM, 4–5 July 1999 (72); Brad Hughes Ranch Headquarters, 9.4 km NW Otero County Road 415-NM Hwy 137, 32°08.417'N, 104°54.538'W, Otero County, NM, 4–5 July 2000 (44); Pipeline crossing on Pecos River, 7.1 km N of Texas state line, 32°03.957'N, 104°00.203'W, Eddy County, NM, 7–8 July 1999 (43); 0.7 km E Devils Den Spring, Lincoln National Forest, 32°02.065'N, 104°47.918'W, Eddy County, NM, 4–5 July 2000 (38); 16.1 km NW Pecos, 31°32.309'N, 103°36.743'W, Reeves County, Texas, 2–3 July 2000 (105); 10.2 km E, 3.9 km S Artesia, 32°48.489'N, 104°17.244'W, Eddy County, NM, 5–6 July 2000 (71).

TABLE 1—Results of monitoring radiotransmitters under the roost of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) in Bat Cave, Carlsbad Cavern, 32°10.716'N, 104°26.439'W, Carlsbad Caverns National Park, Eddy County, New Mexico, 1997 through 2000. Time is given in Mountain Daylight Saving Time.

Locality where radiotransmitter was attached (distance from Carlsbad Cavern in km)	Date of capture	Time of capture	Sex	Dates detected in Carlsbad Cavern
Rattlesnake Spring, Carlsbad Caverns National Park, 32°06.589'N, 104°28.314'W, Eddy County, New Mexico (8.0)	10 July 1997	0028 h	Female	10, 14, 15 July
Sewer Lagoon Tank, Carlsbad Caverns National Park, 32°09.834'N, 104°25.442'W, Eddy County, New Mexico (2.2)	10 July 1997	2058 h	Female	11, 14, 15, 19 July
Sewer Lagoon Tank	11 July 1997	0406 h	Female	11, 14, 15, 19 July
Manzanita Spring, Guadalupe Mountains National Park, 31°54.660'N, 104°47.962'W, Culberson Coun- ty, Texas (46)	13 July 1997	0130 h	Male	13, 14, 15 July
Manzanita Spring	13 July 1997	0211 h	Male	13, 14, 15 July
Sitting Bull Falls, Lincoln National Forest, 32°15.268'N, 104°41.817'W, Eddy County, New Mexico (26)	30 May 1998	2043 h	Male	Not detected
Sitting Bull Falls	30 May 1998	2147 h	Male	Not detected
Noye Tank, 32°26.393'N, 103°47.732'W, Eddy County, New Mexico (68)	1 June 1998	0001 h	Female	Not detected
Black River, 1.2 km N, 12.0 km W Malaga, 32°14.128'N, 104°11.768'W, Eddy County, New Mexico (24)	5 July 1999	2358 h	Female	Not detected
Pecos River, 3.8 km E Malaga, 32°13.391'N, 104°01.733'W, Eddy County, New Mexico (39)	6 July 1999	0315 h	Female	Not detected
Sitting Bull Falls	6 July 1999	2326 h	Male	7, 8, 9, 10 July
Sitting Bull Falls	7 July 1999	0040 h	Male	7, 8, 9, 10 July
Intersection of US Highway 285 and Delaware River, 32°01.357'N, 104°03.256'W, Eddy County, New Mexico (40)	7 July 1999	2300 h	Female	10 July
Intersection of US Highway 285 and Delaware River	7 July 1999	2304 h	Female	Not detected
Intersection of Pecos River and Capitan Reef Road south of Brantley Lake Dam, 32°32.411'N, 104°21.361'W, Eddy County, New Mexico (41)	8 July 1999	2142 h	Male	9 July
Intersection of Pecos River and Capitan Reef Road south of Brantley Lake Dam	8 July 1999	2300 h	Male	9 July
Lake McMillan Dam, 32°35.675'N, 104°20.861'W, Eddy County, New Mexico (47)	9 July 1999	0213 h	Male	9 July
Black River, 1.3 km N, 0.5 km W Malaga, 32°14.166'N, 104°04.428'W, Eddy County, New Mexico (35)	1 July 2000	2230 h	Female	Not detected
Black River, 1.3 km N, 0.5 km W Malaga	1 July 2000	2230 h	Male	2 July
Intersection of US Highway 285 and Salt Creek, 6.9 km NW Orla, 31°52.763'N, 103°56.863'W, Reeves County, Texas (56)	3 July 2000	0106 h	Male	4, 7 July
Intersection of US Highway 285 and Salt Creek, 6.9 km NW Orla	3 July 2000	0143 h	Male	3, 4, 5, 7 July
Ranch-house pond, 7.7 km S intersection of TX Highways 652 and 1108 on TX Highway 1108, 31°52.075'N, 104°28.673'W, Culberson County, Tex- as (36)	3 July 2000	2243 h	Female	Not detected

TABLE 1—Continued.

Locality where radiotransmitter was attached (distance from Carlsbad Cavern in km)	Date of capture	Time of capture	Sex	Dates detected in Carlsbad Cavern
Ranch-house pond, 7.7 km S intersection of TX Highways 652 and 1108 on TX Highway 1108	3 July 2000	2315 h	Male	4, 5, 7 July
Railroad bridge, 3.2 km S intersection of TX High- way 652 and road to Freeport Sulphur Plant, 31°47.629'N, 104°04.760'W, Culberson County, Tex- as (53)	3 July 2000	2254 h	Female	Not detected
Railroad bridge, 3.2 km S intersection of TX High- way 652 and road to Freeport Sulphur Plant	3 July 2000	2256 h	Female	Not detected

National Forest, and other sites in southeast-
ern New Mexico and western Texas by the col-
ony of *T. b. mexicana* that resides in Carlsbad
Cavern. Movement patterns of these bats in-
dicated a direct biological connection between
the 2 national parks, as well as with a variety of
habitats in the region that surrounds Carlsbad
Cavern. The number of *T. b. mexicana* captured
by us at water holes in Carlsbad Caverns Na-
tional Park was greater than at watering places
in Guadalupe Mountains National Park or any
of the outlying areas. This was expected be-
cause the colony inhabiting Carlsbad Cavern is
the only one of significant size in the region.

The nightly foraging range of Mexican free-
tailed bats from Carlsbad Cavern might be larg-
er than we have documented, especially during
years of drought, when bats might have to travel
farther to find insects. Habitat similar to that at
the dam at Lake McMillan along the Pecos Riv-
er extends northward to beyond Artesia, New
Mexico; habitat similar to that near Salt Creek

extends southward along the Pecos River to-
ward Pecos, Texas; and habitat similar to that
around Manzanita Spring in Guadalupe Moun-
tains National Park extends around the south
end of the Guadalupe Mountains. In 2000, we
attempted to capture Mexican free-tailed bats in
these areas, but we were unsuccessful (Fig. 1).
Our lack of success in capturing *T. b. mexicana*
in these areas could mean that individuals from
Carlsbad Cavern are so near the limits of the
foraging range of this population that these bats
rarely occur there, or that the foraging habitat
in these surrounding areas, for some reason, is
not favorable to the bats.

We have documented that the colony of *T.
brasiliensis* living in Carlsbad Cavern during
summer feeds and drinks over: 1) the Pecos
River and its tributaries, including the Black
River, Delaware River, and Salt Creek; 2) nat-
ural springs located along the base of the east-
ern escarpment of the Guadalupe Mountains
(e.g., Rattlesnake and Manzanita springs); 3)

TABLE 2—Results of monitoring radiotransmitters near the natural openings of Carlsbad Cavern, New Mexico, on 11, 13 through 16, and 19 July 1997. Time is given as Mountain Daylight Saving Time. ND = not detected. Blanks indicate evenings when radiosignals were not monitored.

Locality radiotransmitter attached	Rattlesnake Spring		Sewer Lagoon Tank		Manzanita Spring	
Sex	Female		Female	Female	Male	Male
Date of capture	10 July		10 July	11 July	13 July	13 July
Time of capture	0028		2058	0406	0130	0211
Date and time detected on surface						
11 July	ND		2342	ND	—	—
13 July	—		—	—	ND	ND
14 July	2026		ND	ND	2025	—
15 July	2036		2056	2051	0026 and 0031	—
16 July	ND		ND	ND	2030	—
19 July	ND		ND	ND	ND	—

human-made ponds (e.g., Sewer Lagoon Tank in Carlsbad Caverns National Park and the ranch-house pond in Culberson County, Texas); and 4) streams in rugged, dry canyons of the Guadalupe Mountains (e.g., Sitting Bull Falls). Desert-scrub habitats surrounded sites where we captured *T. brasiliensis* along the Pecos River and its tributaries. Likewise, desert scrub also surrounded Rattlesnake Spring, Sewer Lagoon Tank, and the ranch-house pond. The habitat around Manzanita Spring was open juniper woodland. Based on our study, we do not know how much foraging for insects actually is done over arid land. We do know, however, that *T. brasiliensis* and other species of bats take advantage of open water that is distributed in these arid lands, including rivers, creeks, natural springs, and human-made tanks constructed for use by livestock. Many bats from Carlsbad Cavern might travel along tributaries all the way to the Pecos River, where they continue to forage along the riverine habitat and over nearby irrigated croplands. Additional research is needed to more precisely define the foraging range of *T. brasiliensis* that roost in Carlsbad Cavern during summer. Assessment of foraging areas, as well as migratory routes and location of winter colonies of this intriguing species, should become easier to determine in the future with development of new technology, such as long-range, long-lived, and ultra-light radiotransmitters.

We are grateful for the administrative assistance provided by personnel of Carlsbad Caverns and Guadalupe Mountains national parks and the United States Forest Service, Lincoln National Forest. We thank the following persons for assistance in the field: B. Munyan and V. Sartori of Carlsbad Caverns National Park, J. Huebschman of the University of Nebraska at Omaha, and E. Blankenship, J. Bradt, S. Burnett, L. Golembiewski, J. Hunt, H. Hunter, K. Johnson, C. Kilgore, L. McWilliams, K. Noble, L. Reed, K. Smith, and J. Vanderhaar-Miller of Auburn University in 1997; L. McWilliams and M. Mulheisen of Auburn University in 1998; K. Geluso of the University of New Mexico, J. Hunt, C. Kilgore, L. McWilliams, and H. Thomas of Auburn University in 1999; K. Geluso of the University of New Mexico, P. Moosman of Eastern Kentucky University, J. White of the University of Nebraska at Omaha, D. Roemer and V. Sartori of Carlsbad Caverns National Park, and J. Hunt, L. McWilliams, and J. Morris of Auburn University in 2000. We thank A. S. Fox of the Uni-

versity of Nebraska State Museum for preparing Fig. 1, L. C. Hester for translating the resúmen, and 2 anonymous reviewers for helpful suggestions. We are especially grateful to the many farmers and ranchers for granting access to land in their care, for providing valuable information about study sites, and for other assistance. We thank personnel of the Texas Parks and Wildlife Department, the New Mexico Department-of Game and Fish, and the National Park Service for granting permits to conduct research. This project was partially funded by the Adopt-A-Bat Program of Carlsbad Caverns National Park. This is a contribution of the Alabama Agricultural Experiment Station.

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Submitted 8 January 2002. Accepted 6 January 2003.
Associate Editor was Loren K. Ammerman.