

CURRENT STATUS OF WINTERING SITES OF MEXICAN FREE-TAILED BATS *Tadarida brasiliensis mexicana* (CHIROPTERA: MOLOSSIDAE) FROM CARLSBAD CAVERN, NEW MEXICO

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López-González, C. and T. L. Best. 2006. Current status of wintering sites of Mexican free-tailed bats *Tadarida brasiliensis mexicana* (Chiroptera: Molossidae) from Carlsbad Cavern, New Mexico. *Vertebrata Mexicana*, 18:13-22. ISSN 1665-9708.

Resumen: Se visitaron nueve cuevas mexicanas en las cuales se ha reportado la presencia de *Tadarida brasiliensis* provenientes de la colonia de verano de *Carlsbad Cavern National Park*, Nuevo Mexico, USA, con el fin de determinar el estado de éstas, así como de sus potenciales poblaciones de invierno. Se encontraron *T. brasiliensis* vivos en cuatro de las cuevas, la colonia mayor observada contenía cerca de 140,000 individuos y no se encontró ninguna colonia de gran tamaño. La evidencia adicional sugiere que estas cuevas albergan grandes colonias de maternidad en el verano y constituyen refugios temporales o de paso en el invierno. Sólo una de ellas se encuentra bajo riesgo de desaparecer debido a la presión antropogénica. Es necesario llevar a cabo más estudios con el fin de determinar donde pasa el invierno la colonia de *T. brasiliensis* de *Carlsbad Cavern*.

Palabras clave: Chiroptera, migración, *Tadarida brasiliensis*, *Carlsbad Cavern*, refugios de invierno.

Abstract: Nine Mexican caves previously reported to be used as roosts by migratory *Tadarida brasiliensis* that spend the summer at Carlsbad Cavern National Park, New Mexico, USA, were examined to ascertain the current status of the caves, as well as to determine whether they host wintering colonies of this bat. Live *T. brasiliensis* were found in four of the nine caves. The largest colony observed had about 140,000 individuals, and no large winter roost was observed. Evidence found in the caves suggests that they are used as summer maternity colonies and transient winter roosts. Only one of them is currently at risk due to anthropogenic effects. Additional research is needed to ascertain where the large colony of *T. brasiliensis* that forms the summer roost at Carlsbad Cavern spends winter.

Keywords: Chiroptera, migration, *Tadarida brasiliensis*, Carlsbad Cavern, wintering roosts.

Carlsbad Cavern, in Carlsbad Cavern National Park, Eddy Co., New Mexico, is the summer residence for about 800,000 Mexican free-tailed bats (*Tadarida brasiliensis mexicana*), which use the cave as a summer roost and maternity colony. Early observers concluded that these bats were non-migratory and that they spent winter in Carlsbad Cavern

in a state of torpor (Bailey, 1925). Subsequent observations showed that, in fact, these bats were migratory (Christensen, 1947; Villa-R., 1956), often moving great distances between summer and winter roosts (Glass, 1982; Villa-R. and Cockrum, 1962). Mexican free-tailed bats are known to migrate distances up to 1,840 km from where they were

banded (Glass, 1982; Villa-R. and Cockrum, 1962); the maximum documented rate of

travel during migration is about 70 km/night (Cockrum, 1969).

Table 1. Description of possible wintering sites for *Tadarida brasiliensis* from Carlsbad Cavern, visited in December 1999 and 2000. Not. Det.: = measurement not taken.

Locality and date visited	GPS coordinates	Dimensions of cave (m)	Dimensions of Guano pile (diameter x height)	Temperature (°C)	Relative Humidity (%)	Vegetation	Species found	Estimated size of colony
(1) Cueva del Rincon de la Virgen 6.8 km N Villa de García, Nuevo León 10 December 1999	25°51.15'N 100°38.86'W	Mouth (w x h): 4 x 10 Distance from mouth to roost: 20 Height of roost chamber: 2-4 Dimensions of roost: no roost Total length >40	26 x 2 to > 4	At mouth: 16.4 Inside: 18.8	At mouth: 42 Inside: 53	At mouth: 3 m shrubs In area: <i>Larrea</i> desert scrub	<i>T. brasiliensis</i>	No colony, night roost
(2) Cueva del Guano 8.5 km WNW Nazareno 3, Durango 12 December 1999	25°22.48'N 103°31.94'W	Mouth (w x h): 20 x 12 Distance from mouth to roost: >100 Height of roost chamber: not det. Dimensions of roost: not det. Total length: >160	No pile, scattered over floor, height 5-10 cm	At mouth: 16 Inside (20 m): 16.4 Inside (100m): 28.3 Inside (158m): 29.4	At mouth: not det. Inside (20 m): 45 Inside (100m): 61 Inside (158m): 65	At mouth: no obstruction In area: <i>Larrea</i> desert scrub	<i>Mormoops megalophylla</i> <i>T. brasiliensis</i>	>150 >50
(3) Cueva de la Chinacatera Rancho Monte Largo, 12 km SW Pericos, Sinaloa 15 December 1999	25°01.41'N 107°50.44'W	Mouth (w x h): 7.5 x 5 Distance from mouth to roost: 10.7 Height of roost chamber: 4 Dimensions of roost: 10 x 0.5-1 Total length: 30	4.2 x 1	At mouth: 27 Inside (15 m): 22.1 At back (30 m): 30.0	At mouth: 41 Inside (15m): 46 At back (30 m): 51	At mouth: no obstruction, some <i>Mimosa</i> shrubs In area: tropical semi-deciduous forest	<i>M. megalophylla</i> <i>Pteronotus davayi</i> <i>P. parnellii</i> <i>T. brasiliensis</i>	150-200 1 captured 1 captured skeletal material recovered -150 (1999) 40-50 (2000)
(4) Cuevas de Las Garrochas ca. 10 km NW Soyatlán del Oro, Jalisco 17 December 1999 21 December 2000	20°22.63'N 104°20.33'W	Mouth (w x h): E 15.3 x 2.5, M 12.1 x 2.4, W 5.4 x 2.5 Distance from mouth to roost: E 37, M 14.5, W no guano Height of roost chamber: E 3, M 3, W no roost chamber Dimensions of roost: not det. Total length: E 49.7, M 54.2, W 7.7	E 2.0 diameter, no guano pile, M 29.7 x < 1.5, W no pile	At mouth: E 25.8, M 18.9, W 20 Inside (at roost): E 19, M 22.5, W 20.4	At mouth: E 41, M 34, W 40 Inside (at roost): E 57, M 41, W 50	At mouth: E 30% obstructed by trees, M tree and some shrubs, W 50% obstructed In area: oak-pine forest	<i>Desmodus rotundus</i> <i>Anoura geoffroyi</i> <i>Leptonycteris curasoae</i> <i>T. brasiliensis</i>	1 captured (1999) 1 recovered as skeleton (1999) skeletal material recovered - 140,000
(5) Cueva de la Boca 3.2 km N, 6.3 km W Villa de Santiago, 385 m, Nuevo León 12 December 2000	25°26.02'N 100°06.84'W	Mouth (w x h): 25 x 30 Distance from mouth to roost: 300 Height of roost chamber: 60 Dimensions of roost: 5 x 7 Total length >300	No single guano pile	At mouth: 11.5 Inside: not det.	At mouth: 62 Inside: not det.	At mouth: no obstruction In Area: Tropical forest	<i>T. brasiliensis</i>	~ 12,000
(6) Grutas de Quintero 1.5 km W Quintero, Tamaulipas 14 December 2000	22°38.90'N 99°02.50'W	Mouth (w x h): 4 x 3.3 Distance from mouth to roost: not det. Height of roost chamber: 30 Dimensions of roost: 1 x 3 Total length: ~500	No single guano pile	At mouth: 21.6 Inside: (under roost) 23.3	At mouth: 69 Inside: (under roost) 81	At mouth: no obstruction In area: remains of tropical forest	<i>T. brasiliensis</i>	1 dead bat, skeletal material recovered
(7) Cueva del Abra 10 km NNE Antiguo Morelos, 185 m, Tamaulipas 14 December 2000	22°36.52'N 99°01.42'W	Mouth (w x h): 20 x 50 Distance from mouth to roost: not det. Height of roost chamber: not det. Dimensions of roost: not det. Total length: not det.	3 x 6 x 0.5 plus guano scattered in all cave	At mouth: 22.6 Inside: 22.5	At mouth: 69 Inside: 68	At mouth: no obstruction In area: Tropical forest	<i>Nyctinomops laticaudatus</i> <i>N. aurispinosus</i>	Skeletal material recovered 3 observed
(8) Cueva de la Ventana del Jabali 10 km NW Tamuin Railroad Station, 385 m, San Luis Potosí 15 December 2000	22°07.77'N 98°53.14'W	Mouth (w x h): 20 x 60 Distance from mouth to roost: 300 Height of roost chamber: 15 Dimensions of roost: not det. Total length: ~300	20 x 7	At mouth: 22.5 Inside (under roost): 21.6	At mouth: 78 Inside (under roost): 72	At mouth: thick vegetation, but flyway unobstructed In area: Tropical forest	<i>D. rotundus</i> <i>T. brasiliensis</i>	skeletal material recovered
(9) Cueva de la Isla Janitzio Lago de Patzcuaro, 1980 m, Michoacán 17 December 2000	19°34.53'N 101°39.13'W	Mouth (w x h): 8 x 4 Distance from mouth to roost: 10 Height of roost chamber: 4 Dimensions of roost: 2 x 1 Total length: ~15	2 X 1	At mouth: 14 Inside (under roost): 20.5	At mouth: 64 Inside (under roost): 73	At mouth: none In area: used to be pine-oak forest	<i>T. brasiliensis</i> <i>L. curasoae</i>	~500 1 skeleton recovered

The whereabouts and status of winter populations of *Tadarida brasiliensis mexicana* that spend summers in Carlsbad Cavern are unknown. Sites where large winter colonies of these bats can occur have been reported in the literature (Table 1). This list was compiled based upon recoveries of bats that were banded at Carlsbad Cavern, and upon recoveries of bats at Carlsbad Cavern that were banded at the listed sites (Cockrum, 1969; Constantine, 1967; Villa-R. and Cockrum, 1962). The purpose of this paper is to report on the current status of those localities as wintering refuges for *T. b. mexicana*.

MATERIALS AND METHODS

A list of caves (Table 1) was compiled from the literature, which includes localities where bats banded at Carlsbad Cavern were recovered, or where bats recovered at Carlsbad Cavern were released. These sites were visited within two winter seasons (December 1999 and 2000). At each locality, 17 variables were recorded that describe the cave and evaluate the conservation status and suitability of the cave as a refuge: GPS coordinates, height and width of mouth (m), distance from entrance to roost site (m), size of guano pile (diameter and depth in m), temperature (°C) and relative humidity (%) inside and outside the cave (using a digital hygrometer), area occupied by bats (m²), evidence of human activity, vegetation outside the cave, and species of bats that occur in the cave. A sample of bats was captured at each site to obtain information species identity. Bats were captured in mist nets set at the entrance or inside caves, other specimens were recovered as mummies or skeletons from the floor of caves. Voucher specimens of each species were kept for reference at the Colección Regional Durango at CIIDIR, Instituto Politécnico Nacional, Durango, México. All other individuals were released upon examination.

RESULTS

A total of nine caves were visited in December 1999 and/or December 2000. Data on each site are summarized in Table 1; localities are mapped on figure 1.

Cueva del Rincón de la Virgen, 6.8 km N Villa de García, Nuevo León. This cave is located close to the entrance of Grutas de García, near Monterrey, a commercial cave accessible to visitors via a railroad that climbs from the bottom of the sierra. Cueva del Rincón de la Virgen has a similar position on the sierra, but farther West and into a canyon. The cave is visible from the mouth of the canyon, on the southwest-facing, limestone slope, and about 150 m below the peak of a nearly vertical cliff. The mouth of the cave is on a steep hillside covered with thick, thorny, shrubby vegetation (yuccas, sotols, agaves, bromeliads). Disturbance by humans was minimal, and access by bats was unobstructed. No bats were found roosting in the cave during the day, but a large pile of guano was present. Several wings of moths were found, indicating that the cave is used as a night roost. Although Constantine (1967) visited Rincón de la Virgen on 10 December 1957 and found no bats there, his report did not indicate that he attempted to capture bats in the cave with mist nets. We placed a mist net across the opening at night and captured 10 *Tadarida brasiliensis* in 3 hours as they entered.

Villa-R. (1956) reported more than 10,000 *Tadarida brasiliensis* at Rincón de la Virgen on 6 November 1955. He banded 1,400 bats on 27-29 January 1956. He returned two weeks later, but no bat was present. Constantine (1967) found the cave empty on 10 December 1957. Two of the bats marked by Villa-R. were recovered at Carlsbad Cavern (Villa-R. and Cockrum, 1962). We salvaged skeletal specimens from the cave that included adults and subadults of *T. brasiliensis*. Previous evidence thus indicates the cave probably is a summer maternity colony and a transient roost in winter. The nearly vertical limestone cliffs that characterize the habitat nearby contain numerous fissures and caves that may serve as day roosts for *T. brasiliensis*, but our observations and interviews of local residents indicated no caves in the area with significant colonies of bats in winter.

It is puzzling that Constantine (1967) referred to the habitat at Cueva del Rincón de

la Virgen as "mesquite-grassland;" this certainly does not describe the habitat near this cave. Because of the numerous large and conspicuous caves in the vicinity, it is possible that Constantine visited a different cave, but we know of no habitat in the area characterized as mesquite-grassland.

Cueva del Guano, 8.5 km WNW Nazareno Tres, Durango. This cave was reported as "Cueva de la Laguna Seca, 5 mi NW Nazareno (SE Torreón), Coahuila" by Constantine (1967). Our inquiries with local residents at Laguna Seca, Coahuila, near the border between Coahuila and Durango, were fruitless. No cave close by was known as Cueva Laguna Seca. However, we were informed of a large cave with bats in nearby Durango, known as Cueva del Guano. Once we found the cave, we determined that it was 8.5 km west-north-west of Nazareno Tres, and not from Nazareno. Also, we were informed that the boundaries between Durango and Coahuila have changed across time, which could explain the previous report of the cave being in Coahuila. We are confident that the cave we visited was the one reported by Constantine (1967). Cueva del Guano was heavily mined for guano until 1961, when operations ceased (Reddell, 1977). Nonetheless, it shows evidence of recent disturbance by humans, there were sacks of guano and tin cans with candles along the trail within, which indicate that guano is taken at least sporadically. The cave continued beyond 160 m from mouth, we did not fully explore it because access was restricted by the high concentration of ammonia in the chambers. However, the cave has been mapped by Reddell and collaborators (Reddell, 1977). A 6-m mist net was placed about 20 m inside the mouth, and left open between 1822 and 2022 hours. We caught 153 *Mormoops megalophylla* and 53 *Tadarida brasiliensis*. Numerous skeletons and mummified individuals of *T. brasiliensis* were scattered throughout the cave. Assuming this is the cave that Constantine (1967) visited on 6 December 1957, he saw about 50 live, somewhat lethargic *T. brasiliensis* in the cave, noted fresh guano, and a strong odor of ammonia. Reddell (1982) also reported *T. brasiliensis* and *M. megalophylla* from Cueva del Guano. All

these observations verify the presence of a small colony of *T. brasiliensis* in winter. Further research by CLG (unpublished data) confirms the presence of a summer maternity colony of at least 20,000 *T. brasiliensis* (in 2005), and a winter colony of at least 2,000 individuals.

Cueva de la Chinacatera, Rancho Monte Largo, 12 km SW Pericos, Sinaloa. This cave is about 5 km northwest of Restaurante La Loma, near km 58 on the Culiacán–Los Mochis toll highway, southwest of Pericos. The cave is almost on top of a mountain; the access route was a steep trail on the south slope. It was a well-worn trail, which apparently is the result of the guano-mining operation that goes on there about 4–5 months of the year. Each year, about 7,500 kg of guano are mined, placed into grain bags, and hand-carried down the steep trail to the valley below. No graffiti or damage was noticed. La Chinacatera is a system of at least two caves; our observations were restricted to the largest one.

We found a colony of about 150–200 *Mormoops megalophylla* roosting on the left side of the cave in a 10-meter-long fissure in the ceiling that was 0.5–1 meter wide. We mist-netted 41 *M. megalophylla*, one male *Pteronotus davyi*, and one female *P. parnellii*. In addition, one mummified *Tadarida brasiliensis* was found on the cave floor.

On 14 November 1957, one male and two female *Tadarida brasiliensis*, banded at Tucson, Arizona, were recovered alive at Cueva de la Chinacatera (Villa-R. and Cockrum, 1962). Constantine (1967) observed about 200,000 *T. brasiliensis* on 15–16 November 1957. He recovered an immature female, which was banded at Carlsbad Cavern on 29 August 1957, as well as three bats banded in Arizona. Sex ratio of the colony was about equal. Constantine examined a second cave about 25 meters distant, which contained 15 *Desmodus rotundus* and three *Myotis velifer* (Constantine, 1967). Villa-R. (1958) collected *Pteronotus davyi*, banded part of a colony of about 3,000 *T. brasiliensis*, and observed a large number of *D. rotundus* and an unspecified number of *Balantiopteryx*

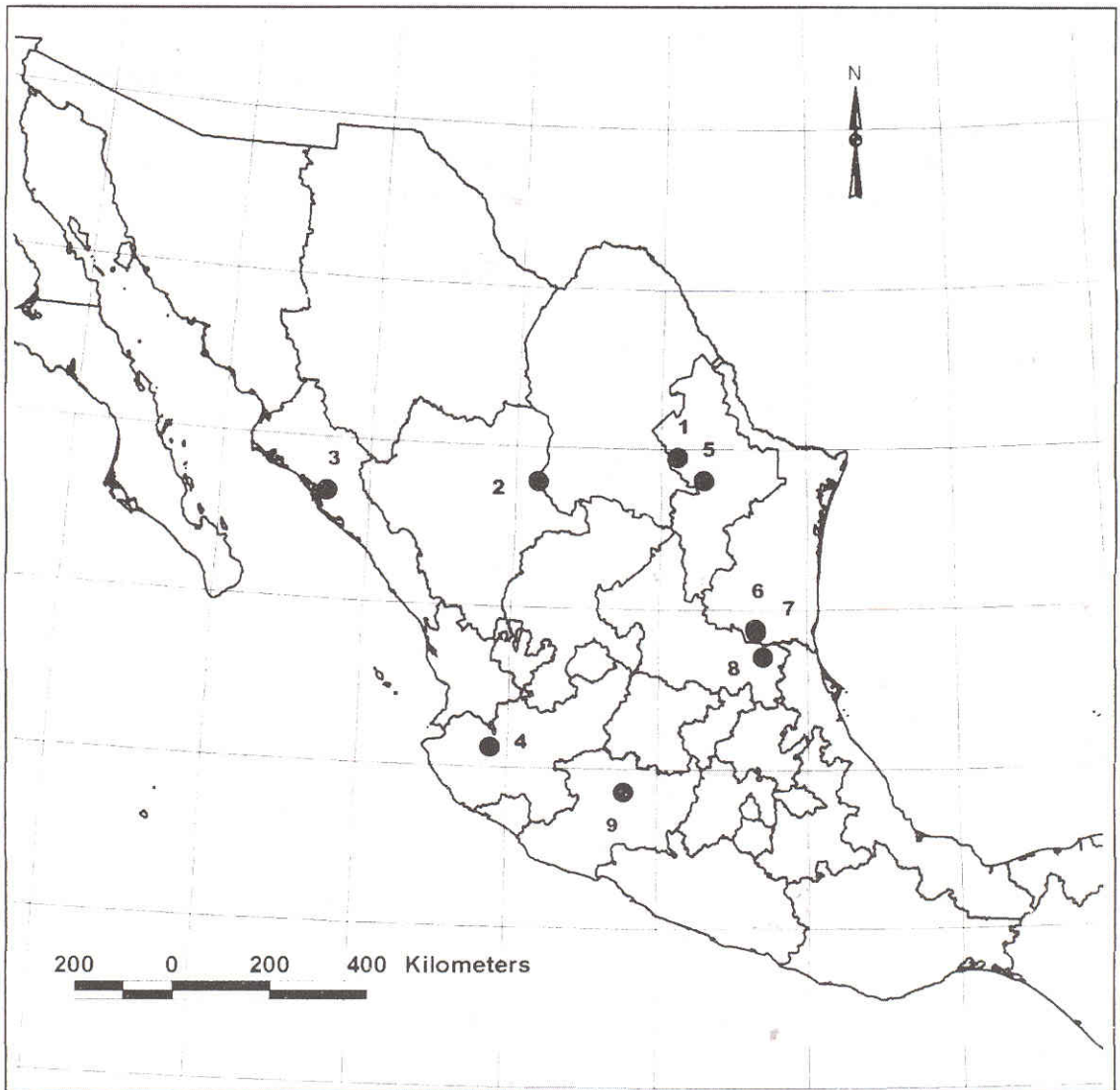


Figure 1. Localities in Mexico known as winter refuges for bats from Carlsbad Cavern, New Mexico. Numbers correspond to those of caves in Table 1.

plicata in the same cave on 29 December 1957. One of these banded bats was recovered at Cueva del Tigre, Sonora, on 18 April 1959 (Villa-R. and Cockrum, 1962). On 2 March 1963, Cockrum and associates (Cockrum, 1969) banded 7,700 male and 3,900 female *T. brasiliensis* at Cueva de la Chinacatera. On the same day, they also observed about 5,000 *Pteronotus personatus* and about 10,000 *P. davyi*. Recoveries of banded bats were at Eagle Creek Cave, Arizona; Tajitos (Mina de la Virgen), Sonora; Cueva del Tigre, Sonora; and Guamuchil, Sinaloa. On 31 October 1975, J. S. Altenbach and

associates observed about 50,000 *T. brasiliensis* in Cueva de la Chinacatera (K. N. Geluso, pers. comm.). Based on all these observations we conclude that this cave probably serves as a transient and summer maternity roost for *T. brasiliensis*.

Cuevas de las Garrochas, ca. 10 km NW Soyatlán del Oro, Jalisco. This is a system of three caves (East, Middle, and West, Table 1) set about 30 m apart, located on the north slope of a mountain in Ejido Macuchi, Municipio de Atengo. We visited these caves twice (Table 1). In 1999, in the east

cave we observed a colony of about 150 *Desmodus rotundus* in a fissure in the ceiling near the back of the cave. One female was carrying a baby when she left the roost. Also, captured in a mist net was one *Anoura geoffroyi*, which was roosting in the same crevice as the vampire bats. In 2000, we observed about 40-50 *D. rotundus* and two unidentified small bats in the east cave. In 1999, one bat was flying in the middle cave, but it could have flown in from the east cave, where we had disturbed the colony of vampire bats. One skull of *Tadarida brasiliensis* and one skull of *Leptonycteris curasoae* were found inside. No bat was present in 2000, but fresh guano (3 by 5 meter diameter and 0.5 meter deep) was found about 35 meter inside the cave.

No bat was observed in the west cave in either visit. Neither was any evidence that bats had recently inhabited it. There are two small tunnels less than 1 meter in diameter at the back of the cave; water was dripping from their ceilings and we could not see the end of the tunnels. These caves have been mined for guano by local residents, floors of the three caves were swept clean by the guano-mining efforts.

Villa-R. (1955) reported fruit bats of the genus *Artibeus* and a colony of the large-eared forest bat (*Micronycteris sylvestris*) at Cuevas de las Garrochas in late November 1952. On 26 November 1952, Villa-R. (1955) recovered a *Tadarida brasiliensis* at Las Garrochas that had been banded at Carlsbad Cavern, New Mexico, on 18 September 1952 (Constantine, 1967). In late February 1955, Villa-R. found no *T. brasiliensis* in the cave, but a few days before his arrival, workers had removed all of the guano left by the large colony of *T. brasiliensis* that had recently vacated the cave (Villa-R., 1955; 1956; Villa-R. and Cockrum, 1962). Constantine (1967) visited the caves 19 November 1957 and found mummified carcasses of *T. brasiliensis* and *Myotis velifer*, as well as a colony of about 35 *Desmodus rotundus*. Among the mummies of *T. brasiliensis* were remains of newborns, indicating that these caves were a summer maternity colony. He concluded that the caves primarily were a summer roost of *T. bra-*

siliensis.

No *Tadarida brasiliensis* was present on 19 November 1957 (Constantine, 1967), 17 December 1999 (our visit), 21 December 2000 (our visit), or in late February 1955 (Villa-R., 1955, 1956). Because of the presence of skeletons of adults and newborns, and because of the intermittent presence of *T. brasiliensis*, we believe the Cuevas de las Garrochas serve as transient and summer maternity roosts as assessed by Constantine (1967).

Cueva de la Boca, 3.2 km N, 6.3 km E Villa de Santiago, 385 m, Nuevo León. Cueva de La Boca is on a forested hillside at the base of a steep limestone cliff. This cave can be reached by paved road, and it is located near Presa de La Boca, on the Monterrey-Ciudad Victoria highway. The mouth of the cave is clearly visible about 100 meters in elevation above the road. Access to the cave is by means of a steep, slippery trail of rocks. There was much trash and graffiti spray painted on rocks along the well-worn trail from the highway to the mouth of the cave.

At Cueva de la Boca, bats have been reported to be numerous in winter (Villa-R. 1956), but none was present on 9 December 1957 (Constantine 1967). Assuming there were 4,000 bats/square meter, there was about 140,000 bats in the roost when we visited it. Cueva de la Boca also contains a large maternity roost in summer. It is a well-known place in the region, and currently is under protection by Programa para la Conservación de Murciélagos Migratorios (PCMM), a Mexico-USA program for the protection and conservation of migratory bats. According to PCMM (Bat Conservation International 2000, *in litt.*), the population has increased to nearly 1 million *Tadarida brasiliensis*. *Glossophaga soricina* and *Natalus stramineus* also have been reported from this cave (Davis and Carter, 1962; Mollhagen, 1971).

Grutas de Quintero, 1.5 km W Quintero, Tamaulipas. This cave is a tourist attraction located near the town of Quintero,

south of Ciudad Mante, Tamaulipas. Access is easy, there are signs leading to the cave, parking space at the base of the hill where the cave is located, and steps that lead to the mouth. The main passageway forked near the mouth of the cave. Above the left passageway was an opening that allowed light to enter the cave from above, this muddy passageway ended at a deep pit. Beyond the left passageway, the main passageway continued to an underground pond. The passageway to the right went to the bat roost. Beneath the bat roost there were large piles of guano, which were wet and slippery in places. We found a *Tadarida brasiliensis* roost with approximately 12,000 individuals about 15 meters above the cave floor in the first large passageway to the right. *Mormoops megalophylla*, *Micronycteris megalotis*, *Glossophaga soricina*, *Artibeus jamaicensis*, *A. lituratus*, *Desmodus rotundus*, *Diphylla ecaudata*, *Natalus stramineus*, and *Eptesicus fuscus* also have been recorded at Quintero (Mollhagen, 1971; Reddell and Mitchell, 1971). This cave also serves as a summer maternity roost.

Cueva del Abra, 10 km NNE Antigua Morelos, 185 m, Tamaulipas. A large cave easily visible from the paved highway, it is about 0.5 kilometers up the mountainside from the highway. It is accessible via a steep talus slope and then through a huge natural arch near one of the mouths of the cave. It has at least three openings to the surface. The arch, mouths of the cave, and most passageways were more than 50 meters in height. Most areas of the cave that we visited were lighted from openings to the surface. One mouth of the cave was more than 100 meters above a deep vertical shaft. The floor slopes sharply down to a talus-covered floor. Beyond this was another huge, dark crevice. There is a well-worn trail in the cave, as well as numerous graffiti. The cave probably is visited by many tourists, and it is a place commonly visited by cavers. We found a dead *Nyctinomops laticaudatus* in the cave, and skeletal material of *N. laticaudatus* and *N. aurispinosus*. No *Tadarida brasiliensis* was identified.

Dalquest and Roth (1970) provided a

detailed description of Cueva del Abra. In winter and early spring, large numbers of bats have been heard in the cave; their urine falling in a fine mist (Villa-R., 1960; Villa-R. and Cockrum, 1962). Carter and Davis (1961) noted that there were no specimens of *Tadarida brasiliensis* from this cave. Dalquest and Roth (1970) did not encounter *T. brasiliensis* when field crews made collections at Cueva del Abra late in January and in April, when presumably this species should have been present, nonetheless they reported fossil material (late Pleistocene). Mollhagen (1971) and Reddell and Mitchell (1971), in contrast, reported the occurrence of this species at El Abra. He also reports *Artibeus jamaicensis*, *Desmodus rotundus*, *Natalus stramineus*, *Nyctinomops laticaudatus*, and *N. aurispinosus*.

Cueva del Abra probably serves as a summer maternity roost for free-tailed bats of the species *Nyctinomops laticaudatus* and *N. aurispinosus*. Because of the very high ceilings it was difficult to capture bats in mist nets. During our visit, we believe that our lights and noise would have caused any *T. brasiliensis* in the cave to become active, as in other caves we visited. This cave may be used as a transient cave, but it does not appear to be used as a winter roost by *T. brasiliensis*.

Cueva de la Ventana del Jabalí, 10 km NW Tamuín Railroad Station, San Luis Potosí. The cave is located about half way up the side of a mountain, and clearly visible from the valley below. There is no trail to the cave, but there is ample thick vegetation (tropical deciduous forest), rocks, and steep slopes. There is a 100-150-meter abandoned mine shaft about 200 meters down the steep slope from the mouth of the cave. Between the abandoned mine shaft and the mouth of the cave there was a trail covered by vegetation that lead to the left side of the mouth. Evidence of disturbance by humans was a large, rusty cable extended from the abandoned mine shaft deep into the cave, by a well-worn trail into the mine, and by several pits and holes in the floor from past mining operations. There were some graffiti at the entrance, but no evidence of recent distur-

bance by humans. There were two large archways above the mouth of the cave. The ceiling was more than 200 meters at its highest elevation, and had two openings directly in the top of the large passageway. Vegetation was present around the mouth of the cave, but the opening is large, thus leaving an unobstructed flyway. The roost was in the twilight zone. A few bats were heard above the roost, but we could not determine their identity. The guano pile at the back of the cave, spilled out from a narrow crevice about 15 meters high. The guano appeared to be fresh. In the abandoned mine shaft near the cave, we observed three *Desmodus rotundus*. We recovered skulls of *Tadarida brasiliensis* from the cave floor.

The cave was visited 7 January 1957; much squeaking was heard from the ceiling, perhaps 250 meters above the floor. Evidently a huge colony of unidentified bats was present (Constantine, 1967). *Tadarida brasiliensis* has been reported previously from this cave (Mollhagen, 1971). The fresh guano pile that indicated the cave had been used as a transient roost. Previous observations, as well as our own, lead us to believe that this cave is used as a maternity colony by *T. brasiliensis*. Because of the large guano pile and the lack of a trail to the cave, it appears that the guano is not mined now, and that it is visited rarely by humans.

Cueva de la Isla Janitzio, Lago de Pátzcuaro, Michoacán. This cave is located on the north side of the island, which can be reached via tour boat from the shore in the city of Pátzcuaro. The cave is located about 500 meters southeast of the "Morelos" statue in the center of the island. It is made of crumbly, volcanic rock, which was very loose at the entrance. There was a steep cliff directly above and below the entrance, but there was a well-worn trail to it along the cliff face. No vegetation obstructed the mouth. In addition to the trail, we found graffiti as evidence of human disturbance. Also, the cave is less than 50 meters from the houses that cover most of the island.

The roost had about 2 m² of bats, about 200 individuals. We placed a 3-meter

mist net across the entrance of the cave. From 1135 to 1152 hours, we captured 14 male and 2 female *Tadarida brasiliensis*. We also collected a skeleton of *Leptonycteris curasoae* at the entrance. This cave contains *T. brasiliensis* year-round, including a much larger maternity colony in summer (C. Huerta, pers. comm.). On 22 November 1957, about 700 *T. brasiliensis* were present; sex ratio was about equal (Constantine, 1967). On 23 March 1967, this cave contained thousands of *T. brasiliensis* (Ueshima, 1968). The colony currently is under monitoring and protection by local researchers associated with the PCMM.

DISCUSSION

We recorded basic descriptive and ecological data at each of the nine caves we visited (Table 1). Except for Cueva de la Isla Janitzio, Cueva de la Boca, and Grutas de Quintero, these caves were located in remote areas, well away from human habitations and villages, and required considerable effort for access. Cueva del Rincón de la Virgen was especially difficult to access; in addition to our experience, the relative inaccessibility of this cave was evidenced by presence of large accumulations of guano in the cave. The guano in Cueva del Guano, Cueva de la Chinacatera, and Cuevas de las Garrochas was or still is mined in great quantities for use as fertilizer by local residents. Nonetheless, guano-mining activities do not appear to have an adverse impact on bats inhabiting these caves, as the bats return annually as transients and as summer residents. We concluded that there was no obvious threat to these caves by activities of humans. Isla Janitzio, Cueva de la Boca, and Grutas de Quintero, in contrast, are regularly visited by tourists. Disturbance is evidenced by graffiti, remains of fires, trash left by visitors, or the visitors themselves. Janitzio and La Boca are currently under protection and management by PCMM personnel, but to our knowledge the bats at Grutas de Quintero are not under any kind of conservation program.

We observed live *Tadarida brasiliensis* in winter at four of the nine caves we visited. The largest colonies of this taxon that

we observed were about 140,000 individuals in Cueva de la Boca, Nuevo León, and an undetermined number at Cueva del Guano. Further research (unpublished) has shown that Cueva del Guano hosts at least 2,000 individuals of *T. brasiliensis* in winter and above 20,000 in summer. Grutas de Quintero also contained a colony of about 12,000 *T. brasiliensis*. Cueva de la Isla Janitzio contained about 500 *T. brasiliensis* in December 2000. Cockrum (1969) noted that most *Tadarida brasiliensis* spend winter months (December-January) in México, presumably at locations south of Pericos, Sinaloa. Some, mostly males, winter as far north as Cueva del Tigre, Sonora, and a few winter in southern Arizona.

Cockrum (1969) hypothesized that bats from eastern Arizona and western New Mexico migrate into western México, whereas colonies in Eastern New Mexico (including Carlsbad), Texas, and Oklahoma migrate into eastern México, these two groups being isolated by the Sierra Madre Occidental. If true, a distinct genetic structure would be expected on each of these independently breeding groups. Neither Svoboda et al. (1985) nor McCracken et al. (1994) found evidence of genetic differentiation. Furthermore, genetic data indicate that any one large colony of *Tadarida brasiliensis mexicana* has the genetic diversity in the total migratory population of this subspecies, suggesting a large effective population size (McCracken et al., 1994; Russell and McCracken, 2006).

Evidently, additional research is needed to ascertain where the large colony of *Tadarida brasiliensis* that forms the summer roost at Carlsbad Cavern spends winter. The colony at Carlsbad Cavern represents less than 1% of the estimated 100,000,000 *T. brasiliensis* that live in the United States during summer. It would be naive to speculate that the summer colony from Carlsbad Cavern remains together, but no accounting can be made for even 1% of *T. brasiliensis* in winter. Where do these bats overwinter? Do they form thousands or millions of small colonies that roost in tree cavities or human habitations? Do they move southward into Central and South America? If the latter is true,

specimens banded in Carlsbad and recovered by earlier workers in some of the caves studied were probably on their way somewhere farther south, to places where bats from the purported eastern and western migration routes may interbreed and produce the genetic structure observed by McCracken et al. (1994) and Svoboda et al. (1985).

At present, we cannot answer these questions, but knowing the locations and ecological stability of overwintering sites should have significant implications for long-term management of populations of *T. brasiliensis* at Carlsbad Cavern and elsewhere in the United States and México.

ACKNOWLEDGMENTS

This project was a cooperative effort between the United States National Park Service, the Centro Interdisciplinario para el Desarrollo Integral Regional Unidad Durango, and Auburn University. We are grateful to Programa para la Conservación de Murciélagos Migratorios, H. B. Cuevas-Arellano, L. M. Guevara-Chumacero, J. L. Hunt, L. A. McWilliams, D. M. Roemer, and G. Villegas-Guzman for assistance in the field. H. Chávez-Almodóvar, M. Chávez-Puerto, P. Gregorio-Codallos, M. Guzmán-Treviño, the Hernández-Bocanegra family, F. Meza de los Santos, J. Morelos, as well as numerous other local residents and local officials who facilitated access to caves and who provided generous hospitality during our visits. N. I. Enríquez collaborated in clerical tasks. We thank Dirección General de Vida Silvestre, SEMARNAT, for granting collecting permits to CLG (FAUT -0085). This project was funded by the United States National Park Service, the Adopt-a-bat Program at Carlsbad Cavern National Park, and CGPI IPN (Project 200269). We thank J. Arroyo-Cabrales and R. López-Wilchis for helpful revisions of the manuscript.

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