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LOSS OF A SIGNIFICANT MATERNITY POPULATION OF BRAZILIAN FREE-TAILED BATS (*TADARIDA BRASILIENSIS*) IN OKLAHOMA

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ABSTRACT—Based on site-visits over the past several years to Conner Cave in Major County, Oklahoma, it appears that the large population of Brazilian free-tailed bats that historically used the cave as a maternity site has abandoned the cave. This was one of the northernmost maternity caves in the Great Plains. Previous estimates of the size of the population were several hundred thousand.

RESUMEN—Basados en visitas en los últimos años a la cueva Conner en el condado de Major en Oklahoma, parece que la gran población de murciélagos guaneros brasileños que históricamente utilizaba la cueva como un sitio de maternidad ha abandonado la cueva. Esta era una de las cuevas de maternidad más septentrionales de las Planicies Grandes. Estimaciones previas del tamaño de la población fueron de varios cientos de miles.

The Brazilian free-tailed bat, *Tadarida brasiliensis*, is one of the most abundant bats in western Oklahoma (Hibbard, 1934; Blair, 1939; Caire et al., 1989), and its large numbers in some caves make it a keystone species. The rarity ranking of the Oklahoma Natural Heritage Inventory (http://oknaturalheritage.ou.edu/ranking_guide.html) for the Brazilian free-tailed bat is G5 suggesting the species is globally secure, although it might be rare in portions of its range. It has a state ranking of S3 implying that it is rare but locally abundant in some areas of Oklahoma. *Tadarida brasiliensis* has an Oklahoma Wildlife Species endangerment ranking of SS2 which designates it a species of special concern because hundreds of thousands of individuals might be concentrated in only a few roost sites, thereby increasing its vulnerability.

The Brazilian free-tailed bat migrates into western Oklahoma from Mexico in early spring to establish large maternity roosts in just a few gypsum caves (Glass, 1958, 1982; Villa and Cockrum, 1962; Caire et al., 1989). Historically, five caves in Oklahoma have been utilized by

T. brasiliensis as large maternity sites (Glass, 1958; Caire et al., 1989): Merrihew Cave in Woods County; Selman Bat Cave in Woodward County; Reed Cave in Greer County; Vickery Cave and Conner Cave (sometimes listed in the literature as Connor Cave) in Major County. These are some of the northernmost maternity roosts of the species in the Great Plains. The loss of a large population of *T. brasiliensis* from any one of these caves would negatively impact the biodiversity of the cave, the local environs, and the continued survival of *T. brasiliensis* in Oklahoma.

Prior to the addition of buildings and other human-made structures, caves were probably the main structures used by *T. brasiliensis* as maternity roosts (Wilkins, 1989). There are hundreds of gypsum caves in the karst region of western Oklahoma, but few of these caves are suited to serve as maternity roosts for *T. brasiliensis*. The caves must have the proper microclimates and size of rooms and entrances and be located in suitable areas for the bats to forage. Typically, a good maternity roost will have ample ceiling and wall space to support thousands of female bats

and their pups. These caves usually have dome-ceiling rooms about 10 m from ceiling to floor (Wilkins, 1989). The advantage of being able to support a large maternity colony is that it provides a critical mass of bats necessary to generate and maintain the elevated temperatures required for development of the pups. The entrances to maternity caves are usually 5 m high by 10 m wide (Wilkins, 1989) and clear of vegetation and breakdown, which allows large numbers to emerge simultaneously.

Conner Cave was the smallest of the five major sites of maternity roosts in Oklahoma. The cave was described as being ca. 60-m long with an opening facing to the east-southeast that was 9-m wide by 5-m high (Perry, 1965; Rogers, 1972). Conner Cave was later described and mapped by the Central Oklahoma Grotto (Baker and Bozeman, 1986). They recorded the entrance as 17-foot high by 30-foot wide (5.2 by 9.1 m) and the length of the cave as 248 m. In 1985, they observed free-tailed bats in the eastern two rooms of Conner Cave and estimated the population to be several hundred thousand bats.

As part of a recent project of the Oklahoma Department of Wildlife Conservation to use thermal imaging to estimate the size of populations of *T. brasiliensis* in each of the major maternity caves in western Oklahoma, we visited Conner Cave in June 2011 and observed no bats emerging from the cave. We revisited the cave in late July 2011 and 2013 and, on both occasions, saw no bats exit at dusk, nor were there any inside the cave. The ceiling was stained where bats had previously roosted, but there was no fresh strong odor of bats or any fresh guano. It appears that Conner Cave has been abandoned by *T. brasiliensis*.

The cave has been used by *T. brasiliensis* as a maternity roost for many years. The earliest colonization of Conner Cave by *T. brasiliensis* will probably remain unknown. The current owner of Conner Cave, R. Conner, recalls free-tailed bats being in the cave in 1942 and that her relatives observed them there years earlier, but she does not know when they first observed the emergence from the cave in those earlier years. She estimated the population numbered in the hundreds of thousands. The bats arrived at the cave in late March and early April and departed by mid to late October. She could not recall the last time she saw the bats. The current lease holder has no recollection of the last time he saw the bats.

Images from NEXRAD Doppler radar can display the emergence of large populations of *T. brasiliensis* from caves (Horn and Kunz, 2008). We accessed NEXRAD files from the National Climatic Data Center of the radar station closest to Conner Cave (KVNK, Vance Air Force Base, Oklahoma) to determine the last date of a large emergence-flight. We examined radar-images from August of the years 1993–2011. Unfortunately, after inspection of the images, we found permanent radar-interference in the region around Conner Cave. Additional sites of radars were considered, but their distance from the cave prevented sampling of the near-ground

emergence and flight of the bats. Therefore, historic and current radar-recordings could not be used to determine when the bats were last present at Conner Cave.

The number of *T. brasiliensis* in Conner Cave combined with Vickery, Selman, and Merrihew caves was estimated to be more than three million (Glass, 1982; McCracken, 2003). The emergence flight from Conner Cave was last observed, as near as we can determine, by B. Chapman (pers. comm.) in 1999 when he watched the exit flight and estimated the population to be at least 100,000 or more. Elliott (1994) reported that there was reputedly a population of several hundred thousand *T. brasiliensis* in Conner Cave, but he did not visit the cave to observe the emergence the year he investigated the viability of populations of *T. brasiliensis* in Oklahoma.

We offer the following ideas as to why there are presently no *T. brasiliensis* in the cave. First, although not investigated in *Tadarida*, it is conceivable that the noise and other disturbances associated with the construction of a gas-oil pipeline near the cave could have disturbed the bats, causing them to abandon the cave. Ambient noise, including that from traffic, has recently been shown to have a potentially negative effect on the foraging ability of some bats (Schaub et al., 2008).

Secondly, the entrance of the cave where the bats emerged opens into a small canyon that is now overgrown by vegetation. A photograph of Conner Cave in 1986 (Baker and Bozeman, 1986) shows the area around the mouth of the cave unobstructed by vegetation. On our visits to the cave in 2011 and 2013, the actual mouth of the cave was unobstructed; however, ca. 7.5 m from the entrance, trees now extend up to and above the rim of the canyon. *Celtis reticulata* (western hackberry) is the dominant tree in the canyon, and closest to the entrance. Other trees in the canyon include *Juniperus virginiana* (eastern red cedar), *Sapindus drummondii* (soapberry), *Ulmus* (elm), *Sideroxylon lanuginosum* (chittamwood), and *Quercus macrocarpa* (bur oak). Above the canyon where the entrance of the cave is located are gypsum outcrops that support a community composed of the native plants *Opuntia* (pricklypear), *Heterotheca stenophylla* (stiffleaf false golden aster), *Psilostrophe tagetina* var. *cerifera* (wooly paperflower), *Echinocereus reichenbachii* (lace hedgehog cactus), *Paronychia jamesii* (James' nailwort), *Aristida purpurea* (three-awn grass), *Thelesperma filifolium* (green-thread), *Mentzelia nuda* (sandlily), *Sporobolus* (dropseed), *Plantago* (plantain), and *Gaillardia pulchella* (Indian blanket). The tops of the trees within the canyon now extend above the top of the entrance of the cave, and a large population of *T. brasiliensis* would have difficulty emerging in mass from the entrance as they have been observed to do at most other maternity cave roosts. *Tadarida brasiliensis*, when returning to a cave after foraging, are known to free-fall from several hundred meters. As they near the entrance, they open their wings and enter the cave. Increasing vegetation in front of the

entrance could be blocking the arrival area, thereby preventing the bats from having enough open space to flare and glide into the cave.

There are no data to support this, but the number of *T. brasiliensis* in Conner Cave might have declined over time causing a drop in the critical thermal mass in the cave to support the growth of the young. The females might have relocated to one of the other four maternity caves. Vickery Cave is only 30 km NW of Conner Cave.

Conner Cave has been a site for significant research on *T. brasiliensis* and associated biota. If Conner Cave has been abandoned by *T. brasiliensis*, the biodiversity of the cave will be negatively impacted. Historical records of its use for research and the importance of *T. brasiliensis* as a keystone species are included in the following accounts.

Some of the earliest records of Conner Cave serving as a site for scientific research are found in the literature associated with ectoparasites of *T. brasiliensis*. Bat flies (*Trichobius*) were collected from *T. brasiliensis* in Conner Cave by Zeve (1958, 1959). Free-tailed bats in Conner Cave served as a key population in the bat-banding studies of Glass (1958, 1982) to determine where *T. brasiliensis* from Oklahoma migrated in the winter. The loss of the bats also might have had an impact on the seasonal changes in various taxa among the caves further south in Oklahoma and Texas that are used by transient bats during migration. Bats banded at Conner Cave have been recovered in Texas (Glass, 1958) and Kansas (Jones et al., 1967). In July 1963, Perry (1965) banded 9,600 neonates at Conner Cave, and, in 1964, another 12,700 were banded as part of a study to determine age of bats based on eye-lens weight. Perry (1965) provided a very rough estimate of a peak population of 800,000 bats in Conner Cave during 1963 and suggested the cave served primarily as a female-dominant nursery cave. Perry and Rogers (1964) describe finding *T. brasiliensis* in the pellets of great horned owls near Conner Cave.

Rogers (1972) examined population characteristics such as sex ratios and age structure of *T. brasiliensis* in Conner Cave from 1965–1967. Rogers (1972) indicated that sex ratios in Conner Cave were the highest of the five maternity caves in terms of percentage of females, but mean percentage of the young-of-the-year was lowest. He suggested that because Conner Cave was the smallest maternity cave, during the late summer when most of the pups were becoming volant, Conner Cave quickly became overcrowded, and some bats moved to other caves. Influx of the overflow *T. brasiliensis* from Conner Cave into other maternity caves where they relocated probably influenced the biological interactions of those caves.

We suggest that the Oklahoma Department of Wildlife Conservation and the Nature Conservancy assist landowners who own caves used by *T. brasiliensis* in clearing the vegetation near the front of caves that might be restricting bats during emergences and returns. The Oklahoma Natural Areas Registry, a cooperative program

of the Nature Conservancy, has an agreement with R. Conner to preserve and protect the cave system and the free-tailed bats. Other significant caves with *T. brasiliensis* in other regions of the United States should be inspected and assessed for vegetative growth around the entrance and any collapse of rocks that might be hindering emergences and re-entries.

It is unfortunate that we did not have the opportunity to thermally image the emergence flights from Conner Cave to estimate the size of populations of *T. brasiliensis* prior to its disappearance. These estimates might have supplied information relative to whether the bats abandoned the cave all at once or if the abandonment occurred over several seasons. Did the bats simply die out or did they relocate to other caves in the area such as Vickery Cave 30 km to the northwest, or did the free-tailed bats in Conner Cave suffer some catastrophic event after they began their southern migration to Mexico in the fall or before they returned to Oklahoma in the spring? Surely, caves have become unfavorable through the years for other populations of bats, but how populations fare and what they do when the environment of a cave deteriorates remains in many cases a mystery.

Conner Cave was a significant maternity cave in the northern part of the range of *T. brasiliensis* in Oklahoma and the Great Plains. The loss of this population might have a negative impact on the long-term existence of the species in Oklahoma and to other biological taxa in the cave. The loss of a large population of *T. brasiliensis* also could have economic consequences because *T. brasiliensis* is known to consume agricultural pests (Cleveland et al., 2006). There are increasing anthropogenic threats (e.g., pesticides, loss of foraging habitat, vandalism of caves, drilling for oil and gas, wind-turbine farms) to bats, and the loss of any population is significant. A new threat, in the form of climatic change (e.g., perhaps increasing vegetative growth in mouths of caves) might alter the suitability of some caves for use as maternity roosts for *T. brasiliensis*. McCracken (2003) suggested that populations of *T. brasiliensis* in North America are on a decline but it is difficult to determine the magnitude because of absence of regular monitoring of populations. Elliott (1994) indicated that the remaining bat caves in the United States are extremely important to the survival of migratory species like *T. brasiliensis*. The loss of roosting caves for bats could threaten the species and might be a reason that it is colonizing abandoned mine tunnels, old buildings, and bridges. We also have observed the continuing collapse of the entrance of Vickery Cave over the past few years and how it has restricted the emergence flight of that maternity colony, which could lead to the abandonment of that cave as well. The vegetation at the entrance to Selman Cave also is increasing, and we have observed bats colliding with trees and shrubs as they emerge. The Oklahoma Department of Wildlife Conservation is taking steps to remove the vegetation there to

allow the bats more room to emerge. We are aware of another large cave, Cattle Cave, on the Selman Living Lab in Woodward County that used to be a large bat cave, possibly a cave with *T. brasiliensis*, which now has an entrance covered with vegetation and no *T. brasiliensis*. We are hopeful that Conner Cave has been abandoned only temporarily for some undetermined reason and the bats might recolonize the cave in the near future. We encourage biologists to continue to monitor maternity caves across the range of *T. brasiliensis* and to work closely with landowners and government agencies to clear the mouths of caves of obstructions so that these large maternity populations can continue to exist.

We are appreciative of R. Conner for allowing us access to Conner Cave and to the students of the University of Central Oklahoma (Edmond) and West Texas A&M University (Canyon) who assisted us in the thermal-imaging projects that led to the discovery that Conner Cave has been abandoned by *T. brasiliensis*. M. N. Shackford was instrumental in helping us gain access to Conner Cave.

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ALTERNATIVE SPAWNING STRATEGY AND TEMPERATURE FOR LARVAL EMERGENCE OF LONGFIN DACE (*AGOSIA CHRYSOGASTER*) IN STREAM MESOCOSMS

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