
TEXAS TECH UNIVERSITY
Natural Science Research Laboratory

Occasional Papers

Museum of Texas Tech University Number 346 4 April 2017

Recurrence of the Spotted Bat (*Euderma maculatum*) at Historical Sites in New Mexico, with Notes on Natural History

Keith Geluso

Abstract

The Spotted Bat (*Euderma maculatum*) is an uncommon species of insectivorous bat in the western United States, and in New Mexico, it is considered a state-threatened species. In this study, I examined the recurrence of *E. maculatum* at historical sites in New Mexico because little information has been reported or published on the species in recent decades from the state. From mid-May to early August 2006, I documented *E. maculatum* at 69% of historical sites visited (11 of 16 sites), which accounts for 85% of historical sites (11 of 13) with records during warmer months. Spotted Bats also were documented from six new sites in New Mexico. Capture rates for *E. maculatum* in 2006 were similar to those in the 1960s. These data support that at least regional occupancy has remained relatively similar during the last 40 years in the state. Data on natural history included that the species was reproductively active during a drought, fed almost exclusively on Lepidoptera, and was active from dusk to dawn in New Mexico. Much information regarding the natural history of *E. maculatum*, including population trends at sites, remains poorly understood and warrants further research.

Key words: diet, distribution, *Euderma maculatum*, New Mexico, recurrence, reproduction, Spotted Bat

Introduction

The Spotted Bat (*Euderma maculatum*) is one of the rarest and most infrequently or sporadically captured species of insectivorous bat in the western United States (Fenton et al. 1987; Best 1988). Spotted Bats occur from southern British Columbia to central Mexico (Hall 1981). Despite inhabiting 12 states in the United States (Geluso 2000; Gitzen et al. 2001), much remains to be learned about the natural history of this species (Rodhouse et al. 2005; Chambers et al. 2011). Paucity of data associated with *E. maculatum* is related to limited captures throughout its range and rarity of specimens (Fenton et al. 1987; Best 1988). For example, Best (1988) discovered that only 73 specimens of *E. maculatum* existed in collections as of 1985, and Hoffmeister (1986) reported on each specimen of *E. maculatum* from Arizona because so few records existed from the state. Only scant natural history data have been published on *E. maculatum* in New Mexico and other states (e.g., Jones 1961, 1965, 1966; Findley et al. 1975; Hoffmeister 1986). Lim-

ited information inhibits making sound management decisions about a species, which unfortunately might be requisite for this species if the devastating fungus, *Pseudogymnoascus destructans* that causes white-nose syndrome (WNS) in many hibernating species, continues to expand westward across the Great Plains. WNS recently was detected in Washington (Lorch et al. 2016), and additional populations of western hibernating bats are at risk.

In New Mexico, *E. maculatum* has been captured at few sites compared to most other vespertilionid bats, and little information is known about its abundance, reproductive patterns, and seasonal activities (Findley and Jones 1965; Findley et al. 1975; Findley 1987; Perry et al. 1997; Sherwin and Gannon 2005). In recent years, few individuals have been reported from New Mexico, although *E. maculatum* bears and raises young in the state (Findley et al. 1975). For example, Perry et al. (1997) reported that only a single Spotted Bat was captured from 1985 to 1995 in New Mexico. With limited data and few recent reports, it is unclear whether populations have declined or still exit in some areas of New Mexico. Some researchers have postulated possible population declines or absences at some historical sites for *E. maculatum* in New Mexico and throughout its distribution (Fenton et al. 1987; NMDGF 1994).

Spotted Bats are known from 12 published locations in western and southern New Mexico (Perry et al. 1997). It is unclear whether individuals regularly occur at those sites every year or whether prior captures at historical sites represent transient individuals or now extirpated populations. In New Mexico, *E. maculatum* is considered a state-threatened species (Jones and Schmitt 1997; NMDGF 2006). The primary objective of my study was to assess recurrence of *E. maculatum* at previous sites of observation in New Mexico, which serves as a benchmark in time to allow for comparisons with future surveys. The secondary objective was to amass natural history information on all observations of *E. maculatum* from the state.

METHODS

To determine netting sites in 2006, I originally compiled records of localities from published literature, unpublished reports, communications with other bat researchers, and museum specimens in the Museum of Southwestern Biology (MSB), University of New Mexico in Albuquerque and in Western New Mexico University (WNMU) in Silver City. In 2017, I acquired and updated locality records for tables below from the Mammal Networked Information System (MaNIS) via the VertNet portal (last accessed 8 January 2017; http://manisnet.org/) and updated the total number of specimens known from each locality via MaNIS and Best (1988). Not all museum holdings can be obtained through MaNIS, thus there likely are additional specimens in collections. Museums and their acronyms with holdings include: MSB; Instituto de Biologia, Universidad Nacional Automoma de Mexico, Mexico City (UNAM); United States National Museum of Natural History, Washington, D.C. (USNM); New Mexico Museum of Natural History, Albuquerque, New Mexico (NMMNH); New Mexico State University, Las Cruces, New Mexico (NMSU); Nevada State Museum and Historical Society, Las Vegas, Nevada (NSMHS); University of Arizona Museum of Natural History, Tucson, Arizona (UAZ); University of Colorado Museum, Boulder, Colorado (UCM); and WNMU.

Specific locations of some sites were not described in detail, and sometimes, multiple descriptions of localities were used for a single location. To reduce such ambiguities, I combined duplicate localities and reported them as a single location. Herein, I define historical sites as any site with at least one previous observation prior to 2006. I also surveyed a few areas where *E. maculatum* had not been documented previously, but the possibility existed of its occurrence on the basis of distributional limits (Hall 1981).

From 11 May to 8 August 2006, I surveyed many of the localities across New Mexico with prior reports of *E. maculatum*. At many of these historical sites, I attempted to capture individuals with mist nets (Avinet Inc., Dryden, New York), observe individuals with spotlights, or listen for their distinctive audible calls. At most sites, I placed mist nets over water, including rivers, streams, earthen ponds, and steel-rimmed stock

tanks. Multiple nets generally were deployed over water sources to increase capture rates. In May and June 2006, drought conditions persisted in the region. Lack of precipitation prior to this study caused some earthen ponds at historical sites to be dry. On such occasions, I attempted to find a nearby larger water source to deploy mist nets. At some sites, nets were not set up, and observations consisted of listening for audible calls. At other sites, I abandoned the area because of dry conditions or threat of forest fires.

For each bat captured, I recorded species, time of capture, sex, age, and reproductive condition. I also recorded forearm length and body weight for all *E. maculatum*. A small dot of ink was placed on the wing of individuals at time of release to determine whether subsequent individuals captured that night represented recaptures. All *E. maculatum* captured were held for about 1 h to obtain fecal pellets of recently eaten insects (see Buchler 1975) and then released at sites of capture. Localities were recorded using a handheld global positioning system (GPS; Garmin GPS 12, Garmin International, Inc., Olathe, Kansas), using North American Datum 1983.

To determine the diet of *E. maculatum*, I examined fecal pellets with a dissection microscope following techniques reported in Whitaker (1988). All fecal pellets from an individual were treated as a single sample, and number of pellets collected varied from 4 to 18 pellets. Each sample was placed in a Petri dish with 95% ethanol, and pellets were gently pulled apart to observe small fragments of insects. I identified fragments to the lowest identifiable taxonomic group. In each sample, I determined the volume of each food type as a percentage. This represents the quantity visually estimated of each food type in the sample. I reported average percentage volume, which equals the sum of sample volumes for each food type divided by total volume possible multiplied by 100. I also reported percentage frequency, which represents the total percentage of samples containing that taxon.

In New Mexico, three species of bats that frequently occur in the study area produce audible echolocation calls (e.g., Woodsworth et al. 1981), and those calls can be distinguished by trained individuals (Findley and Jones 1965; Barbour and Davis 1969; Rabe et al. 1998). I also used audible calls to document species at sites, besides using mist nets and visual observations with spot lights. Big Free-tailed Bats (*Nyctinomops macrotis*) produce the highest pitched calls that were distinct from calls of *E. maculatum* and Allen's Big-eared Bats (*Idionycteris phyllotis*). For me, calls of *Nyctinomops* are high-pitched chirps with some length to each call (i.e., each call is drawn out compared to other audible calls). Spotted Bats and Allen's Big-eared Bats produce calls that are similar in pitch and duration to each other but lower in pitch than *N. macrotis*. For me, audible calls of *E. maculatum* and *I. phyllotis* can be described as two small steel balls or rocks being hit together. Duration of each call is short and quick with no length to calls. Sounds produced by *E. maculatum* and *I. phyllotis* are best described as a sharp click. The most notable difference between the latter two species is frequency and loudness of calls. Spotted Bats produce calls that can easily be counted when individuals fly overhead; that is, when individuals are not engaged in feeding or on approach to drink. Moreover, audible sounds of *E. maculatum* are loud (Woodsworth et al. 1981) and considerably louder than those of *I. phyllotis* (Findley and Jones 1965). Allen's Big-eared Bats produce calls that are very rapid and difficult to count, especially when counting into double digits. Calls of *I. phyllotis* also are softer than *E. maculatum* in my experiences. During this study and others, I have observed that *E. maculatum* always produce audible calls. In contrast, *I. phyllotis* does not always produce audible calls. Based on audible calls immediately prior to capture in nets or observations with spotlights, I have recognized without error at least 15 *E. maculatum* and over 30 *I. phyllotis*. I was not able to classify some distant calls or calls produced on windy nights.

RESULTS

In 2006, I deployed nets on 37 nights and captured 1,752 bats representing 20 species (Table 1). I captured a total of nine *E. maculatum*, which ranked 16th in abundance of species (Table 1). Silver-haired

Table 1. Species and total number of bats captured from 11 May to 8 August 2006 at historical and potential sites for Spotted Bats (*Euderma maculatum*) in New Mexico. Prevalence represents the total number of nights that each species was documented in mist nets of 37 nights that nets were deployed.

Species	Number of individuals captured	Prevalence
Lasionycteris noctivagans	587	22
Eptesicus fuscus	258	26
Myotis volans	131	19
Myotis californicus/ciliolabrum	114	19
Myotis occultus	110	15
Tadarida brasiliensis	101	20
Lasiurus cinereus	93	14
Myotis evotis	87	12
Myotis thysanodes	80	17
Myotis yumanensis	54	14
Myotis auriculus	38	8
Parastrellus hesperus	30	9
Antrozous pallidus	28	10
Idionycteris phyllotis	15	7
Myotis velifer	12	3
Euderma maculatum	9	3
Lasiurus blossevillii	2	1
Perimyotis subflavus	1	1
Corynorhinus townsendii	1	1
Nyctinomops macrotis	1	1
Totals	1,752	

Bats (*Lasionycteris noctivagans*) and Big Brown Bats (*Eptesicus fuscus*) were the most frequently captured species, whereas the American Perimyotis (*Perimyotis subflavus*), Townsend's Big-eared Bat (*Corynorhinus townsendii*), and Big Free-tailed Bat were the least frequently captured species, each represented by a single capture. Spotted Bats were captured on three nights (Table 1).

I visited 17 of 18 historical sites where *E. maculatum* previously was documented in New Mexico (Table 2). At three sites, the water source was dry (Table 2), but for two of those sites, I netted at a nearby site (i.e., site at Aqua Chiquita was near Rogers Ruins, Otero County, and site near Springtime Campground was near Weir Tank, Socorro County). Considering the nearby sites as evidence for *E. maculatum* occurring at historical sites, I documented Spotted Bats at 69% of historical sites that I visited in 2006 (11 of 16; Table 2). Three historical sites had dates of occurrence only in autumn and winter (Albuquerque, Bernalillo County; Mesilla Park in Las Cruces, Dona Ana County; and

Table 2. List of localities where Spotted Bats (*Euderma maculatum*) have been documented in New Mexico. The original source for each published ($n = 15$) or unpublished[1] ($n = 3$) historical site is shown in parentheses, along with the number of museum specimens (for museum acronyms, see Methods). Also listed are "new sites" documented in this study ($n = 6$), although some are near former historical sites. Other information includes whether individuals were captured, observed with spotlights (i.e., sighting), or detected via audible calls in 2006. See Appendix for specific details on localities of captures.

County	Site (Source)	Visited in 2006	Capture	Sighting	Audible
Bernalillo	Albuquerque (Findley et al. 1975; MSB 3)	Yes	No	No	No
Catron	9 mi E of Mogollon (Jones 1961; MSB 4, UAZ 1)	Yes (dry)			
	10 mi E of Mogollon, Willow Creek (Jones 1966; MSB 2)	Yes	No	No	Yes
	Woodland Park (Best 1988; WNMU 1)	No			
	Burnt Cabin Cienega (new site, this study)	Yes	No	No	Yes
	Glenwood Fish Hatchery (new site, this study)	Yes	No	No	Yes
Cibola	Mount Taylor (Reynolds 1981; MSB 3)[2]	Yes	Yes	Yes	Yes
	El Malpais National Monument (Bogan et al. 2007)	Yes	No	No	Yes
Dona Ana	Mesilla Park, Las Cruces (Miller 1903; USNM 1)	Yes	No	No	No
Grant	Lake Roberts (Best 1988; WNMU 1)	Yes	No	No	No
	TNC Lichty Farm, Gila River (calls heard previously by K. Geluso)[1]	Yes	No	No	Yes
	Gila River, 16 km E Buckhorn (calls heard previously by K. Geluso)[1]	Yes	No	No	Yes
	Gila River, Bird Area, Big Burro Mountains (new site, this study)	Yes	No	No	Yes
	Black Canyon Campground (new site, this study)	Yes	No	No	Yes
Otero	Rogers Ruins, Sacramento Mountains (Perry et al. 1997; MSB 1, a photograph)	Yes (Dry)			
	Agua Chiquita, Sacramento Mountains (new site, this study, near historical site)	Yes	No	No	Yes
Rio Arriba	Ghost Ranch (Constantine 1961; MSB 1, UNAM 1)	Yes	No	Yes	Yes

Table 2. (cont.)

County	Site (Source)	Visited in 2006	Capture	Sighting	Audible
Sandoval	East Fork Jemez River (Findley et al. 1975; MSB 9, NSMHS 1, UAZ 1)	Yes	Yes	Yes	Yes
	Bandelier National Monument (Bogan et al. 1998)	Yes	No	No	Yes
San Juan	3.2 km N Aztec (Rodeck 1961; UCM 1)	Yes	No	No	No
	Chaco Culture National Historical Park (Bogan et al. 2007)	Yes	No	No	No
Socorro	Weir Tank, San Mateo Mountains (Findley et al. 1975; records[3])	Yes (Dry)			
	5.6 km E Springtime Campground (new site, this study, near historical site)	Yes	No	No	Yes
	Tank south of Bingham (observation by A. Hope, pers. comm.)[1]	Yes	No	Yes	Yes

[1]Historical unpublished sites represent those where *E. maculatum* were documented prior to 2006 by myself or colleagues.

[2]Only one specimen is known from this site, but I deposited two voucher photographs from the area (Geluso 2008). The specimen (a dried mummy) was reported from Valencia County, but this part of the county is presently named Cibola County.

[3]MSB 6, NMMNH 1, NMSU 1.

Aztec, San Juan County). If I exclude sites with dates of occurrences outside my study period during warmer months, I documented Spotted Bats at 85% of historical sites with prior warm-season records (11 of 13 sites). In addition to the two new locations near historical sites, I also documented *E. maculatum* at four new sites away from former sites—two localities in Catron County and two in Grant County (Table 2; Appendix).

I observed *E. maculatum* at sites from 18 May to 3 July 2006 in New Mexico (Table 3; Appendix). The only reproductive data gathered for *E. maculatum* in 2006 was a lactating female captured on 30 June at Mt. Taylor, Cibola County (Table 3; Geluso 2008). Nightly activity varied at sites, but in general, observations were made from shortly after sunset to almost dawn (Table 3). At Ghost Ranch, for example, I heard and watched a Spotted Bat drink over a large pond at 2155 h. I watched this individual for 8 min. It was light enough outside to observe the individual without flashlights, and it made many low passes over the water and drank at least four times. I noted that audible calls were faster when drinking than when it or other individuals were flying overhead. At times the individual was 5 m away. For over an hour at this site, I heard the conspicuous audible calls of individuals, with as many as three flying overhead at one time.

The diet of six *E. maculatum* captured in this study consisted almost entirely of Lepidoptera. Lepidoptera comprised 97.5% and Coleoptera comprised 2.5% of total volume. Percentage frequency was 100% for Lepidoptera and 17% for Coleoptera.

Table 3. Notes on Spotted Bats (*Euderma maculatum*) captured in 2006 in New Mexico. Individuals are listed chronologically by date of capture.

Sex	Age	Reproductive status	Time captured (h)	Forearm length (mm)	Body weight (g)	Date captured	County	Locality[1]
male	adult		2240	50.5	13.9	18 May	Sandoval	Jemez River
unknown	adult					18 May	Sandoval	Jemez River
male	adult		2158	52.0	14.4	17 June	Sandoval	Jemez River
male	adult		2233	51.0	15.2	17 June	Sandoval	Jemez River
unknown			0003			18 June	Sandoval	Jemez River
female	adult	lactating	2219	54.0	16.9	30 June	Cibola	Mt. Taylor
female	adult	non-repro	2224	53.0	15.3	30 June	Cibola	Mt. Taylor
male	adult		2240	50.0	14.9	30 June	Cibola	Mt. Taylor
female	adult		0327	54.5	17.8	1 July	Cibola	Mt. Taylor

[1]See Appendix for specific details on localities of captures.

DISCUSSION

I documented *E. maculatum* at 85% of historical sites with prior warm-season records throughout New Mexico. Those results are positive in regards to the continued occupancy for *E. maculatum* at historical sites. Such data demonstrate that at least some individuals inhabit most areas where the species has been documented in the past. The drought in 2006 likely improved my detection rates, as limited availability of drinking water concentrates bats around remaining water sources (Jones 1966; Geluso and Geluso 2012). The general lack of water throughout the region also might have been responsible for detecting the species at new localities (Table 2), which likely required individuals to fly farther distances to drink. Considering the potential limitations of a one-year, single-season survey, the detection rate for *E. maculatum* was positive for a species generally considered rare and sporadic throughout its distribution. However, although an encouraging result from this project, my study was not able to assess population trends for the species at historical sites, indicating a clear need for future research. However, see section on "Relative abundance past and present" below.

Historical sites lacking evidence of Spotted Bats in 2006.—I documented *E. maculatum* at 11 of 16 visited historical sites in 2006, but I did not detect observations at five localities. I suspect that three sites represented areas where *E. maculatum* was not present due to the seasonal timing of my surveys. In New Mexico, Findley and Jones (1965) suggested that *E. maculatum* moves seasonally from ponderosa pine forests in summer to lower elevations in winter. For example, in Albuquerque, specimens for *E. maculatum* are reported from 25 October 2016 (MSB 295012), 9 November 1971 (MSB 32594), and 28 January 1999 (MSB 135536; Sherwin and Gannon 2005); a specimen from Las Cruces was from September 1903 (Miller 1903); and a record from Aztec was from 21 September 1960 (Rodeck 1961). All three historical records are from habitats below ponderosa pine forests, and thus might have represented individuals that already moved from summer areas to areas near winter hibernacula. To date, direct evidence of seasonal movements has not been documented, but indirect evidence is reported from New Mexico and other states (Findley and Jones 1965; Geluso 2000).

It is not clear why *E. maculatum* was not detected at the other two historical sites in 2006 (Lake Roberts in Grant County and Chaco Culture National Historical Park in San Juan County). The specimen from Lake

Roberts was captured on 12 May 1970, and the individual might have been in route to higher elevations in the Mogollon Mountains from a winter roosting area. I also failed to detect the species from Chaco Canyon National Historical Park in 2006. Colleagues and I originally observed *E. maculatum* in the park in 1999, 2000, 2003, and 2004 (Valdez et al. 2002; Bogan et al. 2007). My initial surveys in 2006 were in mid-May, possibly before individuals returned to the area, but additional trips were in mid-June and mid-July, and I still did not detect *E. maculatum*. One possibility of my failure to detect this species at these two sites might be associated with drought conditions in the region.

Relative abundance of E. maculatum *in 2006 and in the past*.—Three studies comment on the relative abundance of *E. maculatum* in New Mexico (Findley and Jones 1965; Jones 1965, 1966), with data in Findley and Jones (1965) incorporated into the latter two papers. Moreover, some data in Jones (1965, 1966) represent some of the same captures. Jones (1965) reported 1,595 individuals of 20 species of bats during 101 night of netting from the Mogollon Mountains of New Mexico and adjacent areas in Arizona, including seven captures of *E. maculatum*. Jones (1966) reported on 1,257 bats of 19 species during 70 nights of netting from five sites in the Mogollon and San Mateo mountains of New Mexico, including nine captures of *E. maculatum*.

On the basis of Jones (1965), I calculated that he captured 0.07 individuals of *E. maculatum* per night of netting, and *E. maculatum* comprised 0.4% of total captures. From Jones (1966), I calculated that he captured 0.16 individuals of *E. maculatum* per night, and *E. maculatum* comprised 1.0% of total captures. For the latter calculation, I subtracted the number of nights and bats from Bear Trap Canyon in the San Mateo Mountains because *E. maculatum* is not known from that site (Geluso and Geluso 2012). During my 37 nights of netting throughout New Mexico in 2006, I captured 1,752 bats of 20 species, including nine captures of *E. maculatum*. From my data, I captured 0.24 individuals per night, and *E. maculatum* comprised 0.5% of my total captures.

Comparison of individuals captured per night of netting and relative percentage of captures of *E. maculatum* showed no evidence of a decrease in *E. maculatum* in New Mexico in the last four decades. My capture rate per night was higher than in both studies by Jones (1965, 1966), and my calculation of relative percentage of total captures was between survey results shown by Jones (1965, 1966). My data are based on fewer nights of netting than Jones, but to my knowledge, my survey represents the only recent and widespread study on the species in New Mexico.

Seasonality, reproduction, and diet.—Spotted Bats occur in New Mexico throughout the year. My dates of capture in 2006 (May, June, and July; Table 3) were within the known dates of warm-season activity for the species in the state. Dates of occurrence in New Mexico exist from 12 May to 11 November (WNMU 1842 and MSB 32594, respectively) and in January and February (MSB 135536; Sherwin and Gannon 2005). Dates of occurrence in the state for volant individuals not in or on buildings are from 12 May (WNMU 1842) to 21 September (UCM 7335). Individuals from buildings occurred on 25 October, 9 November, and 28 January (MSB 295012, 32594, and 135536, respectively). Thus far, there are no dates for pregnant individuals from New Mexico. My capture of a lactating female on 30 June falls within the known dates of lactation in New Mexico (9 June–30 July; Perry et al. 1997 and MSB 29400, respectively). The only reported flying young was from 21 September (Rodeck 1961). Forearm lengths and body weights of males and females in this study were within the range for the species from New Mexico and other areas across its distribution (Best 1988; Wai-Ping and Fenton 1989; Chambers et al. 2011). I documented volant *E. maculatum* from dusk to dawn, which is in agreement with more recent studies on this species (Leonard and Fenton 1983; Navo et al. 1992; Wai-Ping and Fenton 1989; Rabe et al. 1998; Chambers et al. 2011). Spotted Bats are known to feed mainly on moths (Ross 1967; Painter et al. 2009), but this information is based on relatively few samples from New Mexico. In the present study, I examined diets of six additional individuals from New Mexico, and those additional data demonstrated again that *E. maculatum* feeds almost exclusively on Lepidoptera.

Water sources for Spotted Bats.—After visiting many historical sites, I observed that almost all capture sites of *E. maculatum* were large, open areas of water containing few surrounding obstacles, such as trees, shrubs, or cliffs. The most common source of water consisted of human-made, earthen ponds in meadows

or in other areas without trees. In 2006, some water sources were ephemeral because of the lack of winter and spring precipitation. Spotted Bats might not be affected as much as other bat species by a scarcity of surface water during droughts because individuals fly long distances to forage and drink (Rabe et al. 1998; Chambers et al. 2011) and are good at conserving urinary water (Geluso 1978). However, their fast (Woodsworth et al. 1981; Wai-Ping and Fenton 1989; Chambers et al. 2011) or less maneuverable flight might limit the number of possible water sources available for drinking, if water sources have small surface areas. As observed in this study and by other researchers, human-made livestock ponds are important water resources for *E. maculatum* throughout their distribution (e.g., Geluso 2000; Chambers et al. 2011; this study). Moreover, Chambers et al. (2011) recommend that some larger ponds should be maintained as water sources for bats, especially during droughts. My observations further demonstrate that such resources should be maintained for bats, as a number of historical sites used by *E. maculatum* dried up during the summer of 2006. Chambers et al. (2011) further stated that an important management strategy for bats is to determine critical or important water resources used by bats and to ensure that they continually contain water. In New Mexico, a winter bat survey also demonstrated that a great number of bats use low-elevation water sources to drink in winter (Geluso 2007).

Conclusions.—The Spotted Bat is uncommon throughout its range and only limited information is known about its natural history (e.g., Findley et al. 1975; Hoffmeister 1986; Rodhouse et al. 2005; Chambers et al. 2011). Additional studies on *E. maculatum* in New Mexico are warranted. Two focal needs include gathering information on roost sites in both summer and winter, as well as understanding seasonal movements of the species. If *E. maculatum* is affected by WNS in the future, it will be essential to know where the species roosts in winter. In addition, it would be valuable to learn whether males and females use separate roosts, whether they form large or small aggregations in roosts (especially in winter), how far individuals move between seasonal roosts, and what are threats to those roosts, if any. Bat researchers need to make a concerted effort to continue to publish information gathered on all bats and to not let data remain as unpublished reports or remain unknown in personal field notes. In general, little is understood about western species of hibernating bats compared to eastern species, thus in the new era of major threats to many temperate North American bats, including WNS and wind-energy development, all data need to be reported and accessible.

ACKNOWLEDGMENTS

I thank Jason P. Damm, Duane J. Eberle, Kenneth N. Geluso, Mary J. Harner, and Christa D. Weise for their assistance in the field. I thank Donna J. Howell, Mary L. Medina, and Chuck L. Hayes for their assistance and support with matters concerning funding and reporting with this contract. Kenneth N. Geluso, Paul M. Cryan, and one anonymous reviewer made valuable contributions on earlier versions of this manuscript. I thank Randy D. Jennings for assistance with museum matters at Western New Mexico University in Silver City. I also thank Ernie W. Valdez for assistance with diet analysis. This study was funded by the New Mexico Department of Game and Fish, Share with Wildlife Program in 2006.

LITERATURE CITED

Barbour, R. W., and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington.

Best, T. L. 1988. Morphologic variation in the Spotted Bat *Euderma maculatum*. American Midland Naturalist 199:244–252.

Bogan, M. A., T. J. O'Shea, P. M. Cryan, A. M. Ditto, W. H. Schaedla, E. W. Valdez, K. T. Castle, and L. Ellison. 1998. A study of bat populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. FY95–97 Report to Los Alamos National Laboratory and Bandelier National Monument, LA-UR-98-2418. Los Alamos National Laboratory, Jemez Mountains, New Mexico.

Bogan, M. A., K. Geluso, S. Haymond, and E. W. Valdez. 2007. Mammal inventories for eight national parks in the Southern Colorado Plateau Network. Natural Resource Technical Report NPS/SCPN/NRTR-2007/054. National Park Service, Fort Collins, Colorado.

Buchler, E. R. 1975. Food transit time in *Myotis lucifugus* (Chiroptera: Vespertilionidae). Journal of Mammalogy 56:252–255.

Chambers, C. L., M. J. Herder, K. Yasuda, D. G. Mikesic, S. M. Dewhurst, W. M. Masters, and D. Vleck. 2011. Roosts and home ranges of Spotted Bats (*Euderma maculatum*) in northern Arizona. Canadian Journal of Zoology 89:1256–1267.

Constantine, D. G. 1961. Spotted Bat and Big Free-tailed Bat in northern New Mexico. The Southwestern Naturalist 6:92–97.

Fenton, M. B., D. C. Tennant, and J. Wyszecki. 1987. Using echolocation calls to measure the distribution of bats: The case of *Euderma maculatum*. Journal of Mammalogy 68:142–144.

Findley, J. S. 1987. The natural history of New Mexican mammals. University of New Mexico Press, Albuquerque.

Findley, J. S., and C. Jones. 1965. Comments on Spotted Bats. Journal of Mammalogy 46:679–680.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque.

Geluso, K. N. 1978. Urine concentrating ability and renal structure of insectivorous bats. Journal of Mammalogy 59:312–323.

Geluso, K. 2000. Distribution of the Spotted Bat (*Euderma maculatum*) in Nevada, including notes on reproduction. The Southwestern Naturalist 45:347–352.

Geluso, K. 2007. Winter activity of bats over water and along flyways in New Mexico. The Southwestern Naturalist 52:482–492.

Geluso, K. 2008. Spotted Bat (*Euderma maculatum*) from Mt. Taylor, New Mexico. Western North American Naturalist 68:119–122.

Geluso, K. N., and K. Geluso. 2012. Effects of environmental factors on capture rates of insectivorous bats, 1971–2005. Journal of Mammalogy 93:161–169.

Gitzen, R. A., S. D. West, and J. A. Baumgardt. 2001. A record of the Spotted Bat (*Euderma maculatum*) from Crescent Bar, Washington. Northwestern Naturalist 82:28–30.

Hall, E. R. 1981. The Mammals of North America. Second edition. Volume 1. John Wiley and Sons, New York, New York.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press, Tucson.

Jones, C. 1961. Additional records of bats in New Mexico. Journal of Mammalogy 42:538–539.

Jones, C. 1965. Ecological distribution and activity periods of bats of the Mogollon Mountains area of New Mexico and adjacent Arizona. Tulane Studies in Zoology 12:93–100.

Jones, C. 1966. Changes in populations of some western bats. The American Midland Naturalist 76:522–528.

Jones, C., and C. G. Schmitt. 1997. Mammal species of concern in New Mexico. Pp. 179–205 in Life Among the Muses: Papers in honor of James S. Findley (T. L. Yates, W. L. Gannon, and D. E. Wilson, eds.). The Museum of Southwestern Biology, University of New Mexico, Albuquerque.

Leonard, M. L., and M. B. Fenton. 1983. Habitat use by Spotted Bats (*Euderma maculatum*, Chiroptera: Vespertilionidae): Roosting and foraging behavior. Canadian Journal of Zoology 61:1487–1491.

Lorch, J. M., J. M. Palmer, D. L. Lindner, A. E. Ballmann, K. G. George, K. Griffin, S. Knowles, J. R. Huckabee, K. H. Haman, C. D. Anderson, P. A. Becker, J. B. Buchanan, J. T. Foster, and D. S. Blehert. 2016. First detection of bat white-nose syndrome in western North America. mSphere 1:e00148-16.

Miller, G. S., Jr. 1903. A second specimen of *Euderma maculatum*. Proceedings of the Biological Society of Washington 16:165–166.

Navo, K. W., J. A. Gore, and G. T. Skiba. 1992. Observations on the Spotted Bat, *Euderma maculatum*, in northwestern Colorado. Journal of Mammalogy 73:547–551.

NMDGF (New Mexico Department of Game and Fish). 1994. Endangered Species of New Mexico—1994 Biennial Review and Recommendations. New Mexico Department of Game and Fish. Santa Fe, New Mexico.

NMDGF (New Mexico Department of Game and Fish). 2006. Comprehensive Wildlife Conservation Strategy for New Mexico. New Mexico Department of Game and Fish. Santa Fe, New Mexico.

Painter, M. L., C. L. Chambers, M. Siders, R. R. Doucett, J. O. Whitaker, Jr., and D. L. Phillips. 2009. Diet of Spotted Bats (*Euderma maculatum*) in Arizona

as indicated by fecal analysis and stable isotopes. Canadian Journal of Zoology 87:865–875.

Perry, T. W., P. M. Cryan, S. R. Davenport, and M. A. Bogan. 1997. New locality for *Euderma maculatum* (Chiroptera: Vespertilionidae) in New Mexico. The Southwestern Naturalist 42:99–101.

Rabe, M. J., M. S. Siders, C. R. Miller, and T. K. Snow. 1998. Long foraging distance for a Spotted Bat (*Euderma maculatum*) in northern Arizona. The Southwestern Naturalist 43:266–269.

Reynolds, R. P. 1981. Elevational record for *Euderma maculatum* (Chiroptera: Vespertilionidae). The Southwestern Naturalist 26:91–92.

Rodeck, H. G. 1961. Another Spotted Bat from New Mexico. Journal of Mammalogy 42:401.

Rodhouse, T. J., M. F. McCaffrey, and R. G. Wright. 2005. Distribution, foraging behavior, and capture results of the Spotted Bat (*Euderma maculatum*) in central Oregon. Western North American Naturalist 65:215–222.

Ross, A. 1967. Ecological aspects of the food habits of insectivorous bats. Proceedings of the Western Foundation of Vertebrate Zoology 1:204–263.

Sherwin, R. E., and W. L. Gannon. 2005. Documentation of an urban winter roost of the Spotted Bat (*Euderma maculatum*). The Southwestern Naturalist 50:402–407.

Valdez, E. R., S. Haymond, M. A. Bogan, and L. Ellison. 2002. Bat population study and monitoring program at Chaco Culture National Historical Park, New Mexico, 1999 and 2000. Final Report to National Park Service.

Wai-Ping, V., and M. B. Fenton. 1989. Ecology of Spotted Bat (*Euderma maculatum*) roosting and foraging behavior. Journal of Mammalogy 70:617–622.

Whitaker, J. O., Jr. 1988. Food habits analysis of insectivorous bats. Pp. 171–190 in Ecological and Behavioral Methods for the Study of Bats (T. H. Kunz, ed,). Smithsonian Institution Press, Washington, D.C.

Woodsworth, G. C., G. P. Bell, and M. B. Fenton. 1981. Observations of the echolocation, feeding behavior, and habitat use of *Euderma maculatum* (Chiroptera: Vespertilionidae) in southcentral British Columbia. Canadian Journal of Zoology 59:1099–1102.

Address of author:

KEITH GELUSO

Department of Biology
University of Nebraska at Kearney
Kearney, NE 68849 USA
gelusok1@unk.edu

APPENDIX

Locations visited from May to August 2006 during 42 nights to survey for Spotted Bats (*Euderma maculatum*) in New Mexico. Type of water source follows specific locality, and habitat immediately surrounding water is shown next in parentheses. I report the dates of capture for each locality followed by parentheses that contain the number of males and females of each species captured. "unk" represents individuals of unknown sex that either escaped from mist nets without determining sex or where investigators forgot to include data in notebook. Dates below also refer to the evening nets were deployed, as some bats actually were captured after midnight on some nights. I also note whether audible calls or sightings of *E. maculatum* or *Idionycteris phyllotis* occurred on date if individuals were not captured. Abbreviations for species are as follows in order of frequency captured (Table 1): *Lasionycteris noctivagans* (LANO), *Eptesicus fuscus* (EPFU), *Myotis volans* (MYVO), *Myotis californicus/ciliolabrum* (MYCA/CI), *Myotis occultus* (MYOC), *Tadarida brasiliensis* (TABR), *Lasiurus cinereus* (LACI), *Myotis evotis* (MYEV), *Myotis thysanodes* (MYTH), *Myotis yumanensis* (MYYU), *Myotis auriculus* (MYAU), *Parastrellus hesperus* (PAHE), *Antrozous pallidus* (ANPA), *Idionycteris phyllotis* (IDPH), *Myotis velifer* (MYVE), *Euderma maculatum* (EUMA), *Lasiurus blossevillii* (LABL), *Perimyotis subflavus* (PESU), *Corynorhinus townsendii* (COTO), and *Nyctinomops macrotis* (NYMA).

BERNALILLO COUNTY: Albuquerque, Rio Grande Nature Center State Park, Rio Grande, river (riparian/city), 11 May 2006 (no nets, only listened).

CATRON COUNTY: 3.3 km NNE Wall Lake, 33°22.701′N, 108°04.103′W, no water source (piñon/juniper woodland), 27 May (no nets, only listened; IDPH audible calls); Mogollon Mountains, Willow Creek Campground, 33°23.948′N, 108°34.937′W, pool in mountain stream (meadow in mixed coniferous forest), 5 June (LANO 35♂ 1♀, MYOC 7♂ 3♀, LACI 4♂, EPFU 3♂ 1♀, IDPH 1♀ 1 unk, TABR 1♂, EUMA audible calls), 4 July (MYOC 4♂, LANO 1♂); Mogollon Mountains, Burnt Cabin Cienega, 33°27.839′N, 108°34.633′W, earthen pond (meadow in ponderosa pine forest), 6 June (MYOC 14♂ 32♀, LANO 37♂ 4♀, MYEV 16♂ 2♀ 2 unk, EPFU 9♂ 4♀, MYVO 6♂ 5♀, TABR 5♂ 4♀, MYTH 4♀, LACI 4♂, MYCA/CI 2♂, MYAU 1♀, IDPH 1♀, EUMA audible calls), 3 July (MYOC 17♂ 2♀, LANO 17♂, MYEV 13♂ 1♀, EPFU 9♂ 2♀, MYVO 5♂ 1♀, IDPH 2♀, MYCA/CI 1♂ 1♀, TABR 2♂, LACI 2♂, MYTH 1♂, EUMA audible calls); Gwynn Canyon, 33°32.227′N, 108°31.820′W, earthen pond (ponderosa pine forest), 7 June (MYTH 2♂ 5♀, EPFU 1♂ 5♀, MYOC 1♂ 3♀, MYEV 1♂ 2♀, MYAU 2♂, MYVO 1♂, LANO 1♂, MYCA/CI 1♂); Glenwood, Glenwood Fish Hatchery, 33°19.253′N, 108°52.856′W, earthen pond (riparian woodland), 8 June (MYYU 1♂ 7♀, MYVE 4♂ 1♀, LABL 1♂ 1♀, TABR 1♀, IDPH audible calls), 24 June (MYYU 1♀, MYVE 1♀, TABR 1♂, EUMA audible calls, IDPH audible calls).

CIBOLA COUNTY: Mt. Taylor, Junction Forest Service Roads 451 and 453, American Canyon Spring, 35°16.691′N, 107°33.647′W, steel-rimmed tank (meadow in mixed coniferous forest), 17 May (LANO 10♂, EPFU 1♀, MYVO 6♂ 3♀, MYEV 1♂ 2♀ 1 unk, MYTH 3♂); Mt. Taylor, T12N, R8W, SW1/4 Sec. 22, 35°14.902′N, 107°40.243′W, earthen pond (ponderosa pine forest), 30 June (LANO 73♂, MYVO 20♂ 12♀, EPFU 22♂ 9♀, MYCA/CI 16♂ 8♀, MYEV 7♂ 8♀, MYTH 5♂ 3♀ 1 unk, LACI 5♂, EUMA 1♂ 3♀, MYYU 1♂, TABR 1♂); La Ventana Arch, El Malpais National Monument, 34°52.360′N, 107°53.367′W, no water (scrubland), 1 July (no nets, only listened, EUMA audible calls).

DOÑA ANA COUNTY: Las Cruces, Rio Grande, NM HWY 80, 32°18.608′N, 106°49.557′W, river (city), 26 June (no nets, only listened).

EDDY: Carlsbad Caverns National Park, Rattlesnake Springs, Rattlesnake Spring, rock-lined pond (desert oasis), 29 May (MYVE 6♀, TABR 3♂ 1♀, PAHE 1♂ 2♀, ANPA 2♂, MYCA 1♂, PESU 1♂, EPFU 1♂, COTO 1♀), 17 August (TABR 15♂ 4♀, ANPA 3♂ 3♀, EPFU 2♀, MYTH 1♀, MYCA/CI 1♂), 8 August 2006 (TABR 19, ANPA 6, EPFU 2, MYCA 1, MYTH 1).

GRANT COUNTY: Black Range, Junction Cooney Canyon and Mimbres River, 33°02.521′N, 107°58.794′W, small river (riparian woodland), 22 May (LANO 22♂ 2 unk, MYVO 1♂ 6♀, EPFU 2♂ 4♀, MYEV 3♀, MYAU 2♂, MYTH 1♀, LACI 1♂, TABR 1♂, MYYU 1♂, MYCA/CI 1♂, IDPH audible calls); Black Range, NM HWY 152, 0.4 km SE Railroad Canyon Campground, 32°54.310′N, 107°49.184′W, intermittent mountain stream (piñon/juniper and ponderosa pine woodlands), 23 May (LANO 93♂, LACI 12♂ 1♀, EPFU 2♂ 6♀, MYEV 2♂ 4♀, MYVO 1♂ 1♀ 1 unk, MYCA/CI 2♂); Gila River, The Nature Conservancy Lichty Farm, 33°00.897′N, 108°32.957′W, river (riparian woodland), 24 May (LANO 7♂ 7♀, TABR 2♂, EPFU 1♀, PAHE 1♀, EUMA audible calls); Lake Roberts, Upper End Campground, 33°01.718′N, 108°09.205′W, lake (riparian), 25 May (LANO 8♂ 2♀, EPFU 2♀, MYOC 2♂, MYAU 1♀, TABR 1♂, MYYU 1♀), 5 July (MYYU 2♂ 2♀, ANPA 2♀, MYOC 1♂); Lake Roberts, Below Dam, stream (riparian woodland), 5 July (EPFU 1♂ 1♀, MYYU 1♂, MYCA/CI 1♀); Black Canyon Creek, Black Canyon Campground, 33°11.102′N, 108°01.669′W, stream (piñon/juniper and ponderosa pine woodlands) 26 May (LANO 6♂, MYCA/CI 1♀ 1 unk, IDPH 1♀, MYVO 1♀, MYOC 1♂, EPFU 1♂), 28 June (EPFU 2♂ 13♀, LANO 4♂, MYOC 2♂, MYYU 2♂, IDPH 2♀, MYVO 1♀, ANPA 1♀, EUMA audible calls); Big Burro Mountains, Junction Saddle Rock and Black Hawk canyons, T17S, R16W, SE1/4 Sec. 23, 32°46.822′N, 108°30.055′W, steel-rimmed tank (scrubland), 4 June (EPFU 5♂ 14♀, MYTH 11♀, PAHE 2♂ 3♀, MYCA/CI 1♂ 3♀, LANO 3♂, ANPA 3♂, TABR 1♂ 2♀, IDPH audible calls), 23 June (EPFU 4♂ 15♀, MYCA/CI 4♂ 3♀, ANPA 3♂ 3♀, MYTH 4♀, PAHE 2♂ 1♀, MYVO 1♀, TABR 1 unk, MYAU 1♀); 16.8 km E Buckhorn, Gila River, 33°02.651′N, 108°31.761′W (NAD27), river (riparian woodland), 25 June (TABR 5♂ 2♀, MYYU 5♂, MYOC 2♂, PAHE 1♂, LACI 1♂, EUMA audible calls); Big Burro Mountains, Gila Bird Area, Gila River, 32°50.108′N, 108°36.481′W, river (riparian woodland), 27 June (MYYU 7♂ 12♀, PAHE 5♀, TABR 1♂ 1♀, MYOC 2♂, EUMA audible calls).

OTERO COUNTY: Sacramento Mountains, Agua Chiquita Creek, down canyon of Rogers Ruins, 32°42.593′N, 105°40.537′W, mountain stream (mixed coniferous forest), 20 May (LANO 9♂ 2♀, LACI 3♂ 1♀ 1 unk, EPFU 4♂, MYOC 1♂ 1♀, TABR 1♀, MYVO 1♂, EUMA audible calls only), 22 June (LANO 21♂, EPFU 2♂ 8♀, LACI 6♂, MYOC 3♂ 2♀, MYVO 4♀, EUMA audible calls).

RIO ARRIBA COUNTY: Ghost Ranch, Sewage Ponds, 36°19.465′N, 106°28.895′W, cement lined ponds (scrubland), 19 May (LANO 2♂ 1♀, MYYU 1♂ 5♀, MYCA/CI 1♀); Ghost Ranch, Upper Earthen Pond, 36°20.446′N, 106°28.002′W, earthen pond (scrubland), 19 May (no bats captured), 19 June (ANPA 1♂, MYYU 1♂, EUMA sightings and audible calls).

SANDOVAL COUNTY: Jemez Mountains, East Fork Jemez River, 35°49.624′N, 106°35.110′W, small river (mixed coniferous forest), 18 May (LANO 29♂ 1♀, LACI 6♂, MYTH 1♂, EPFU 2♀, MYVO 2♀), 17 June (LANO 24♂ 1 unk, TABR 4♂ 2♀, LACI 4♂, EUMA 2♂ 1 unk, MYEV 2♂, MYVO 1♂, NYMA 1♀), 2 July (LANO 27♂, LACI 2♂, MYVO 1♂ 1♀, EPFU 1♀, MYTH 1♀, MYEV 1♂, MYYU 1♂, EUMA audible calls); Jemez Mountains, East Fork Jemez River, 35°49.648′N, 106°35.330′W, small river (mixed coniferous forest), 18 May (LANO 35♂ 4♀ 6 unk, LACI 9♂ 1 unk, MYTH 3♂ 2♀, EPFU 1♂ 1♀, MYVO 1♀, EUMA 1♂ 1 unk, MYCA/CI 1♂, MYEV 1♂), 17 June (LANO 35♂, LACI 15♂, EPFU 3♂ 3♀, MYVO 1♂ 5♀, TABR 1♂ 3♀, MYCA/CI 3♂, MYTH 2♂, MYEV 1♀); Bandelier National Monument, NM HWY 4, no water (ponderosa pine and piñon/juniper woodlands), 2 July 2006 (no nets, only listened, EUMA audible calls).

SAN JUAN COUNTY: Aztec, Las Animas River, 36°49.535′N, 107°59.700′W, river (riparian, city, agricultural), 15 May (MYYU 2♀), 18 June (no bats captured); Chaco Cultural National Historical Park, Maintenance Area, no water (scrubland), 16 May (no bats captured), 17 July (no nets, only listened).

SIERRA COUNTY: Black Range, Burnt Canyon Flat, 33°26.325′N, 107°53.681′W, earthen pond (meadow in ponderosa pine forest), 2 June (EPFU 9♂ 32♀ 3 unk, LANO 26♂ 2♀, TABR 2♂ 11♀, MYTH 6♂ 1♀, MYEV 2♂ 4♀, LACI 6♂, MYOC 3♂ 1♀ 1 unk, MYVO 1♂ 1♀ 1 unk, ANPA 1♂, MYAU 1♂, MYCA/CI 1♀), 21 June

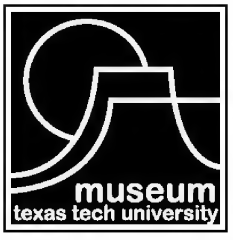
(LANO 29♂, EPFU 7♂ 18♀, MYEV 3♂ 8♀, TABR 1♂ 9♀, LACI 9♂, MYTH 6♂ 1♀, MYVO 4♂ 2♀, MYOC 5♂, MYCA/CI 2♂, IDPH 1♀).

SOCORRO COUNTY: San Mateo Mountains, 5.6 km E (by road) Springtime Canyon Campground near Weir Tank, 33°33.827′N, 107°21.152′W, cement tank (piñon/juniper and oak woodland), 21 May (MYCA/CI 11♂ 7♀ 1 unk, MYAU 5♂ 7♀, MYVO 2♂ 2♀ 2 unk, MYTH 3♂, EPFU 1♂ 1♀, ANPA 1♀, PAHE 1♂, IDPH audible calls), 20 June (MYCA/CI 27♂ 10♀, MYVO 18♂ 8♀ 1 unk, EPFU 14♂ 6♀, MYAU 7♂ 11♀, MYTH 8♂ 4♀, PAHE 10♂, IDPH 3♂ 2♀ 1 unk, ANPA 5♂, MYYU 1♂, EUMA audible calls); 4.6 km S Bingham, near N end of Oscura Mountains, 33°50.795′N, 106°22.412′W, earthen pond (desert grassland/scrubland), 1 June (TABR 2♂ 10♀, MYCA/CI 1♂ 1♀, MYTH 1♂, PAHE 1♀, EUMA sighting and audible calls).

Publications of the Museum of Texas Tech University

Institutional subscriptions to Occasional Papers are available through the Museum of Texas Tech University, attn: NSRL Publications Secretary, Box 43191, Lubbock, TX 79409-3191. Individuals may also purchase separate numbers of the Occasional Papers directly from the Museum of Texas Tech University.

Series Editor: Robert D. Bradley
Production Editor: Lisa Bradley



ISSN 0149-175X

Museum of Texas Tech University, Lubbock, TX 79409-3191