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BATS OF PALO DURO CANYON STATE PARK, TEXAS: COMMUNITY COMPOSITION, ABUNDANCE, AND SEASONAL ACTIVITY

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Abstract.—Basic natural history information is lacking for many bats, especially for bats of the Texas Panhandle. We examined community composition, relative abundance, and seasonal activity of bats in Palo Duro Canyon State Park, Texas, using 3 survey methods (mist net, roost surveys, and acoustic monitoring) between July 2006 and May 2009. Twelve species of bats were captured or observed, with the Brazilian free-tailed bat (*Tadarida brasiliensis*), canyon bat (*Parastrellus hesperus*), and big brown bat (*Eptesicus fuscus*) being the most common. Acoustic calls of 2 additional species, most likely the California myotis (*Myotis californicus*) and big free-tailed bat (*Nyctinomops macrotis*), were also recorded. The Brazilian free-tailed bat was captured year-round, and an evening bat (*Nycticeius humeralis*), uncommon in the area, was captured. This study increases our understanding of the occurrence, abundance, and seasonality of bats in the Texas Panhandle.

Resumen.—Hace falta información básica sobre la historia natural de muchos murciélagos, especialmente en la región saliente del norte de Texas. Examinamos la composición de la comunidad, la abundancia relativa y la actividad estacional de los murciélagos en el parque estatal Palo Duro Canyon, Texas, utilizando tres métodos de estudio (red de niebla, revisión de nidos de murciélagos y monitoreo acústico), entre julio de 2006 y mayo de 2009. Se capturaron u observaron doce especies de murciélagos, entre las cuales las más comunes fueron el murciélago cola de ratón (*Tadarida brasiliensis*), el murciélago de cañón (*Parastrellus hesperus*) y el murciélago grande marrón (*Eptesicus fuscus*). Además se registraron llamadas acústicas de dos especies adicionales, probablemente el miotis californiano (*Myotis californicus*) y el murciélago cola de ratón grande (*Nyctinomops macrotis*). El murciélago cola de ratón fue capturado durante todo el año y se capturó a un murciélago nocturno (*Nycticeius humeralis*), que no es común en esa área. A través del presente estudio podremos comprender mejor la incidencia, abundancia y estacionalidad de los murciélagos en la región saliente del norte de Texas.

There are still major gaps in the information known about many bat species. Even basic information relating to the conservation requirements of many bats is lacking, with current distribution and abundance being a major void (O'Shea et al. 2003, Racey and Entwistle 2003). Few studies have described the bat community in the panhandle region of Texas, and none have been full-year, multiyear monitoring studies (e.g., Blair 1954, Milstead and Tinkle 1959). Historically, most bat studies have taken place during only warmer months of the year. However, studies in the southwestern United States in colder months have shown that many species are active in winter (e.g., O'Farrell and Bradley 1970, Geluso 2008). Our study establishes a baseline of the local bat community in the Texas Panhandle by recording community composition, relative abundance, and seasonal activity.

Study Area

Much of the Texas Panhandle is covered by a broad flat plateau known as the Llano Estacado. The Llano Estacado has a dearth of natural roost sites because it has few trees or geologic formations. However, the Llano Estacado is bordered on the east by a steep rugged escarpment that runs for >300 km in a north–south orientation and contains numerous resources for bats, including caves, overhangs, crevices, and riparian areas (Milstead and Tinkle 1959, Lotspeich and Everhart 1962). Palo Duro Canyon State Park (8094 ha) is located near the center of the Texas Panhandle, on the eastern edge of the Llano Estacado. This canyon is approximately 100 km long with walls that are 183–244 m high (Hood and Underwood 1979). Temperatures on the Llano Estacado average 27 °C in July and 4.5 °C in January (Wendorf 1961). Vegetation within the canyon is dominated by mesquite-juniper associations (*Prosopis glandulosa–Juniperus* spp.), grasses (*Bouteloua* spp.), and cacti (*Opuntia* spp.), with a riparian zone of cottonwood (*Populus deltoides*) and salt cedar (*Tamarix ramosissima*). The Prairie Dog Town Fork of the Red River flows through the canyon with a floodplain up

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TABLE 1. Acoustic designations used to determine species of bat calls recorded in Palo Duro Canyon State Park, Texas, between 9 June 2008 and 7 May 2009.

Bat species or species group	F_{min}[a] (kHz)	Other distinguishing features
Nyctinomops macrotis	<20	
Antrozous pallidus	20–34	Calls near vertical, harmonics not present
Corynorhinus townsendii	20–34	Calls near vertical, harmonic present around 50 kHz
25k group: *Eptesicus fuscus*, *Tadarida brasiliensis*, *Lasionycteris noctivagans*	20–34	Calls with knee, F_{min} constant
Lasiurus cinereus	20–34	Calls with knee, F_{min} variable
Lasiurus borealis	35–45	F_{min} variable
Nycticeius humeralis	35–38	
40k *Myotis*: *Myotis ciliolabrum*, *Myotis velifer*	38–45	Calls near vertical
40k non-*Myotis*: *Parastrellus hesperus*, *Perimyotis subflavus*	38–45	Calls with knee
Myotis californicus	>45	

[a]F_{min} is minimum call frequency.

to 32 km wide in some places. The canyon's sloping walls are composed primarily of sandstone, shale, and limestone and have many piping caves, which are subsurface drainage tubes (Parker 1964, Hood and Underwood 1979).

METHODS

Thorough inventories of species assemblages require multiple survey methods (O'Farrell and Gannon 1999, Flaquer et al. 2007, MacSwiney et al. 2008). Therefore, our study included mist netting, roost surveys, and acoustic monitoring.

We conducted mist net surveys on 13 nights between 15 July and 21 October 2006, and on 113 nights between 5 April 2007 and 7 May 2009. An average of 2.92 nets were opened each night for a total of 368 net nights (number of nets open each night multiplied by number of nights). Nets were opened at dusk and kept open an average of 3 h. Early in the study, sessions in which nets were left open for longer periods showed that activity was generally greatly reduced after 3 h post-dusk. Mist netting primarily occurred over the river, but also occurred over flooded sections of roads, over a cattle tank, and over a low ridge on a mesa. For each bat captured, we recorded species, sex, age, reproductive condition, and morphological measurements (Barbour and Davis 1969, Racey 1988). Captured bats were temporarily marked using a nontoxic ink marker to identify recaptures made in the same night.

Between 19 October 2006 and 6 March 2009, we conducted 12 roost surveys of 9 small caves and one manmade tunnel. We entered roosts during the day and visually searched for bats with the aid of headlamps. The species of bats observed were recorded. Three individuals were captured from roosts to obtain morphological measurements for species identification. Capture and handling of all animals was approved by an animal care and use committee and conformed to guidelines approved by the American Society of Mammalogists (Gannon et al. 2007).

We performed acoustic monitoring (AnaBat II detector with CF storage ZCAIM, AnaBat SD1 detectors, Titley Electronics NSW, Australia) using 6 bat detectors on 48 nights (288 detector nights) between 9 June 2008 and 7 May 2009. Thirty-six locations on the canyon floor were each monitored for 2 consecutive nights each season from 30 min prior to sunset until 30 min after sunrise. We viewed recorded calls with AnalookW (Chris Corben, www.hoarybat.com) and visually classified them as one of 7 species or 3 species groups (Table 1). Call characteristics were pulled from numerous resources (Fenton and Bell 1981, Thomas et al. 1987, Corben and O'Farrell 2010, Division of Mammals 2010). Detections of <2 call pulses were discarded.

We provide simple descriptive numbers and percentages to characterize the sampling effort and results by monitoring method, year, season, and species. Sex ratios of captured bats are also given.

RESULTS

Community Composition

From 15 July 2006 to 7 May 2009, we accumulated 1329 captures of 12 species; made

TABLE 2. Relative abundance of species by mist net captures, acoustic monitoring, and roost surveys in Palo Duro Canyon State Park, Randall County, Texas, between 15 July 2006 and 7 May 2009. Percentages of totals are given in parentheses. Asterisk indicates that the number of calls represents multiple species in an acoustic group.

	Number of captures					Acoustic monitoring	Roost surveys
Species	2006	2007	2008	2009	Total	Calls	Observations
A. pallidus	12 (5%)	14 (2%)	9 (2%)	1 (1%)	36 (3%)	1064 (3%)	—
C. townsendii	1 (<1%)	1 (<1%)	1 (<1%)	—	3 (<1%)	48 (<1%)	65 (64%)
E. fuscus	73 (29%)	136 (24%)	85 (20%)	8 (12%)	302 (23%)	22,786*	21 (21%)
L. noctivagans	—	11 (2%)	21 (5%)	12 (18%)	44 (3%)	22,786*	—
L. borealis	1 (<1%)	7 (1%)	5 (1%)	3 (4%)	16 (1%)	217 (1%)	—
L. cinereus	—	14 (2%)	17 (4%)	3 (4%)	34 (3%)	357 (1%)	—
M. californicus	—	—	—	—	—	26 (<1%)	—
M. ciliolabrum	1 (<1%)	1 (<1%)	2 (<1%)	—	4 (<1%)	1589* (5%)	13 (13%)
M. velifer	1 (<1%)	1 (<1%)	—	—	2 (<1%)	1589*	—
N. humeralis	1 (<1%)	—	—	—	1 (<1%)	14 (<1%)	—
N. macrotis	—	—	—	—	—	4 (<1%)	—
P. hesperus	123 (48%)	114 (20%)	99 (23%)	15 (22%)	351 (26%)	5722* (18%)	—
P. subflavus	4 (2%)	2 (<1%)	6 (1%)	—	12 (1%)	5722*	3 (3%)
T. brasiliensis	38 (15%)	267 (47%)	194 (44%)	25 (37%)	524 (39%)	22,786* (72%)	—
TOTAL	255	568	439	67	1329	31,827	102

102 observations of roosting bats of 4 species; and recorded 40,692 files containing bat calls, 31,827 of which were identified as calls of 7 species and 3 species groups (Table 2). Altogether, 14 species of bats were documented in our study area. Calls with minimum frequencies above 45 kHz and below 20 kHz were recorded and determined to most likely belong to the California myotis (*Myotis californicus*) and big free-tailed bat (*Nyctinomops macrotis*). However, these species were not documented by other methods during our study. One capture of an evening bat (*Nycticeius humeralis*) occurred (voucher photograph submitted to the Museum of Texas Tech University, number pending). The evening bat is uncommonly encountered in the panhandle region (Ammerman et al. 2012). The sex ratio of captured species ranged from all male to all female (Table 3).

Relative Abundance

Taken together, 3 species—Brazilian free-tailed bat (*Tadarida brasiliensis*), canyon bat (*Parastrellus hesperus*), and big brown bat (*Eptesicus fuscus*)—made up 88% of all captures (Table 2). Silver-haired (*Lasionycteris noctivagans*), pallid (*Antrozous pallidus*), and hoary bats (*Lasiurus cinereus*) each made up 3% of total captures, and the remaining species each made up ≤1% of total captures (Table 2). The acoustic group composed of the Brazilian free-tailed, big brown, and silver-haired bats was the most commonly recorded group, with 72% of calls (Table 2). The canyon bat and tricolored bat (*Perimyotis subflavus*) acoustic group made up 18% of recorded calls, the western small-footed myotis (*Myotis ciliolabrum*) and cave myotis (*Myotis velifer*) acoustic group accounted for 5% of calls, and pallid bats composed 3% of calls. All other species accounted for ≤1% of calls (Table 2). The Townsend's big-eared bat (*Corynorhinus townsendii*) was the most commonly observed roosting species, with 64% of observations (Table 2). Big brown bats made up 21% of roosting observations, western small-footed myotis 13%, and tricolored bats 3%.

Seasonal Activity

Sampling effort was not even throughout the year; however, sampling did continue year-round (Table 4). Bats were captured and recorded during every month of the year (Tables 5, 6).

The Brazilian free-tailed bat was captured in the study area in every month except for June, with the greatest numbers of captures occurring between April and September. Only males were captured during portions of the year (Table 3).

Canyon, big brown, and pallid bats were captured most commonly in June, July, and August. Canyon and big brown bats were captured in near equal ratios of males to females, with a greater number of males captured during the winter (Table 3). Captures of pallid bats were male biased (Table 3). Male pallid bat were captured over 8 months, whereas

TABLE 3. Monthly and overall sex ratios (males : females) of bats captured in Palo Duro Canyon State Park between 15 July 2006 and 7 May 2009, Randall County, Texas.

Species	n	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Overall
A. pallidus	35	0:1	1:0	—	2:1	5:0	3:0	5:5	7:3	—	1:0	1:0	—	2.5:1.0
C. townsendii	3	—	—	1:0	—	—	0:1	1:0	—	—	—	—	—	2.0:1.0
E. fuscus	296	4:5	5:1	3:0	9:9	13:27	2:4	60:78	24:30	8:8	1:2	3:0	—	1.0:1.2
L. borealis	15	—	—	1:0	3:0	—	—	1:0	2:2	2:1	0:1	1:0	—	2.8:1.0
L. cinereus	31	—	—	—	0:4	4:7	—	—	3:3	4:3	2:1	—	—	1.0:1.4
L. noctivagans	44	7:4	1:1	—	5:2	4:1	—	—	—	—	3:2	11:3	—	2.4:1.0
M. ciliolabrum	4	—	—	—	—	0:1	0:2	0:1	—	—	—	—	—	0.0:4.0
M. velifer	2	—	—	—	—	—	—	1:0	1:0	—	—	—	—	2.0:0.0
N. humeralis	1	—	—	—	—	—	—	1:0	—	—	—	—	—	1.0:0.0
P. hesperus	342	6:4	10:0	0:3	5:1	9:6	5:16	56:84	54:36	8:12	0:3	11:11	2:2	1.0:1.1
P. subflavus	12	—	—	—	—	—	—	2:0	—	5:4	—	0:1	—	1.4:1.0
T. brasiliensis	523	24:4	14:7	10:0	22:23	55:29	—	16:30	107:91	36:23	13:9	6:2	3:0	1.4:1.0

TABLE 4. Distribution of sampling effort by month including 126 nights (368 total net nights) of mist netting, 12 roost surveys (each consisting of surveying 7–9 separate locations within the park), and 48 nights (288 total detector nights) of acoustic monitoring in Palo Duro Canyon State Park, Randall County, Texas, from 15 July 2006 to 7 May 2009. Numbers of net nights and detector nights per month are in parentheses.

	Mist netting				Roost surveys				Acoustic	
Month	2006	2007	2008	2009	2006	2007	2008	2009	2008	2009
January	—	—	4 (12)	5 (15)	—	—	1	—	—	6 (36)
February	—	—	5 (15)	3 (9)	—	1	—	—	—	2 (12)
March	—	—	3 (9)	2 (6)	—	—	—	1	—	4 (24)
April	—	2 (4)	5 (15)	4 (13)	—	1	1	—	—	5 (30)
May	—	4 (12)	5 (14)	1 (3)	—	—	—	—	—	3 (18)
June	—	6 (13)	3 (9)	—	—	—	—	—	4 (24)	—
July	7 (24)	10 (29)	4 (11)	—	—	1	—	—	3 (18)	—
August	2 (6)	12 (34)	3 (9)	—	—	—	1	—	5 (30)	—
September	2 (6)	7 (20)	5 (15)	—	—	—	—	—	2 (12)	—
October	2 (5)	6 (18)	3 (9)	—	1	—	—	—	5 (30)	—
November	—	5 (15)	3 (9)	—	1	1	1	—	5 (30)	—
December	—	1 (3)	2 (6)	—	1	—	—	—	4 (24)	—

TABLE 5. Average number of individuals captured per night of mist netting effort by month in Palo Duro Canyon State Park, Randall County, Texas, between 15 July 2006 and 7 May 2009. Shading indicates the monthly average of captures per night.

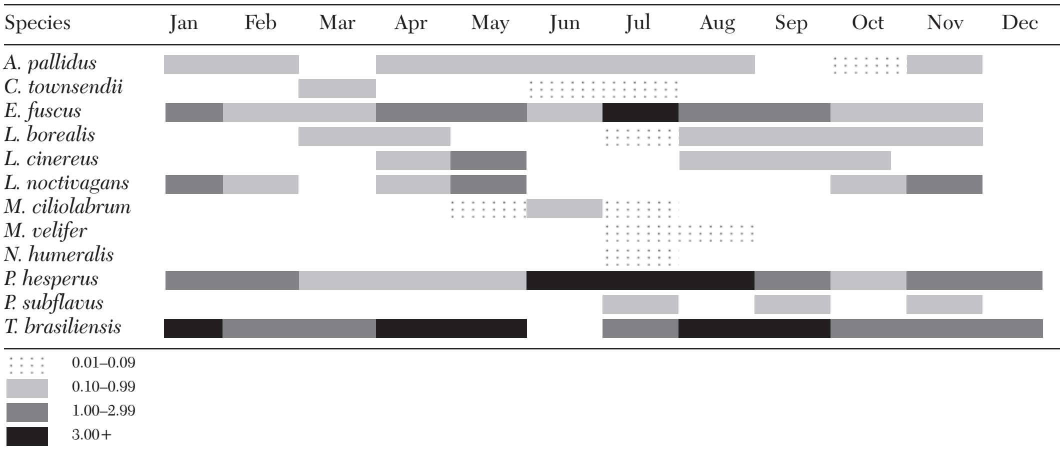
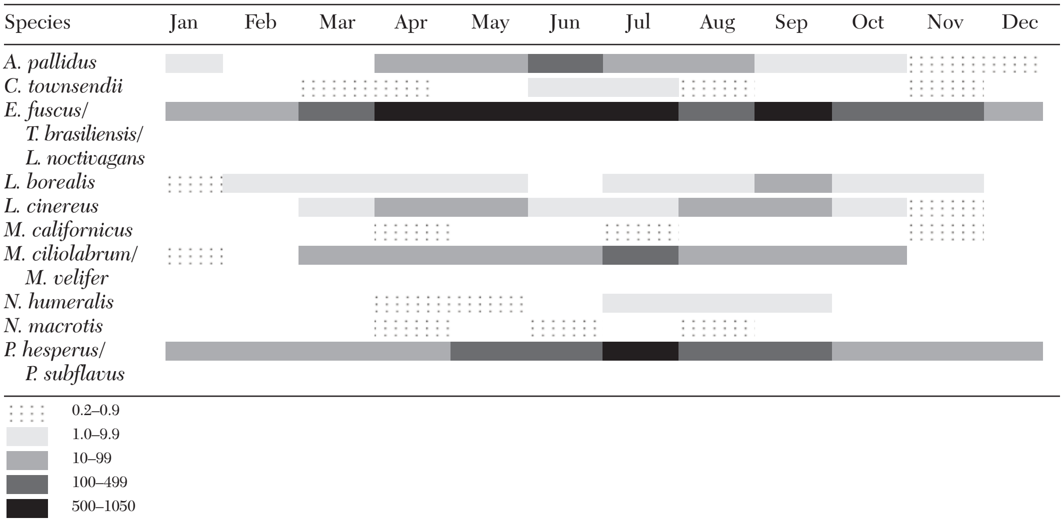


TABLE 6. Average number of calls recorded in each acoustic group per night of acoustic monitoring per month in Palo Duro Canyon State Park, Randall County, Texas, between 9 June 2008 and 7 May 2009.



females were captured during only 4 months (Table 3).

Townsend's big-eared bats were observed roosting in at least one cave during each of the 12 roost surveys and were captured in an additional month. Townsend's big-eared bats were documented in all months except May and September (Tables 5, 7). Numbers observed during roost surveys were slightly higher in the colder months.

Silver-haired bats were captured during 6 months of the year. Captured males were more than twice as common as females (Table 3).

Hoary bats were captured during the spring and fall (Table 5). Acoustic monitoring showed this species to be active outside of the months when captures occurred (Tables 5, 6).

Eastern red bats (*Lasiurus borealis*) were captured in both the spring and fall (Table 5). Aside from a single call recorded on 8 January, acoustic monitoring records expand the period of occurrence known from capture by only a few days (Table 6).

Tri-colored bats were captured or observed in the study area during 5 months of the year, but 9 out of 12 captures occurred in September

TABLE 7. Average number of individuals observed during roost surveys per month in Palo Duro Canyon State Park, Randall County, Texas, between October 2006 and March 2009.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C. townsendii	6.0–10.0	6.0–10.0	6.0–10.0	2.0–5.0			2.0–5.0	2.0–5.0		2.0–5.0	6.0–10.0	2.0–5.0
E. fuscus	0.5–1.0	2.0–5.0	2.0–5.0				0.5–1.0	2.0–5.0		2.0–5.0	2.0–5.0	2.0–5.0
M. ciliolabrum				0.5–1.0			2.0–5.0			2.0–5.0		
P. subflavus				0.5–1.0						0.5–1.0		

0.5–1.0
2.0–5.0
6.0–10.0

(Tables 5, 7). The western small-footed myotis was captured or observed roosting during 5 months of the year, whereas its acoustic group was recorded almost year-round (Tables 5, 6, 7). The remaining species—cave myotis, evening bat, California myotis, and big free-tailed bat—were detected sporadically over the warmer portion of the year (Tables 5, 6).

DISCUSSION

Community Composition

Of the species documented during this study, 3 species merit some note. The California myotis has been previously represented in the area by a single specimen (Choate and Killebrew 1991). Choate and Killebrew (1991) suggested that this species might occur sparingly in Palo Duro Canyon and other areas along the edge of the Llano Estacado. The fact that 50-kHz bat calls were recorded 26 times in 9 nights over the course of a year supports the idea of this species' occasional occurrence in the area.

Although the evening bat is generally considered to be a bat found in the southeastern half of Texas, this species has been submitted to the Texas Department of State Health Services in Bailey County, only 2 counties distant from the study area (Ammerman et al. 2012). Evening bats prefer to roost in trees, which are relatively scarce throughout much of the panhandle (Boyles and Robbins 2006). However, portions of the escarpment contain well-developed riparian areas that would provide the necessary roosts.

The big free-tailed bat is primarily a Trans-Pecos bat, but it has been recorded at scattered locations across Texas and has been found as far north as British Columbia (Cowan 1945, Ammerman et al. 2012). The 4 calls attributed to this species during our study support the idea of big free-tailed bats irregularly straying through the Texas Panhandle, but the species is likely not a resident here.

More males than females of most species were captured during the winter months (Table 3). However, the data should be interpreted carefully because observed differences might result from differences between the sexes in seasonal activity, differences in abundance, or differential capture success in nets because of behavior or physiology (Cockrum and Cross 1964, O'Farrell and Bradley 1970).

Relative Abundance

Based primarily on mist net captures, only 3 species in this study could truly be called common: Brazilian free-tailed bat, canyon bat, and big brown bat. Moderately abundant species were the silver-haired bat, pallid bat, hoary bat, eastern red bat, tri-colored bat, western small-footed myotis, and Townsend's big-eared bat. Uncommon species include the cave myotis, evening bat, and most likely the California myotis and big free-tailed bat.

The canyon bat was more common than previously reported, as Milstead and Tinkle (1959) stated that this species was infrequently present in northwestern Texas. However, Choate (1997) attributed the few records in this area to lack of sampling effort rather than true scarcity. Palo Duro Canyon, with all of its cracks and crevices, is an excellent roosting site for the canyon bat (Cross 1965). Where this species occurs, it is often quite abundant (Bailey 1905).

The pallid bat was less commonly captured than expected, as the area includes the species' preferred life zones and an abundance of roosts within the canyon (Orr 1954). However, the panhandle is near the eastern edge of the pallid bat's range, which might explain its lower numbers. Also, though pallid bats use echolocation for orientation, they often hunt using sounds made by their prey instead of relying on active echolocation (Fuzessery et al. 1993). This behavior decreases the likelihood of acoustical detection of this species.

The Townsend's big-eared bat was the most commonly observed roosting bat while being rarely documented by other methods. Townsend's big-eared bat is both an agile and cautious flyer that is capable of avoiding mist nets. It also produces low intensity calls, making both capture and acoustic detection difficult (Dalquest 1947, O'Farrell and Gannon 1999). Many species in the study area are primarily crevice- or tree-roosting species and therefore would not be observed using the methods of our roost surveys.

It is difficult to determine the relative abundance of Townsend's big-eared bat because it was detected primarily during roost surveys in this study. The caves in the park are carved out of dirt and soft rock. Heavy rains often cause structural collapses, resulting in a change in the number and location of caves this species might use as roosting sites. It is possible this species is more common than now thought if it is roosting in caves unknown to us. It is also possible that Townsend's big-eared bat may become more or less common in the future as available roosting sites change or as park visitors discover and disturb roosting sites.

The acoustic group consisting of the western small-footed myotis and the cave myotis was the third most commonly recorded group, even though these species were not commonly documented with other survey methods. The western small-footed myotis can be difficult to capture in mist nets, so it is possible that this species is truly underrepresented in our other survey methods (Choate 1997). Another possibility is that the very common canyon bat's call pulses may lose much of their constant frequency portion and be reduced to a steep frequency modulated line in certain situations, such as seen with other species in cluttered habitat (e.g., Wund 2006) or during insect capture attempts (e.g., Jones and Rydell 2003). This change would artificially inflate the number of calls attributed to the western small-footed myotis/cave myotis call group.

Seasonal Activity

The Brazilian free-tailed bat is known to be migratory throughout most of its range, but it is also known to be present and active year-round in some parts of southern Texas and New Mexico (Bailey 1905, Christensen 1947, Barbour and Davis 1969, Geluso 2008). This species is present year-round in the study area but has much higher levels of activity in the warmer months. It is possible that some individuals are seasonal migrants and some are year-round residents. The fact that females are not captured during portions of the winter and summer may indicate that they may be leaving the area during unfavorable temperatures to give birth to their young elsewhere in more favorable maternity roosts (e.g., Scales and Wilkins 2007).

Canyon, big brown, and pallid bats were documented most commonly in the warmer months, probably because of the increased bat activity due to warm temperatures and the young-of-the-year becoming volant during this time.

The timing of silver-haired bat occurrence in this area agrees with previous studies (Izor 1979, Cryan 2003). Records of this species in the eastern United States indicate that males may remain at the wintering grounds longer than females (Cryan 2003). This pattern probably does not occur here, as both sexes were captured for the last time on the same day (4 May) in the spring of 2008, and males were captured only 13 days later (7 May vs. 24 April) than females in the spring of 2009.

It is possible that spring migration of female hoary bats occurs before males in our area as has been reported in New Mexico (Findley and Jones 1964). However, both sexes were captured migrating in the spring of only 1 of 3 years, so further effort is needed to confirm this pattern.

Eastern red bats may use different fall and spring migration routes (Johnson et al. 2003). As only males were captured in our study area in the spring, it is feasible that females take an alternate route during this season. However, our captures of red bats were low, so it is also possible that females do travel through in the spring but have yet to be documented.

Tri-colored bats are most commonly captured in the fall. It is possible that these bats are expanding their range westward by following wooded riparian areas (Geluso et al. 2005). If so, this species will become more common in the study area over time, and additional monitoring may document this species in additional months.

The western small-footed myotis was only physically observed in the canyon between April and October. However, its acoustic group was recorded almost year-round. It has been speculated that this species may sporadically hibernate in the area (Choate 1997). It is possible that additional winter monitoring would lead to winter observations of this species.

The cave myotis was once considered the most common winter bat in northwestern Texas; however, our only captures of this species occurred in July and August (Milstead and Tinkle 1959).

The remaining 3 uncommon species—evening bat, California myotis, and big free-tailed bat—are most likely to show up during summer movements between roosts or as juveniles disperse in the fall.

Information collected from our study represents the longest year-round study of bats in the Texas Panhandle. Studies of this nature are more valuable now than ever as bats face unprecedented conservation challenges ranging from white-nose syndrome to the physical alteration of the landscape by wind turbines across the nation, especially in our area. White-nose syndrome has been recorded just one state over, in Oklahoma (Puechmaille et al. 2011). The movement toward green energy has resulted in an ever-growing number of wind turbines throughout the country (Ackermann and Soder 2002). The panhandle contains Texas's greatest area of high-quality winds (Texas Comptroller of Public Accounts 2008). The lack of knowledge about the effects of wind farms on both local and migrant bat populations and the lack of baseline data for bat populations make risk assessments difficult (Reynolds 2006, Kunz et al. 2007).

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