Summer Acoustic Monitoring of Bats at the Cibolo Preserve

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Abstract

Acoustic bat monitors were placed near stream, in prairie, in oak savannahs, and along edge sites in the Cibolo Preserve from May to August, 2017. During the 16 week sampling period, 185 gigabytes of acoustic calls were recorded representing 156,021 calls. A total of seven bat species were identified and each species was detected in each of the four habitats. Mexican free-tailed bats making up the majority of the activity. Bat activity was not different ($P > 0.05$) among habitat types. Bat activity was significantly different ($P = 0.004$) in May compared to the other months. There was moderate correlation ($R^2 = 0.59$) between temperature and bat activity.

Key words: chiroptera, echolocation, habitat use, seasonal activity

Introduction

The Cibolo Preserve is protected land used specifically for scientific research and is located 4 km (2.5 miles) southeast of Boerne and 40 km north of San Antonio in Central Texas. While multiple research projects have occurred in Cibolo Preserve, no projects have studied bats. Bats have a role as a bioindicator organisms, as they are sensitive to stressors that affect other organisms, making ongoing monitoring of them useful (Jones et al. 2009). *Tadarida brasiliensis* are estimated to provide a $741,000 value in pest control services to cotton farmers in south-central Texas annually (Cleveland et al. 2006).

White-Nose Syndrome is a fungal infection caused by *Pseudogymnoascus destructans* that is fatal to bats. White-nose Syndrome was recently detected in north Texas in 2017 and is predicted to spread into south Texas (Texas Parks and Wildlife, 2017a). Studies are being conducted to collect pre-White-nose Syndrome baseline data on bats in north Texas (Vigh 2016), but little data exists for bats in the San Antonio area.

Other threats facing bats include pesticides, climate change, and collisions with wind turbines (Clark et al. 1996, Clark 2001, Scheel et al. 2002). Moreover, Kendall county is the second fastest-growing county in Texas as of 2015 (US Census Bureau, 2017). With that growth comes increased urbanization and habitat loss in the areas surrounding the preserve. For these reasons, it is important to document the species of bats and the habitat they use at Cibolo Preserve to provide baseline population estimation data and suggest further studies.

The Cibolo Preserve comprises of over 202 ha (500 ac) that includes 2.4

km (1.5 mi) of the Upper Cibolo Creek. An agreement between the preserve and the City of Boerne supplies 1,522,000 L (410,000 gal) of treated waste-water to the creek daily from two up-stream wastewater treatment facilities (D. Taylor, personal communication, January 26, 2017). Habitats at Cibolo Preserve include the aforementioned stream, prairie, and oak savannah.

Bats are elusive and difficult to study due to their nocturnal habits. Popular methods used to survey bats include mist-netting, roost emergence counts, and acoustic monitoring (Kunz, Betze, Hristov, and Vonhof, 2009; Kunz and Brock, 1975). Each of these methods have their strengths and weaknesses and are used based on the objectives of a study.

Mist-netting is more accurate than acoustic monitoring for correct identification, but may be biased as some bats are more likely to be caught than others (Carroll, Carter, and Feldhamer, 2002). This may result in a false negative, where a bat is present at a site but is not captured. Moreover, mist-netting is more labor-intensive than acoustic monitoring, as it requires teams to set up nets and monitor them for hours every night (Kunz and Brock, 1975).

In contrast, acoustic monitoring is less accurate for identification, and can result in a false positive (Miller et al., 2011). A false positive occurs when a species is detected as being present at a site when it is not. This is especially true when auto-identification classifiers are used as the only method of call identification (Russo and Voigt, 2016). When tested with known species calls, no software can accurately identify 100% of calls (Tyburec, 2013). Although technology has improved since the conception of bioacoustics, there are still gaps in knowledge and accuracy. Acoustic calls can be difficult to differentiate, and automatic identification systems are limited in their accuracy (Barclay, 1999; Frick, 2013).

Roost emergence counts are another accurate way to survey bat densities per roost site without disturbing bats, but species cannot usually be identified. Emergence counts are useful if the roost is in a hazardous or difficult-to-reach location (Kunz et al., 2009). However, this method can only be implemented if there are known roosts in the study area (Kunz, 2003). Moreover, counts can require large number of observers when there are upwards of 1,000 bats, and observers may double-count bats that emerge and re-enter the roost (Kunz et al., 2009). Automated counting systems exist but are often expensive or difficult to implement (Kunz, 2003).

Texas has a very diverse selection of bats, including 33 species in 4 different families (Ammerman, Hice, and Schmidly, 2012). Ten to thirteen species are known to inhabit or intermittently inhabit the vicinity of Cibolo Preserve (Table 2). All species from the San Antonio area are insectivores and typically utilize abandoned mines, caves, man-made structures, or foliage as roost sites (Ammerman et al., 2012). The most numerous species found in the San Antonio is the Mexican free-tailed bat (*Tadarida brasiliensis*). While this bat is considered common and not listed under the US Endangered Species act, the species is frequently studied due to their large colonies, high-speed flying, and economic value (McCracken, 2003; Mccracken et al., 2016). Many of these bats roost during the summer months at Bracken Cave, a protected maternity colony of an estimated twenty million *T. brasiliensis*, that is located 56 km (35 miles) from the Cibolo Preserve (Davis, Herreid II, and Short, 1962). Many smaller roosts can be found throughout San Antonio and Texas, often in manmade structures such as concrete bridge expansion joints (Keeley and Tuttle, 1999).

The objective of this study was to document the species of bats present at Cibolo Preserve and identify their frequency of occupation and preference of habitat with acoustic detectors.

Materials and Methods

Study Area

The study occurred at Cibolo Preserve (29°46’33.5” N, 98°41’53.1”). The Preserve is located 4 km (2.5 miles) southeast of Boerne and 43 km (27 miles) north of San Antonio, Texas. Habitat types that occur in Cibolo Preserve include prairie, stream, and oak savannah. Cibolo Creek is a perennial stream that runs through the center of the preserve. The Preserve is closed to the general public and only approved researchers are allowed on the property. Disturbance in the Preserve is limited to mowing management in prairie areas.

Monitoring Bat and Habitat Use.

Acoustic bat detectors, (model number SM3BAT, Wildlife Acoustics, Inc., Maynard, MA) were mounted on aluminum poles at 6 m (20 ft) above ground level and stabilized with guy lines to decrease call distortion from echoes.

Sampling occurred from May 2 to August 22 of 2017. Two acoustic detectors were placed in two different habitats (stream, prairie, edge, or oak savannah) for 14 days, and all four habitats were sampled four times in the summer of 2017. Sampling two habitats simultaneously allowed for results to be compared despite weather influencing results. Sites within each habitat were selected by likelihood of receiving high bat activity. Detectors were oriented away from clutter to increase probability of detection and prevent call distortion. Open areas along the creek with slow current were surveyed since bats have been found to use similar areas for drinking and foraging (Ober and Hayes, 2008; Scott, McLaren, Jones, and Harris, 2010). Edges where prairie and oak savannahs meet were surveyed, as bat species often utilize edges for travelling between roost and foraging sites (Morris, Miller, and Kalcounis-Rueppell, 2010).

Several factors were taken into consideration during site selection. First, stationary detector microphones were pointed horizontally into open areas, such as clearings, openings, or fields to prevent the microphone from being damaged by water while also recording maximum bat activity (Loeb et al., 2015). Second, microphones were directed in such a way so as to maximize call quality and avoid clutter. Surveys began 20 minutes before sunset and concluded 20 minutes after sunrise. Weather measurements including temperature, wind speed, and precipitation were collected from the detector itself and Cibolo Nature Center weather stations located on or near the study site.

Detector Settings

Detectors were set to record in WAV format and settings were based on expert recommendations and previous research experience (Britzke, Gillam, and Murray, 2013; S. Weaver, personal communication, February 22, 2017).. The frequency was limited 16 kHz and 256 kHz. The call duration was limited between 2 ms and 600 ms. The trigger volume level was set to 18 dB. The trigger window was set to 1 second. The trigger maximum was set to 5 seconds.

Data Analysis

Data from each detector was downloaded from the SD card onto a computer every seven days. Files were batched and automatic ID's were appended to file names through Sonobat Batch Attributor, version 6.5 (southeastern region, Texas and Hat Suite, version 4.1.5). Non-bat files were scrubbed, using a medium scrub level.

All results were referenced with monitor logs for errors with the monitor that may have resulted in down time. Bats were identified to species to determine the species richness at Cibolo Preserve. The number of species and relative abundance detected within each habitat were compared with a one-way ANOVA with an alpha value of 0.05. If differences were detected with the ANOVA, means were separated with the Tukey's means separation tests with an alpha value of 0.05. Linear regression was used to compare composite bat calls in each habitat to mean nightly temperature. Relative abundance is defined as the evenness of distribution of individuals among species in a community (Groves, 2017). In this case, number of calls was used to identify relative abundance of species.

Results

Both acoustic monitors ran for every night over the course of sixteen weeks, for a total of thirty-two recording nights. A total of 156,021 bat detections were recorded. An average of 9,751 detections were recorded each week. For a one-week period, the most detections recorded was 19,398 over stream habitat in May. The fewest detections in a one-week period was 695 for prairie habitat in June. General trends for bat activity by habitat over the study period exhibited higher activity in the early summer and decreased activity in the late summer. Overall, fewer detections were documented in prairie habitat (Table 2). When all bat species and habitats were combined, bat detections was 3-4 times greater from May to mid- June and then decline (Figure 1).

Seven of the 13 bat species known from the Central Texas are were recorded on the property during the study period (Table 3). Theseinclude Mexican free-tailed bats (*Tadarida brasiliensis*), Eastern red bats (*Lasiurus borealis*), Northern yellow bats (*Lasiurus intermedius*), evening bats (*Nycticeius humeralis*), hoary bats (*Lasiurus cinereus*), tri-colored bats (*Perimyotis subflavus*), and cave myotis (*Myotis velifer*). The majority of the activity was from Mexican Free-tailed bats, which comprised 73% of the calls identified with Sonobat (Figure 2). The second most active species were the tri-colored bats, comprising 10% of activity on the preserve.

There were a total of 31,072 bat detections in edge habitat, 24,135 bat detections in prairie habitat, 30,268 detections in oak savannah habitat, and 70,546 detections in stream habitat. Despite stream habitat having the largest number of bat detections, bats used no habitat significantly more than any other (Figure 3, $P>0.05$).

The mean number of recorded bats calls was significantly greater ($P < 0.05$) for May than July and August based on Tukey's mean comparison test

(Figure 2). In May there were an average of 9,117 calls per week (SD=1,547). The mean number of calls decrease to under 4000 for June ($\bar{\chi}$ = 3,560; SD = 1,979), July ($\bar{\chi}$ = 3,067; SD = 557) and August ($\bar{\chi}$ = 1,937; SD = 227).

There was a moderate relationship (R^2 = 0.58, P = 0.03) between bat activity and mean temperature (Figure 5). Bat activity was highest at temperatures between 20 to 24 °C, and lowest at temperatures > 26 °C.. No relationship was recorded with regression (R^2 = - 1.21, P = 0.71) for bat activity and rainfall (data not shown). However, the relationship was skewed by two rainfall events in which precipitation was > 5.0 cm/week.

Average hourly activity changed between early (May and June) and late (July and August) summer. In early summer, bat activity was continuous from 2100 to 0400 hours. . As the summer progressed, bat activity exhibited a bimodal pattern with peaks at 2100 and 0400 hours and minimal activity in between these periods (Figure 6).

Discussion

This study found that the only weather variable affecting bat activity was temperature, which was negatively correlated with bat activity. This is consistent with Brooks' finding that bat activity decreased beyond 21°C (2008). However, the correlation may be a result of other factors that affect bats. There was also a significant relationship between month and bat activity, but it is possible that this is correlated with the activity of Mexican free-tailed bats which can travel > 56 km in one night (Best and Geluso, 2003). It has been suggested that the fluctuations of the activity levels reflected in this data correlate with observed activity patterns of the maternity colony at Bracken Cave (F. Hutchins, personal communication, October 25, 2017). Considering that almost 75% of the activity documented in the Preserve was Mexican free-tailed bats, it is likely that this species was moving from Bracken Cave to Cibolo Preserve to forage. A similar trend exists in a study from Waco, where the activity level in known roosts dipped between mid-June and mid-July, though the bats were not tracked (Scales and Wilkins, 2007). No concrete research on the observation exists, making it difficult to confirm.

The findings of this study also confirm previous findings that bats heavily utilize slow-moving stream, riparian, and edge habitat for foraging and travelling, and avoid open areas (Wolcott and Vulinec, 2012; Morris, Miller, and Kalcounis-Rueppell, 2010). This may be due to the fact that bats often emerge at dusk and fly directly to water sources, either continuing to forage over the water or moving on to other habitats in search of insects. Many aquatic insects have synchronized emergence in which the aquatic nymphs metamorphize into adults and becomes terrestrial. During this period, large swarms of insects are common over water bodies and bats take advantage of this prey source.

The identification of the tri-colored bat and cave myotis could prove to be beneficial for future conservation efforts, as these bats are likely to be the first ones affected by White-nose Syndrome in the San Antonio area. Though only the tri-colored bat has been documented as being affected by the fungus, it is anticipated that the cave myotis will also be strongly affected (Texas Parks and

Wildlife, 2017b). A petition has been submitted to list the tri-colored bat as endangered under the endangered species act, though review of that petition is still pending (Center for Biological Diversity, 2016).

The limitations of this study was the inability to identify 44% of the calls and the fact that the automatic identification software is not 100% accurate (Barclay, 1999). Moreover, the automatic identification software only identifies set bat species based on region package selected, so rare species that migrate and travel through the area would not have been identified. Species calls sometimes overlap in frequency and length, confounding the automatic identifier software.

In conclusion, seven species of bats were detected during the summer of 2017. This study shows the trends of bat activity in regards habitat use, activity periods, and temperature. Bats on the preserve were most active in late May. It reaffirmed the use of stream habitat by bats. The structure and composition of habitats at Cibolo Preserve provides great diversity for insectivorous bats that include savannah habitat, stream corridors and edges. The Mexican free-tailed, one of the most abundant species in the United States, was the most common species detected. The second most common species in Cibolo Preserve was the tri-colored bat, a species in decline and proposed for federal listing under the endangered species act. The *Lasiurus* spp. roost specifically in the foliage of shrubs and trees, while the other species roost in caves, structures, and snags. Bats were detected equally utilizing all of the habitats sampled indicating that the Preserve likely provides excellent foraging habitat and possibly multiple roosts sites for the seven species detected.

More research would be useful in determining the types of roosts in Cibolo Preserve and their colony size. Protections of roosts with large numbers of bats is important in protecting general bat populations. Moreover, more detailed acoustic monitoring over time and space will provide species preference for foraging habitat. A winter survey of the property would provide additional insight to how bat activity levels vary between summer and winter. Finally, a survey of nearby urban areas could provide insight to how bats in the area utilize developed areas compared to the undeveloped areas such as Cibolo Preserve.

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Table 1. Descriptions of habitats surveyed and vegetation dominating areas.

Habitat	**Description**
Prairie	Open field with 0% clutter. Typical vegetation included various native and non-native grasses and forbs < 1 m in height.
Oak savannah	Forest habitat with widely spaced shrubs and trees. Typical vegetation included Escarpment live oak (*Quercus fusiformis*), sugarberry (*Celtis laevigata*), post oak (*Quercus stellate*) and Texas persimmon (*Diospyros texana*) with scattered canopy cover. Maximum canopy height was 8-10 m.
Stream	Within 3 m of Cibolo Creek. Dominant vegetation included bald cypress (*Taxodium distichum*), Eastern cottonwood (*Populus deltoides*) and black willow (*Salix nigra*). Maximum canopy height was 12-15 m.
Edge	Habitat at the interface of the prairie and oak savannah, facing along the edge. Typical vegetation included various native and non-native grasses (prairie) and Escarpment live oak (*Quercus fusiformis*), sugarberry (*Celtis laevigata*) and Texas persimmon (*Diospyros texana*).

Table 2. Total bat detections each week by habitat.

Survey Week	Habitat Surveyed				
	Edge	Prairie	Oak Savannah	Stream	Total
5/2/17		6,654	10,192		16,846
5/9/17		5,406	7,106		12,512
5/16/17	11,217			11,892	23,109
5/23/17	6,058			11,664	17,722
5/30/17		1,587		19,398	20,985
6/6/17		1,505		17,242	18,747
6/13/17	720		2,919		3,639
6/20/17	1,616		2,836		4,452
6/27/17		695	943		1,638
7/4/17		972	798		1,770
7/11/17	3,724			2,024	5,748
7/18/17	4,728			4,277	9,005
7/25/17		4,405	3,607		8,012
8/1/17		2,911	1,867		4,778
8/8/17	1,601			1,715	3,316
8/15/17	1,408			2,334	3,742
Total	31,072	24,135	30,268	70,546	156,021

Table 3. A list of species known to occur in the study area and the species detected at Cibolo Preserve (indicated with X in table)

Common Name	**Scientific Name**	**Detected**
Eastern Red Bat	*Lasiurus borealis*	X
Northern Yellow Bat	*Lasiurus intermedius*	X
Cave Myotis	*Myotis velifer*	X
Mexican Free-tailed Bat	*Tadarida brasiliensis*	X
Evening Bat	*Nycticeius humeralis*	X
Hoary Bat	*Lasiurus cinereus*	X
Tricolor Bat	*Perimyotis subflavus*	X
Silver-Haired Bat	*Lasionycteris noctivagans*	
Big Free-tailed Bat	*Nyctinomops macrotis*	
Big Brown Bat	*Eptesicus fuscus*	
Seminole Bat	*Lasiurus seminolus*	
Pallid Bat	*Antrozous pallidus*	
Peter's Ghost-Faced Bat	*Mormoops megalophylla*	

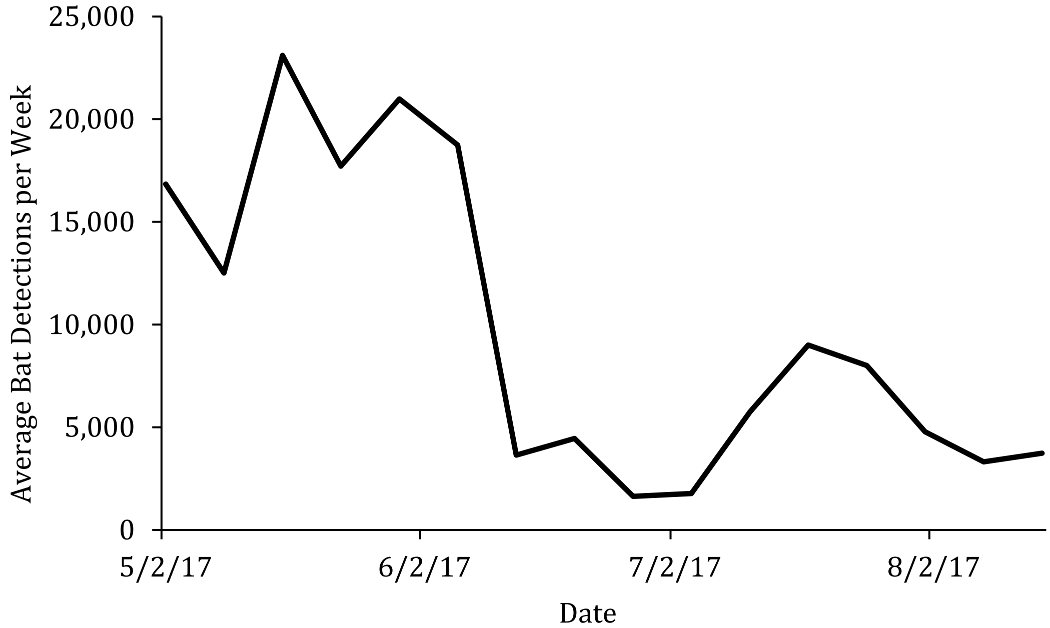

Figure 1. Average bat detections per week for all species and habitat combined for each week of the survey.

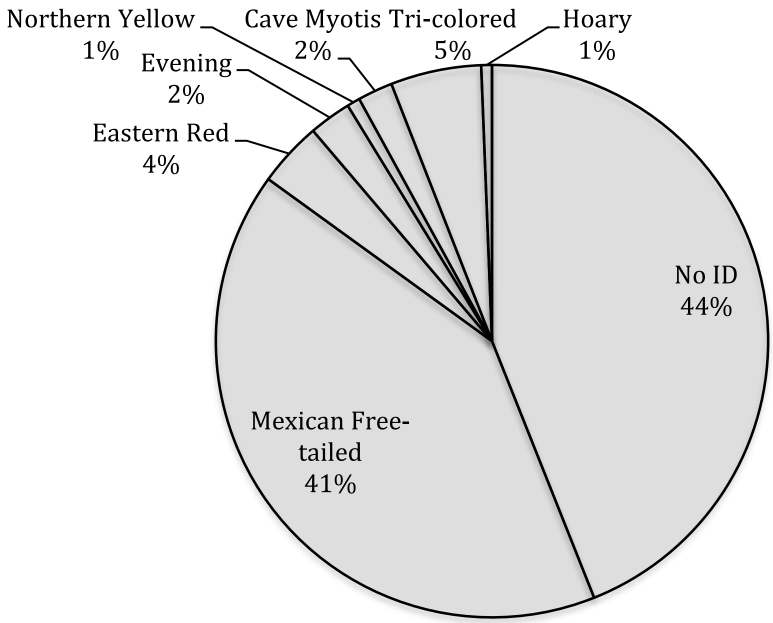

Figure 2. Percentages of identified calls by each species according to Sonobat automatic identifier.

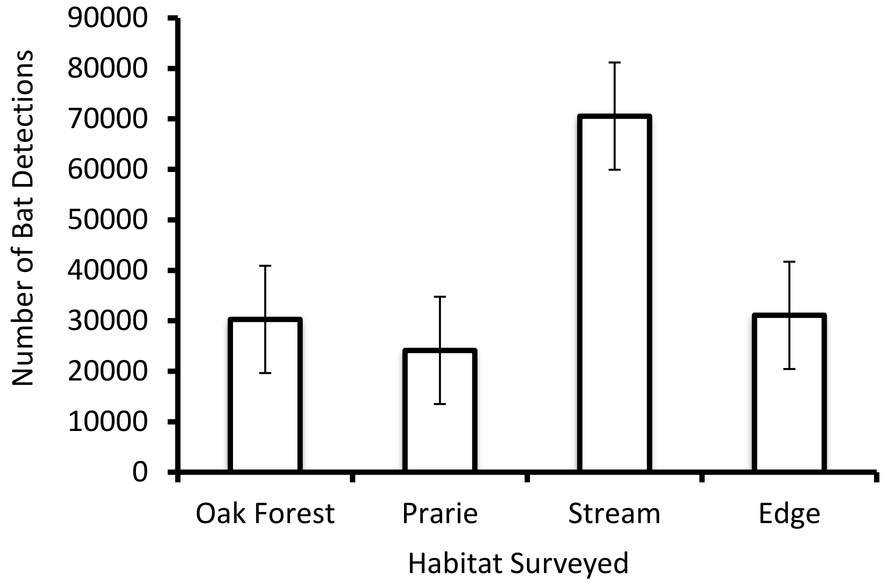

Figure 3**.** Total number of bat detections by habitat surveyed in Cibolo Preserve for all species combined. No habitat was used significantly ($P > 0.05$) more than any other.

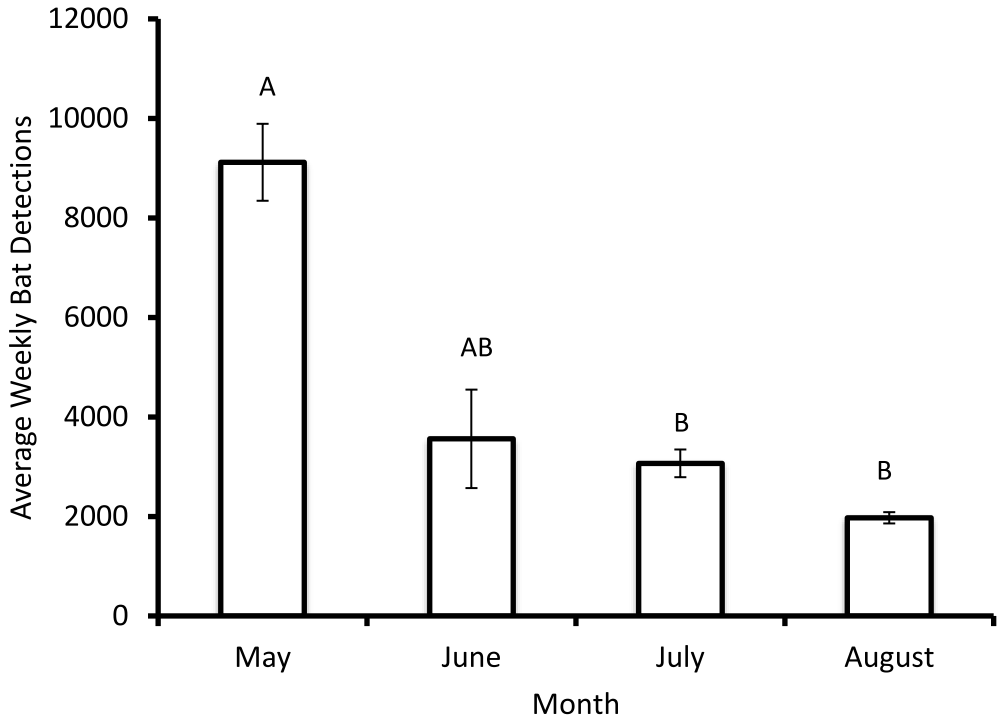

Figure 4. Mean weekly bat passes by month for all species combined. Different letter in bars indicate significant differences (P < 0.05) among months.

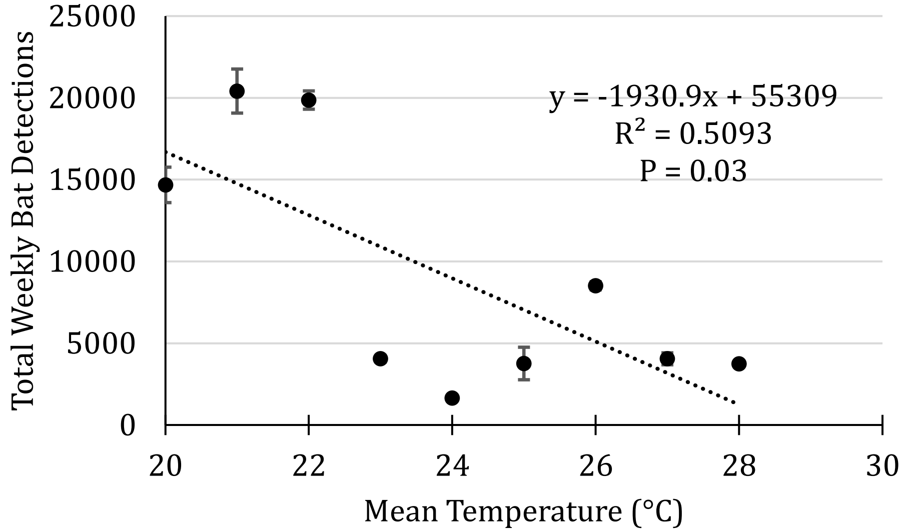

Figure **5.** Linear regression graph comparing total calls and mean temperature. Bars represent standard error.

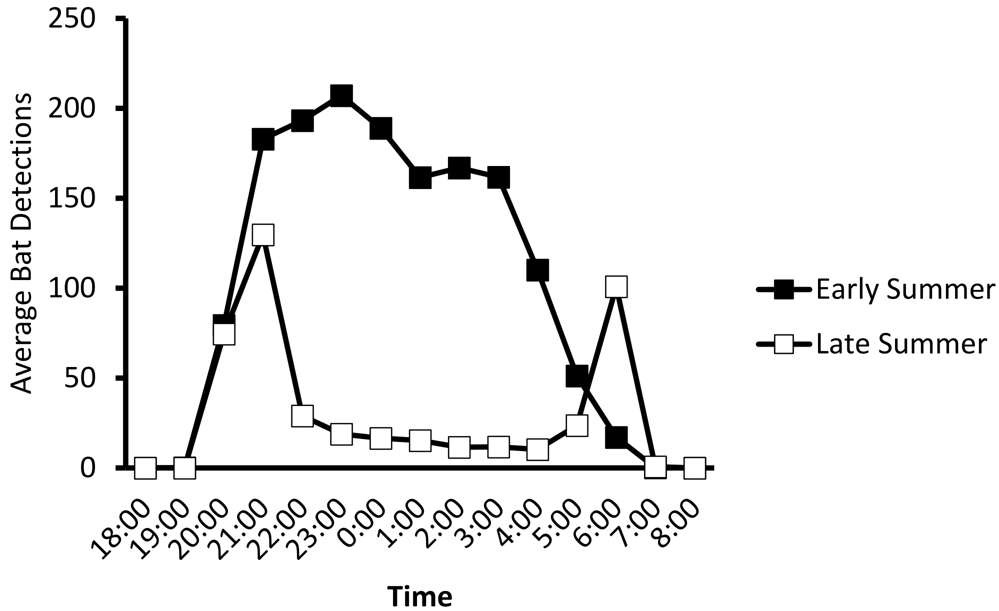

Figure 6. Average bat detections by hour comparing early (May and June) versus late summer (July and August). The data trend in early summer is consistent with bat foraging behavior, while the data trend in late summer is consistent with emergence behavior.

Conflict of Interest: There are no conflicts of interest. Funding for this project was provided by a pre-existing UTSA/Cibolo Preserve partnership.