Seasonal abundance, population structure, and diet of long-nosed bats in southwestern New Mexico in relation to contemporaneous food availability

June 2021 End-of-Fiscal-Year Report

Principal Investigator(s): Kathryn E. Stoner, Theresa M. Laverty (co-PI)

Background

The federally endangered Mexican long-nosed bat (*Leptonycteris nivalis*) and the recently federally delisted lesser long-nosed bat (*Leptonycteris yerbabuenae*) are both identified as Species of Greatest Conservation Need (SGCN) by the New Mexico Department of Game and Fish (NMDGF) in their State Wildlife Action Plan (NMDGF, 2016). Although the geographic distributions of the Mexican long-nosed bat and lesser long-nosed bat overlap across much of their ranges in Mexico, the two species only co-occur in the United States in southwestern New Mexico, where they seasonally share common roosts and food sources in the summer and early fall (Bogan et al., 2017). The lesser long-nosed bat has been documented in the Animas, Peloncillo, Big Hatchet, and Little Hatchet Mountains (Findley et al., 1975; Bogan et al., 2006; Fleming et al., 2013; Bogan et al., 2017), while the Mexican long-nosed bat has been documented in the Animas and Big Hatchet Mountains (Bogan et al., 2006; Bogan et al., 2017). The majority of sightings of these species have been reported in July, August, and September, but can occur as early as June or as late as early October (Findley et al., 1975; Hoyt et al., 1994; Bogan et al., 2006; Fleming et al., 2013; Bogan et al., 2017).

Long-nosed bats in New Mexico are believed to feed almost exclusively on the nectar of agave flowers, which they in turn help pollinate. As agaves only flower once in their lifetime before they die, the density of flowering plants on the landscape can be highly variable from year to year. However, the greatest abundance of long-nosed bats in New Mexico often coincides with the blooming of ephemeral agave flowers in this region (Bogan et al., 2006). Between 2004 and 2005 in the Peloncillo Mountains, agave flowering began in late June, with 90% of the agaves flowering in mid-July and August, and no flowering agaves remained in late September (Bogan et al., 2006). In the northern Animas Mountains, the agaves' blooming period was approximately two weeks behind that of the Peloncillos, though the blooming period still ended in late September (Bogan et al., 2006). Much less is known about the density and timing of flowering agave on the Big Hatchet and Little Hatchet Mountains. Therefore, these migratory nectarivores, as well as their food sources, merit careful monitoring.

Long-nosed bats can travel up to 100 km round-trip between their roosts and nightly foraging grounds, exceeding the known travel distances of other nectar-feeding bats (Medellín et al., 2018). Additionally, flowers of both columnar cacti and paniculate agaves may only be available for short periods of time regionally (Bogan et al., 2017). Therefore, it is difficult to differentiate between the effects of habitat destruction and effects of natural variation in flowering plant density on bat population density (Moreno-Valdez et al., 2000), necessitating a better spatial and temporal understanding of bat and plant populations across their range.

Our team has been working in the Bootheel region of New Mexico, with support from the Bureau of Land Management (BLM), since 2015 and conducted extensive research at the focal roost in the Big Hatchet Mountains for this project in summer/fall 2019 and 2020 prior to being awarded support from a New Mexico Share With Wildlife grant for fiscal years 2021 and 2022.

Objective

Our research aims to document the current status of migratory long-nosed bats (*Leptonycteris nivalis* and *L. yerbabuenae*) at the Big Hatchet Mountains summer/fall roost site and elsewhere in southwestern New Mexico. We are monitoring long-nosed bat population sizes, arrival/departure times, and local food availability, as well as collecting basic population structure and dietary information about these SGCN.

Methods

To achieve our project's objective, we identified a few key tasks that are described in detail below.

1. Flowering agave timing and density effects on bat population ecology — To estimate local bat population sizes, we count long-nosed bats emerging from and entering the Big Hatchet Mountains roost using thermal camera imaging. Our team has been working to obtain estimates of weekly population sizes from the 2019 and 2020 field seasons and we plan to continue this monitoring effort in the years to come. Since 2019, we have had a weather station positioned at the base of the Big Hatchet Mountains that allows us to choose which nights within a week to analyze for bat population size to minimize differences in bat activity due to weather (i.e., rain or wind) patterns. In the thermal camera videos, long-nosed bats can be discerned from sympatric insectivorous bats based on their size and by the prominent musculature in their forearms (Ammerman et al., 2009). To estimate bat food availability, we manually monitor flowering agave density and phenology (i.e., the timing of flowering) and record any observed threats (e.g., intensive cattle grazing, fire, etc.) to agave persistence at a set of randomly-selected points on public land within a 50 km radius of the roost. We follow the recommended forage phenology monitoring protocol supported by the USFWS (Posthumus and Weltzin, 2018). Namely, we have been monitoring phenophases (i.e., flowering and fruiting) of clusters of agaves using a stationary count method to count flowering stalks and determine the percent of open flowers. Lastly, we are currently investigating whether high-resolution satellite imagery (https://www.planet.com/) can be used to create an agave classifier to automatically monitor agave density more comprehensively across years and within flowering seasons. If we find these methods useful, ongoing manual data collection will be used to calibrate and ground-truth the remote sensing algorithm. With these data, we will investigate how weekly bat population sizes relate to contemporaneous food availability using generalized linear models.
2. Seasonal and nightly patterns of bat activity — To study how long-nosed bat activity varies within seasons and between years, we capture long-nosed bats using mist nets placed just outside the Big Hatchet Mountains roost entrance no more than once per week. For captured long-nosed bats, we deploy passive integrated transponder (PIT) tags subcutaneously between the bats' shoulder blades. This roost is already equipped with a Biomark PIT tag antenna system, and these tags allow us to record when marked long-nosed bats leave and enter this roost without the need to recapture individuals. Collaborators in Arizona (e.g., Sandy Wolf, Debbie Buecher), Texas (e.g., Loren Ammerman), and Mexico (e.g., Winifred Frick, Ana Ibarra) use similar setups of PIT tag

antenna systems at other long-nosed bat roosts, allowing us to document movements between key roost sites.

3. Individual dietary behaviors — Given the absence of columnar cacti in southwestern New Mexico, long-nosed bats are presumed to primarily or exclusively feed on agave nectar (Hoyt et al., 1994; Bogan et al., 2017). To determine if this assumption is true, we are examining the diets of individual long-nosed bats using fecal samples collected from a plastic ground sheet positioned just inside the roost and from captured individuals in hand. Samples from the ground sheet are collected every 7–10 days throughout the field season, at which time the sheet is exchanged for a new one. A subset of samples are then sent to Pisces Molecular Lab in Boulder, Colorado for analysis.

Preliminary Results

We have summarized our preliminary results below based on the tasks described above.

1. Flowering agave timing and density effects on bat population ecology — An undergraduate honors student working with our group, Jeanie Coffield, determined in her analysis of weekly thermal camera videos from 2020 that the long-nosed bat population peaked the week of July 31, 2020, at <300 individuals. Due to variation between observers, however, we are not very confident in these results and will be working over the next several months to recount the 2020 results and ensure that these videos all have two or more observers going forward. In terms of bat food availability, agave nectar was available in 2020 from June 14 to September 26, 2020, and peaked during the week of July 12, 2020. Agave phenology seems to be delayed in 2021 and we noted a smaller percentage of fresh flowers in June with the first fresh flowers starting on June 15, 2021. Finally, in terms of creating an agave classifier to automatically monitor agave density more comprehensively across years and within flowering seasons, Ph.D. student Mallory Davies began building a classifier for her landscape ecology class this year. Mallory used remote sensing products paired with ground-truthing to map *Agave* spp. (i.e., the primary food sources of long-nosed bats in New Mexico) distribution and phenology to estimate available nectar across the landscape. Using a Random Forest model with preliminary data, Mallory determined that NDVI values at 10m pixel resolution paired with a previously constructed *Agave* spp. distribution model will allow us to accurately identify patches of agave across the landscape. Further investigation is necessary to explore the possibility of distinguishing flowering agave from non-flowering agave and whether we can identify individual plants at 10m and 5m pixel resolutions.

2. Seasonal and nightly patterns of bat activity — During the 2019 field season in the Big Hatchet Mountains, we tagged 48 lesser long-nosed bats. Thirteen of these bats were recorded using the roost in Big Hatchet Mountains in 2019 after they were tagged, including one bat that was detected intermittently at this roost over a period of 54 days. This suggests the Big Hatchet Mountains roost may have some individuals that reside in New Mexico for extended periods of time. Two other marked individuals were recorded at roosts in Arizona (one as far away as Saguaro National Park), and one bat marked in Arizona was recorded at this New Mexico roost. We were unable to tag additional bats in

2020 due to the COVID-19 pandemic but still detected seven of those 48 bats tagged in 2019 at the roost in 2020. These individuals were all tagged as juvenile or adult females and detected between August 3 and September 3, 2020 (see below for a summary of the PIT tag "recaptures" of these individuals in 2020). We are continuing our tagging efforts in summer/fall 2021, but as of June 18th have yet to capture any long-nosed bats.

a. On 8/3/20, Tag # 982.000364841968 was detected. She was originally tagged as an adult female at 1:16 AM on 8/14/19.
b. On 8/7/20, Tag # 982.000364894153 was detected. She was originally tagged as an adult female at 12:30 AM on 8/14/19.
c. On 8/17/20, Tag # 982.000364938633 was detected. She was originally tagged as a juvenile female at 9:43 PM on 8/13/19.
d. On 8/19/20 and 8/24/20, Tag # 982.000364844508 was detected. She was originally tagged as an adult female at 5:56 AM on 9/7/19.
e. On 8/20/20, Tag # 982.000364843939 was detected. She was originally tagged as an adult female at 10:04 PM on 9/6/19.
f. On 8/24/20, 8/25/20, 8/26/20, and 9/2/20, Tag # 982.000364842048 was detected. She was originally tagged as a juvenile female at 10:00 PM on 7/13/19.
g. On 9/3/20, Tag # 982.000365093084 was detected. She was originally tagged as an adult female at 6:19 AM on 9/7/19.

3. Individual dietary behaviors — For the 2019 field season, 52 individual samples (5 or 6 samples per collection date) were sent to Pisces Molecular Lab in Boulder, Colorado, for genetic analysis to both confirm the bat host species and identify the plant and insect species in their diet. This Share With Wildlife grant in combination with funding from Colorado State University allowed us to send an additional 55 samples from the 2020 field season to the same lab for review. We intend to send samples from the 2021 and 2022 field seasons for comparison. Remaining samples will be investigated under a compound microscope. From previous microscopic and molecular analysis of pooled bat fecal samples collected at the Big Hatchet Mountains roost in 2016 and 2017, our team confirmed that agave is essentially the only plant food source used by long-nosed bats and, surprisingly, about half of the pooled samples also contained insects (Sellers and Stoner, in prep.). Our lab results again confirmed that agave is the only plant food resource in southwestern New Mexico but also found that 80% and 78% of our individual fecal samples in 2019 and 2020, respectively, contained arthropods (Laverty, Davies, and Stoner, in prep.). Long-nosed bats likely prefer nectar food sources, but consume insects on nights when agave nectar is limited. Only continued sampling will allow us to determine how the long-nosed bat diet changes in relation to weather, local food availability, and bat population size. Molecular analysis of earlier pooled fecal samples confirmed the presence of Mexican long-nosed bats at the Big Hatchet Mountains roost in 2016. This species otherwise would have gone undetected that year. The Mexican long-nosed bat has yet to be redetected molecularly, but we switched from pooled to individual fecal sampling when our team restarted fieldwork in 2019. We may consider more pooled sampling efforts in the future (including samples from 2019 and 2020) to target the detection of the Mexican long-nosed bat.

Budget Updates

Of the $49,839.17 that we were awarded, we have spent $10,000 toward this project. The funds went toward the molecular analysis of fecal samples as well as 1% of co-PI Theresa Laverty's salary and associated fringe. The remaining budget will be allocated as salary, tuition, and fringe for Ph.D. student, Mallory Davies, beginning in July 2021.

Literature Cited

Ammerman, L.K., McDonough, M., Hristov, N.I., Kunz, T.H. 2009. Census of the endangered Mexican long-nosed bat *Leptonycteris nivalis* in Texas, USA, using thermal imaging. *Endangered Species Research* 8, 87–92.

Bogan, M.A., Cryan, P.M., Weise, C.D. 2006. Roosts and nocturnal movements of long-nosed bats (Leptonycteris curasoae and L. nivalis) in southwestern New Mexico. Report to Las Cruces Office, Bureau of Land Management.

Bogan, M.A., Cryan, P.M., Weise, C.D., Valdez, E.W. 2017. Landscape movements by two species of migratory nectar-feeding bats (Leptonycteris) in a northern area of seasonal sympatry. Western North American Naturalist 77, 317–330.

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

Fleming, T.H., Eby, P., Kunz, T.H., Fenton, M.B., 2003. Ecology of bat migration. In: Kunz, T.H. (Ed.), Ecology of Bats. Plenum, New York, NY, pp. 156–208.

Hoyt, R.A., Altenbach, J.S., Hafner, D.J., 1994. Observations on long-nosed bats (Leptonycteris) in New Mexico. Southwestern Naturalist 39, 175–179.

Medellín, R.A., Rivero, M., Ibarra, A., de la Torre, J.A., Gonzalez-Terrazas, T.P., Torres-Knoop, L., Tschapka, M. 2018. Follow me: Foraging distances of Leptonycteris yerbabuenae (Chiroptera: Phyllostomidae) in Sonora determined by fluorescent powder. *Journal of Mammalogy* 99, 306–311.

Moreno-Valdez, A., Grant, W.E., Honeycutt, R.L. 2000. A simulation model of Mexican long-nosed bat (Leptonycteris nivalis) migration. Ecological Modelling 134, 117–127.

New Mexico Department of Game and Fish. 2016. State Wildlife Action Plan for New Mexico. New Mexico Department of Game and Fish, Santa Fe.

Posthumus, E.E. Weltzin, J.F. 2018. Lesser long-nosed bat (Leptonycteris yerbabuenae) forage phenology monitoring protocol. Appendix A in U.S Fish and Wildlife Service, 2018. Draft post-delisting monitoring plan for the lesser long-nosed bat (Leptonycteris yerbabuenae). Region 2 USFWS, Arizona Ecological Services Field Office, Phoenix.