Journal of Arid Environments 136 (2017) 38–44

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Mobile acoustic transects detect more bat activity than stationary acoustic point counts in a semi-arid and agricultural landscape

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ARTICLE INFO

Article history:
Received 16 February 2016
Received in revised form
25 August 2016
Accepted 12 October 2016

Keywords:
Car-based surveys
Monitoring
Resource pulse
Encounter rates
Chiroptera
United States

ABSTRACT

Arid environments are characterized by resource pulses that cause spatio-temporal variability in species abundance, which can make population assessments difficult. Mobile acoustic methods may improve survey success by maximizing geographic extent, characterizing landscape distribution patterns, and improving encounter rates. Bats exemplify survey challenges in arid environments as they are highly mobile and aggregate around spatio-temporal resource hotspots. We compared bat detection success of stationary acoustic methods to that of mobile acoustic transects. In a semi-arid landscape, we recorded bat echolocation calls and compared three different sampling methods along the same 24 km route: a driven transect; a set of five, permanent ten-minute point counts; and a set of point counts at nightly randomized locations. The effect of method on the number of bat passes was analyzed using a bootstrapped generalized linear mixed effect model. The mean number of passes for the mobile method was 2.14 (CI: 1.45–2.99) and 0.98 (CI: 0.77–1.21) for the pooled stationary methods. We suggest that driven transects more effectively measure bat activity in arid and open landscapes. Testing of novel survey methods in arid environments is vital to conservation success as climate change increases the extent of these biomes and the variability of resource pulses.

1. Introduction

Arid environments are characterized by highly stochastic precipitation patterns (Morton et al., 2011). Consequently, the availability of food and water resources for arid-dwelling species varies both in space and time, but organisms exploit spatio-temporal increases in resources (resource pulses) numerically, by altering abundances, or functionally through behavioral changes (Abrams and Ginzburg, 2000). Numerical responses can involve baseline increases in population or an aggregation response in which organisms temporarily cluster around resource hotspots (Zach and Falls, 1979). Species that are mobile and employ an aggregation response can thus be challenging to survey or monitor as abundance density will be variable across the landscape. Methods that maximize geographic extent may increase overall species encounter rates, better characterize distributional patterns and landscape usage at large scales, and result in more accurate species abundance assessments.

Mobile methods are effective in characterizing landscape-level trends in populations and distributions because they can maximize geographic coverage. Mobile methods are frequently used in arid environments (Caro, 2011) were species densities can rapidly change in response to shifts in resource availability. Traditionally, mobile surveys involve visually documenting wildlife or indirect signs of wildlife such as nests or scat. Visual mobile methods have successful been used to detect and monitor changes in bird (Sauer et al., 2013) and large mammal populations (Caro, 2011). Conway and Simon (2003) showed that mobile methods detected more burrowing owls per hour when compared to stationary methods, which is beneficial when rapid population assessments are necessary for conservation actions. The advent of bioacoustic detectors has expanded the use of mobile methods from large or easily seen organisms to those that are cryptic, too small, or too fast to identify visually while in a moving vehicle. Mobile acoustic methods have been used to successful assess species distributions and population changes in insects (Jeliazkov et al., 2016), birds (Dawson and Efford, 2009), and bats (Britzke et al., 2011; Roche et al., 2011; Jones et al., 2013); taxa that emit sounds that are easily detected by acoustic technology. Recent advances in bioacoustic technology have expanded mobile acoustic methods to new species (e.g., cryptic

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http://dx.doi.org/10.1016/j.jaridenv.2016.10.005
0140-1963/

mesopredators –Comazzi et al., 2016), community level biodiversity (Sueur et al., 2008), and ecosystem health (Tucker et al., 2014). Arid and open environments are ideal habitats for acoustic monitoring as there is little vegetative clutter to attenuate sound and species density is often low, reducing overlap in emitted bioacoustic signals. The combination of mobile methods and acoustic technology has the potential to be a fundamental tool for those designing biodiversity surveys and monitoring plans in arid environments.

Bats are one of the most diverse and successful mammal taxa in arid regions. For example, insectivorous bats are the most diverse group of mammals in the deserts of Israel with 33 species (Korine and Pinshow, 2004) and almost a quarter (59) of all bat species in South America are found in the dryland savannas of the continent (Sandoval and Barquez, 2013). Bats in arid landscapes provide important ecosystem services as agents of pest suppression, pollination, and seed dispersal and are an ideal bioindicator group for the health and stability of ecosystems (Jones et al., 2009). Despite taxonomic dominance and their importance in arid regions, bats are severely understudied in arid regions with almost nothing known about abundances and distributional patterns (Korine et al., 2016). This is in large part because bats exemplify the challenge of species monitoring in arid environments as they are highly mobile and known to exploit and aggregate around spatio-temporal resource hotspots (Razgour et al., 2011; Müller et al., 2012). For example, bats in arid regions frequently converge at water sources, but sampling only at these areas results in biased understanding of how bats use the landscape. Geluso and Geluso (2012) hypothesized that variation in capture rates from 1971 to 2005 in the arid San Mateo Mountains of New Mexico was caused by bats clustering around the only permanent water source (their capture site) during dry years but dispersing across the landscape in wet years when bats could frequent ephemeral water sources. Similarly, bats in semi-arid agricultural landscapes shift their distribution to match that of food resources; consumption of corn earworm moths in Texas by the Brazilian free-tailed bat (*Tadarida brasiliensis*) tracks with local changes in the insect population's abundance which varies with crop life cycles (McCracken et al., 2012). Survey and monitoring methods for bats in arid regions thus need to account for spatio-temporally variable aggregative responses to resources.

Common methods for bat surveys and monitoring (roost counts, capturing bats at known foraging sites, recording echolocation during flight), assess activity at single points (stationary methods), which may fail to account for spatial variation in bat activity and how spatial variation changes temporally (Hayes et al., 2009). Furthermore, the bat faunas of arid landscapes often comprise of species that specialize in foraging in habitats with little or no vertical complexity (“open-space bats”). Open-space bats have wing morphologies that allow them to fly fast over long distances and often at high altitudes, which makes them very difficult to catch while foraging (Norberg and Rayner, 1987; Lumsden and Bennet, 1995). Fortunately the echolocation calls used by open-space bats are typically of low frequency, high intensity (loud), and long duration which means they can be readily detected using acoustic methods (Schnitzler and Kalko, 2001). Calls are species-specific, allowing for species identification, although detailed analysis is sometimes required to separate similar species (Parsons and Szewczak, 2009). Stationary acoustic methods can be used successfully to survey and monitor bats at the landscape scale, but require a substantial investment in labor and equipment, because arrays of detectors are required (Coleman et al., 2014). Probability of detecting bats using stationary methods may be increased by selecting known areas of high bat activity, such as those around bodies of water, roosts, or linear landscape elements (Hayes et al., 2009), but selection of these sites then biases our perspective of how bats use the landscape.

Mobile acoustic methods, in which a detector is continuously moving along a predetermined route, have been proposed as a basis for a North American bat monitoring program (Loeb et al., 2015). They have been used effectively to survey bat distributions and monitor population changes in Europe and the eastern United States (Britzke et al., 2011; Roche et al., 2011; Jones et al., 2013) while also increasing the scale of surveys and monitoring without dramatically increasing cost or effort (Whitby et al., 2014), which has been useful for state, country, and regional level population size assessments. Whitby et al. (2014) found no difference in the number of species detected between stationary and mobile methods, but the study design did not allow for direct comparison of bat activity between methods as stationary data was converted to presence/absence. Before mobile acoustic methods are used for large-scale monitoring it is important to compare method efficiency in detecting overall activity as well as richness. In areas with high spatio-temporal variability in resources, such as Lubbock County, TX, we hypothesized that mobile methods would indeed detect more bat passes because maximizing geographic rather than temporal coverage at a single point would result in fewer sampling units with zero passes detected. Thus the objective of this study was to determine if mobile acoustic surveys detect more bat passes per unit of sampling time than do stationary acoustic point counts in Lubbock, Texas.

2. Methods

2.1. Study area

The study was conducted in Lubbock County, Texas, USA, which sits on the Llano Estacado, a semi-arid plateau dominated by irrigated agriculture (primarily cotton, corn, and wheat). The Llano Estacado is part of the High Plains which has an average annual rainfall from 380 to 560 mm but the region has had frequent droughts this century, the driest of which occurred October 2010 to June 2014, which was during the study period (National Weather Service, 2014; Texas Parks and Wildlife Department, 2016). The native ecosystem was short-grass prairie but less than 20% remains; today the region is mostly irrigated cropland and mesquite-juniper shrub (Samson et al., 2004; Texas Parks and Wildlife Department, 2016). Insect prey and water resources are variable in the Llano Estacado because the dominant water sources are small, ephemeral playa lakes and insect populations often track crop presence and maturation (McCracken et al., 2012; Collins et al., 2014). Acoustic surveys were conducted along a 24 km transect of public road that spans from the eastern edge of the city of Lubbock to Ransom Canyon, a small suburb surrounding a reservoir (Fig. 1). Roads are known to have a negative effect on bats through direct mortality and as a commuting barrier, but in the present study, all roads were rural two-lane roads with very little traffic that do not have as great a negative effect on bats as larger, busy roads (Medinas et al., 2013). The two crops growing along the transect road were cotton and sorghum, though ground cover was not always present. The larger lakes near Lubbock, Buffalo Springs, and Ransom Canyon always contained water, but the smaller playas scattered through the croplands were ephemeral through the study period. Lubbock County has low bat richness with only eight species and low evenness, with *T. brasiliensis* being the dominant species. We conducted acoustic surveys of bats from August to October 2012 and May to July 2013. Surveys were not conducted from November 2012 to March 2013 due to the lack of bat activity in the area.

2.2. Acoustic transects

Three acoustic survey methods were employed to assess activity along the transect: driven transects, permanent point counts, and