HABITAT USE AND PREFERENCES OF ECHOLOCATING BATS IN AMURUM RESERVE NORTH CENTRAL NIGERIA

Nwankwo Emmanuel C.1,3,4,* & Shiiwua A. Manu1,2

1 A.P. Leventis Ornithological Research Institute, University of Jos, P.O. Box 13404, Jos, Nigeria.
2 Department of Zoology, University of Jos, P.M.B 2084, Jos, Nigeria
3 Department of Forestry and Environmental Management, Michael Okpara University of Agriculture Umudike, P.M.B 7267, Nigeria
4 Behavioural Ecology and Evolution Laboratory, University of Cyprus, Cyprus
* Corresponding author: emmancipate2006@gmail.com

ABSTRACT

The activity of insectivorous bats was studied in four habitat types in and around Amurum Forest Reserve, Nigeria. Transect-based acoustic surveys were used to record bat activity in the gallery forest, savannah, rocky outcrops and farmland habitats. Bat activity was estimated by counting the number of bat passes recorded per minute of echolocation recordings from the field survey. Bat activity differed significantly among habitat types with activity being highest in the gallery forest and least in the farmland. The gallery forest had the potential to host a great degree of bat activity relative to other habitat types due to its associated higher structural complexity, which hosts variety of resources required by bat species. Over the years of management in the Amurum Reserve, the rocky outcrop has become more vegetated which in combination with the caves provided more suitable habitat relative to the savannah habitat for the echolocating bat community. Low bat activity recorded in the farmland is an indication of high levels of habitat simplification and disturbance through various agricultural practices. To improve this, farmland practices should enhance landscape complexity, favour structural variation and connectivity, and make effort to minimize the spraying of pesticides, as these pose serious threats to bat populations. This can be achieved by planting trees indigenous to the plateau.

Keywords: Bat community, echolocation, Amurum Reserve, habitat use, bat activity.

INTRODUCTION

Bats are important component of our ecosystem as they play key roles in maintaining the stability of our ecosystems. One of these roles is that of bio-indicators among other ecological importance. There declining diversity and abundance of bats is a great concern in consideration of the effect of their population on their ecological roles. This necessitates more understanding of the habitat types and characteristics desired preferentially by bat species for effective prescription of management and protection measures (Goodenough et. al. 2015). Bat capturing is invasive, stressful for the animals, resource intensive, and introduces biases, particularly for investigations requiring repeated observations or aimed at studying bat activity or behaviour (Altringham, 2011).

Bats emit information about themselves into the environment in the form of vocalizations, and the echolocation calls of many bats can reveal their species identity, location and activity (Altringham and Fenton, 2003). Thus, acoustic surveys provide an effective means to survey the ecology, behaviour, and biology of bats through detection, recording, and analysis of their
echolocation (Parsons and Szewczak, 2009). However, acoustic identification of echolocation calls relies on the availability of call libraries linking echolocation call parameters to known species (e.g. Jones et al., 2000). Although such information is available for many species in Europe and North America, little such information is available for Africa. The lack of call libraries means that an acoustic survey of bats in Africa is difficult and potentially of limited use.

Nevertheless, understanding of bat habitat use is becoming increasingly important due to bat population declines (Britzke, 2004), especially in Africa. Though data from bat detectors cannot provide information on the number of individuals present in an area, several methods for estimating the amount of bat use in an area have been used. Habitat variability increases with structural complexity; as complex habitat have isolated areas that would be expected to be suitable for bat activity, while less complex habitats would have one large area suitable for bat activity (Britzke, 2004; Vaughan et al., 1997a). For the purposes of habitat conservation, the assessment of relative habitat use by bat species is of great importance, requiring the identification of bat species in flight at their feeding sites (Vaughan et al., 1997b).

Habitat selection and use by bats are species specific and dependent on the variety of species hunting strategies (Kanuch and Kristin, 2006). The knowledge of the time and site at which animals are most active is considered very crucial in effective wildlife management (Rouxa et al. 2014). Hunting strategies are determined by such factors as echolocation type, body morphology and diet composition (Sierro, 1999; Siemers and Schnitzler, 2000). As a result, plant species composition (Rachwald, 1992; Jung et al., 1999; Kalcounis et al., 1999), age (Erickson and West, 1996; Crampton and Barclay, 1998), structure (Brigham et al., 1997; Humes et al., 1999; Jung et al., 1999; Patriquin and Barclay, 2003) and fragmentation of stands (Crampton and Barclay, 1996; Grindal and Brigham, 1998) affect bats foraging activity. Such positions in a habitat as edge of a stand, watercourse or water pool have been reported to strongly influence the presence of bats in a given site (Ciechanoowski, 2002; Kusch et al., 2004). Studies on the relationship between bats and forested corridors in an intensively managed landscape with the view that bat activity may be influenced by nearby roads and distance to water by Hein et al. (2009), revealed higher occupancy rates for bats along corridor edges compared to interior corridor or adjacent stands.

Hutson et al. (2001) reported that the transformation of foraging habitat may seriously affect insectivorous bat populations. Acoustic monitoring by Jung et al. (2012) on species composition and activity of bats revealed that bat occurrence and activity increases with structural heterogeneity in managed forest stands and species-specific structural parameter association explains the occurrence and activity levels of individual species in differently managed production forest types.

Norberg and Rayner (1987) recognized the association of a combination of bats morphological and echolocation characteristics to reflect the habitat in which they forage. Other factors as reproductive state, weather, predation pressure, and insect availability have been observed to influence habitat use (Downs and Racey, 2006). Insect abundance has been observed to significantly correlate with overall bat activity and with the number of taxa recorded per night (Avila-Flores and Fenton, 2005). Studies on microhabitat preference within three landscape features: linear landscape elements, ponds and rivers, showed that bats preferred to commute to ponds along woodland edges and streams and not along hedgerows; with more bat activity over large wide ponds relative to small narrow ones (Downs and Racey, 2006).
Mist nets and ultrasonic bat detectors constitute the two commonly used methods in bat surveys (Kuenzi and Morrison, 1998). Mist nets cannot be effectively employed in sampling of such habitats as open fields, large bodies of water, or high in the canopy. Difference in activity patterns or ecomorphology may contribute to variation in some species’ ability to avoid mist nets (Kunz and Kurta, 1988). The stress and potential harm caused to bats by capture and handling creates a drawback to the use of mist nets (Findley, 1993).

Some of the challenges involved in the use of mist nets can be avoided by the use of ultrasonic detectors in surveying bat communities (Murray et al., 1999). Advantages of bat detectors over mist nets include the ease in setting up of bat detectors, their ability to sample a wider range of habitat types (O’Farrell, 1999a), and ability to be deployed and left to record automatically (Krusic and Neehus, 1996) relative to mist nets that require constant monitoring (Findley, 1993). Ultrasonic detectors have been widely used in surveying bat activity (Rydell et al., 1994, Walsh et al., 1995, Walsh and Harris 1996a, Vaughan et al., 1997a). Potential biases are inherent in the use of ultrasonic bat detectors (Findley, 1993; Barclay, 1999; O’Farrell et al., 1999b), observed in certain habitat types and conditions which limit the use of bat detectors. Less efficiency is observed in the use of detectors in large water-bodies, sites with dense vegetation, and areas high levels of insect noise (Murray et al., 1999). Furthermore, under-representation of species with low intensity echolocation calls contribute to the biases in the use of ultrasonic detectors in bat surveys (O’Farrell and Gannon, 1999a). Vaughan et al. (1997b) and Jones et al. (2000) recommended objective and quantitative identification methods in determining bat species habitat use, and the use of other forms of surveys in order to avoid serious misinterpretation.

To sample bat species assemblages previous studies have used either mist nets or ultrasonic detectors (Hickey and Nelson, 1995; Krusic and Neehus, 1996; Lance et al., 1996; O’Farrell et al., 1999b). A few other studies compared the two methods by using qualitative analysis for species identification (Rautenbach et al., 1996; Kuenzi and Morrison, 1998; O’Farrell and Gannon, 1999a), but did not sample simultaneously with both detectors and mist nets. Murray et al. (1999) evaluated the relative effectiveness of mist nets and the Anabat II ultrasonic bat detector in surveying various habitats by simultaneously sampling with both methods. They concluded that Anabat detects several bat species more effectively than do mist nets. This demonstrates that the combination of both survey techniques provides the most effective means of determining bat species composition in an area.

The aim of this research is to assess habitat use by echolocating bats in Amurum Forest Reserve, Nigeria. More specifically, to determine levels of bat activity in different habitat types (gallery forest, savannah, rocky outcrop, and farmland) in Amurum. The hypotheses for this study was that levels of bat activity will vary across the different habitat types in Amurum. We predicted increase in bat activity with habitat structural complexity based on the observed decreasing order of structural differences across the habitat types: gallery forest, rocky outcrop, savannah and least in farmland.

METHODS

Study area

The study was carried out in Amurum Forest Reserve (9°53’N, 8°59’E). It is located 15km northeast of Jos, Plateau State, North-central Nigeria. The reserve covers an area of about 300 hectares with an altitude of 1280 a.s.l. (Ezealor, 2002) and is characterized by various habitat types, namely patches of gallery forest, scrub savannah, grassland and rocky outcrops (Fig.
1). The gallery forest is comprised of some fringing forests occurring around seasonal creeks and streams. The scrubland consists of a mixture of grasses, shrubs and small trees, while the rocky outcrops are widely distributed in the reserve having a few plant communities at various heights made up of trees and small woody plants.

Figure 1. Map of Amurum Forest Reserve showing topography and distribution of major habitat types.

The general climatic condition of the reserve and its environs comprises 1400mm average rainfall occurring between May and September and a period of dry season occurring between October and March. Temperatures range between 20 - 25°C (and may go below 10°C in extreme cases) during the dry harmattan period and between 30 – 35°C in warm dry periods before the start of the rains. The soil is mostly brick red laterite around gullies, and a mixture of sand and clay in the savannah, with humus from debris of fallen leaves.

These habitat types host such plant species as *Parkia biglobosa*, *Acacia seyal*, *Dichrostachis cinerea*, *Anogeissus leiocarpus*, *Albizia lebbeck*, and *Khaya senegalensis* and many more. Some introduced plant species found within the reserve include *Lantana camara*, *Eucalyptus camadulensis* and *Mangifera indica*. *Marathus glabra* also found in the reserve grows as much as 30m tall with a girth of about c. 3m and c. 1m diameter. The reserve was established as an Important Bird Area (IBA), and managed by the Nigerian Conservation Foundation (NCF) for the Community Participatory Approach to Renewable Resources Conservation Program until 2003, when the A. P. Leventis Ornithological Research Institute (APLORI) took over the management of the reserve.
Acoustic survey

Transect-based acoustic surveys were used to record bat activity in the various habitats. Acoustic sampling was performed using an Anabat II bat detector (Titley Electronics, Ballina, New South Wales, Australia), linked to the Anabat ZCAIM (zero crossings analysis interface module) to store the recordings on the Compact Flash card. This was done by actively walking along the transect in a slow and average speed of 0.27m/s with the detector tilted at 45° and raised to my shoulder level.

Four kilometre line transects were located in four habitats types in Amurum Forest Reserve and surrounding farmlands. Surveys were carried out at two periods: hours after dusk (19:00-23:00) and hours before dawn (02:00-06:00) to determine temporal variation in habitat use. This was carried out for 19 nights between May and June, 2014. The detector was adjusted to its maximum usable sensitivity and its division ratio set to 8 field recordings. The stored data on the compact flash (CF) card were read into a personal computer using CFCread software. The CF card was erased each time a fresh recording was made. Call files were labelled with date and locality information before storing in the hard drive of a computer. Bat calls were visualized in frequency vs time graph for analysis using AnalookW software.

Relationships between bat activity and habitat types were assessed using generalized linear model (GLM) with a Poisson error distribution. Poisson error distribution was chosen due to bat activity which was estimated by counting bat passes recorded per minute during the survey. A quasipoisson function was used to correct for over-dispersion. All statistical analysis were done in R 3.3.1 (R Core Team, 2016).

RESULTS

Overall, 23,543 bat passes were recorded during 38 sampling night periods. Of those, 18% (4,289) passes were recorded in the farmland, 24% (5570) in the rocky outcrop, 28% (6,672) in the gallery forest, while savannah had the highest with 30% (7,012).

Table 1. The relationship between bat activity and habitat types in Amurum Reserve and its surrounding habitats.

| Habitat Type          | Estimate | Std. Error | t value | Pr(>|t|) |
|-----------------------|----------|------------|---------|---------|
| Farmland(Intercept)   | 1.8807   | 0.04184    | 44.951  | <0.00001|
| Habitat(Gallery Forest)| 0.59347 | 0.05363    | 11.067  | <0.00001|
| Habitat(Rock)         | 0.4309   | 0.05566    | 7.741   | <0.00001|
| Habitat(Savannah)     | 0.36264  | 0.05311    | 6.827   | <0.00001|

Significant p values in **bold**.

Bat activity, estimated by the number of bat passes recorded per minute, varied significantly among the habitat types (glm, F = 44.095, df = 3, p <0.00001). On average, this variation was highest in the gallery forest and least in the farmland. Bat activity was higher in rocky outcrop relative to savannah habitat but the difference was not statistically significantly different based on the overlap of the error bars (see Figure 2).
DISCUSSION

Bat activity was highest in gallery forest in the Amurum Forest Reserve, and lower in rocky outcrops, savannah and farmland (Figure 2). This may be attributed to the habitat heterogeneity of gallery forest, which may also contribute to high availability of insect prey relative to other habitat types. This is supported by Colin and O'Donnell (2000) who reported high insect density in sheltered habitats. Rocky outcrop and savannah habitat types did not vary significantly in bat activity probably due to relative likelihood in the two habitat types. It is pertinent to state that rocky outcrops in the reserve were not bare rocky surfaces but had vegetation structure not quite different from that of the savannah habitat. We attribute the relative higher bat activity in the rocky outcrop from the savannah habitat to the habitat roles of the caves for the bats and rocky pockets that seemed to encourage insect colonization in the rocky outcrops. This further suggests the immense role the Amurum Reserve is playing in habitat improvement as the rocky outcrops are becoming more vegetated towards the resemblance of a forest habitat.

Figure 2. Differences in bat activity (mean number of bat passes ± 95% confidence interval) across four habitat types.
Bat activity was significantly reduced in farmland, compared to other habitat types. This may be attributed to the high level of human disturbance in the farmland habitat due to agricultural activities. Such activities may include the use of pesticides, burning of the vegetation cover and tillage disturbance of the soil (Stebbins, 1988, Hutson et al., 2001). Agricultural activities have been known to adversely affect insect abundance (Anthony et al., 1981) and vegetation cover required by the bats for various purposes. The vegetation cover removed for agricultural reasons is normally required by these bats as roosting, foraging, mating, breeding and resting sites (Stebbins, 1988). Also, there is reduced habitat heterogeneity in the farmland which does not support high level of biodiversity. This study therefore quantified levels of bat activity in different habitat types; it rejected the hypothesis that bat activity was constant across habitat types; and it supported the prediction that bat activity would increase with increasing habitat structural complexity. The heterogeneous landscapes of Amurum is greatly desired as they play complementary role in providing a variety of foraging environments comprised of different categories of preys (Charbonnier et al., 2015) for the flying foxes in Amurum

CONCLUSIONS

The Jos Plateau’s gallery forest has the potential to host a great degree of bat activity relative to savannah, rocky outcrops and farmlands, attributable to its associated higher structural complexity and presumed higher availability of resources required by insectivorous bats. Protection of the gallery forests within and outside the Amurum Forest Reserve is therefore crucial, as it shelters foraging sites from wind and other adverse environmental factors. Gallery forest also holds some water pockets throughout the year, an important factor in a water-stressed hot savannah. The savannah and rocky outcrop habitat types also play significant complementary role in improving bat activity in Amurum Forest Reserve. Low echolocating bat activity recorded in the farmland is an indication of high level of habitat simplification and disturbance through various agricultural practices. To this, farmland practices should enhance landscape complexity, favour structural variation and connectivity, and make effort to minimize the spraying of pesticides, as these pose serious threats to bat populations. The present study has shown significantly lower echolocating bat activity in the farmlands relative to the protected natural communities within the reserve, which is an implication of intense habitat destruction and fragmentation in the farmlands relative to the habitats within the reserve. This could be ameliorated by reduced pesticide and herbicide utilization and encouragement of structural complexity in the farmlands through the establishment of hedge rows of indigenous tree plants, which will be beneficial to the farmers against strong wind and to the bat community by providing roosting and foraging habitats.

REFERENCES


