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

Nwankwo Emmanuel C.[1,3,4,*] & Shiiwua A. Manu[1,2]

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 Neefus, 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 Neefus, 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.

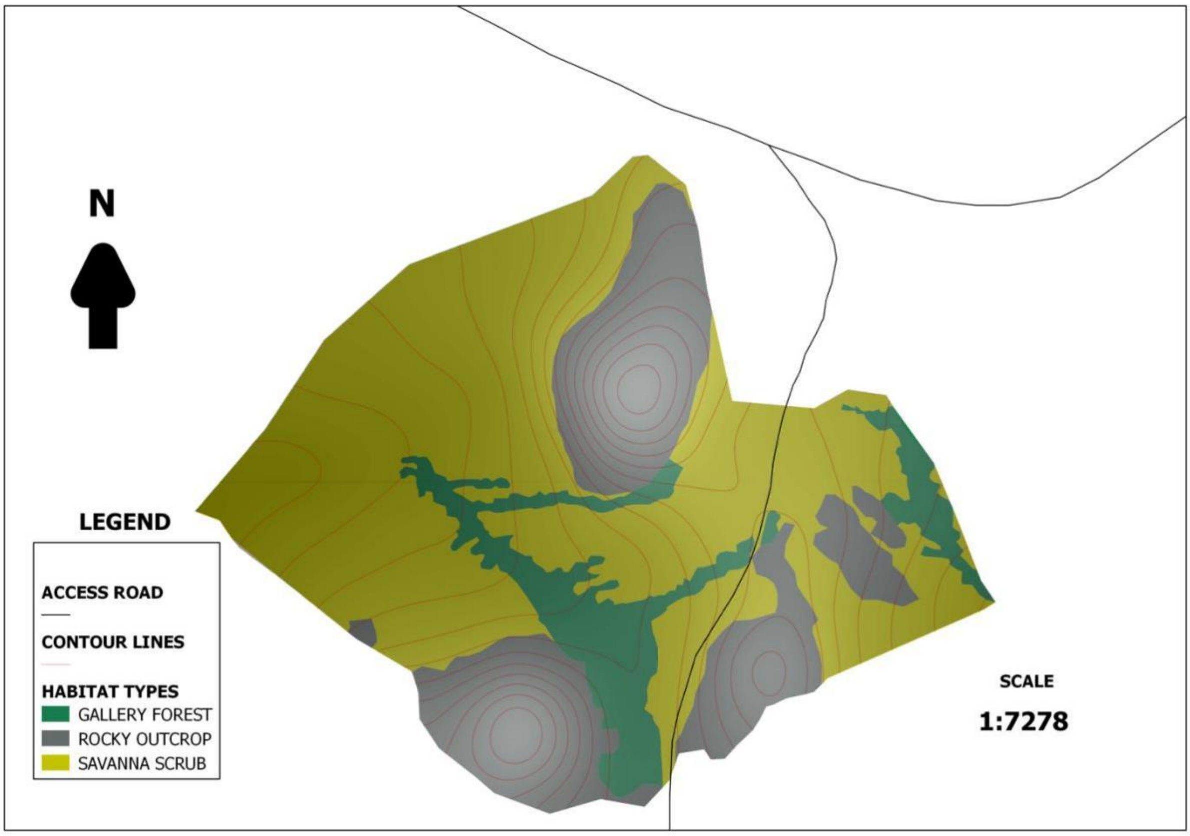

Figure 1. Map of Amurum Forest Reserve showing topography and distribution of major habitat types.

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^{o} 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.

	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**.
glm(Bat_Passes ~ Habitat, quasipoisson)

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).

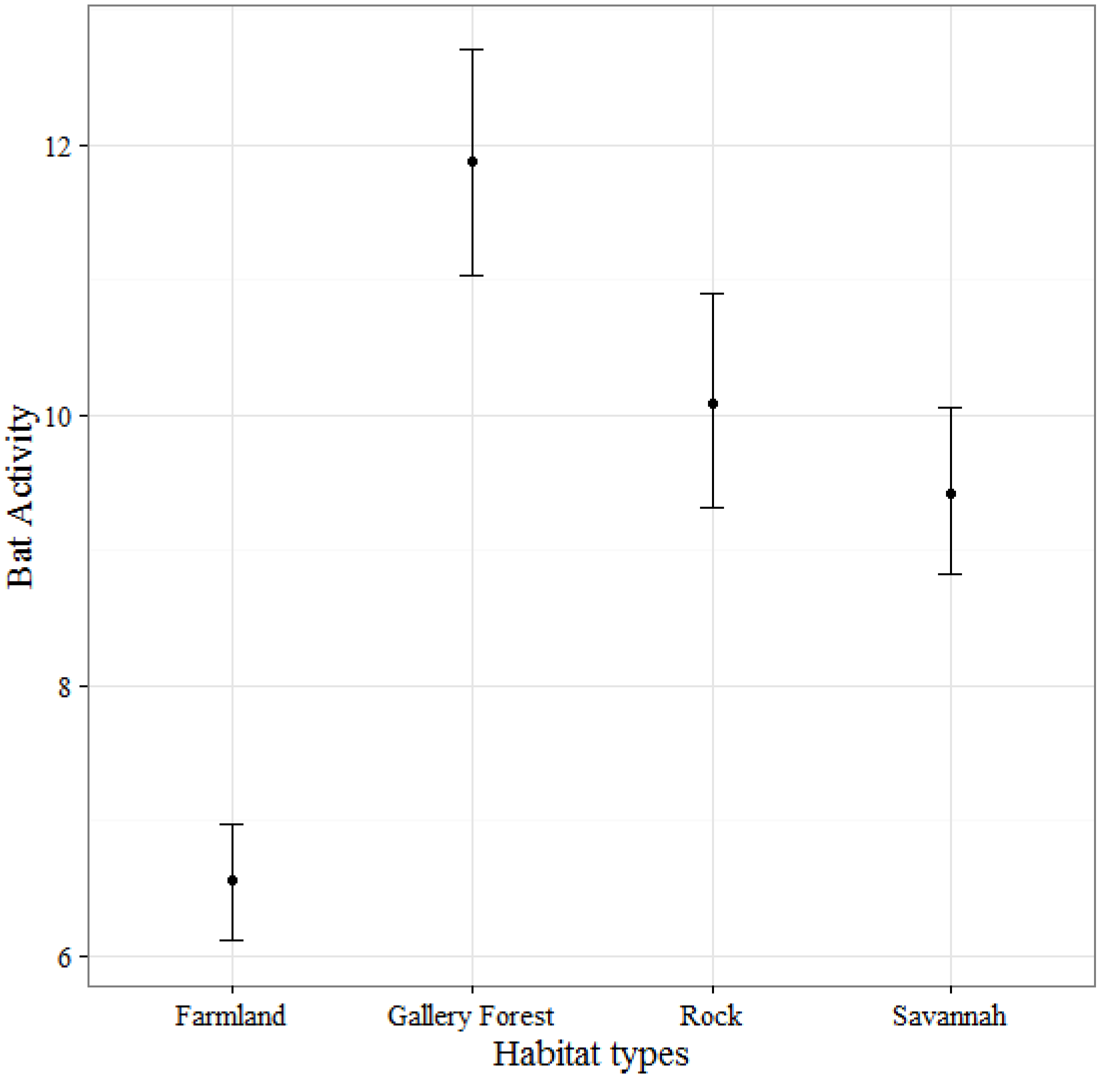

Figure 2. Differences in bat activity (mean number of bat passes ± 95% confidence interval) across four habitat types.

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.

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 (Stebbings, 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 (Stebbings, 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

Altringham, J. D. (2011) *Bats: from evolution to conservation*. Oxford University Press.

Altringham, J. D., & Fenton, M. B. (2003) Sensory ecology and communication in the Chiroptera. *Bat ecology*, 90-127.

Anthony, E. L. P., Stack, M. H., & Kunz, T. H. (1981) Night roosting and the nocturnal time budget of the little brown bat, Myotis lucifugus: effects of reproductive status, prey density, and environmental conditions. *Oecologia*, *51*(2), 151-156.

Avila-Flores, R., & Fenton, M. B. (2005) Use of spatial features by foraging insectivorous bats in a large urban landscape. *Journal of Mammalogy*, *86*(6), 1193-1204.

Barclay, R. M., Fullard, J. H., & Jacobs, D. S. (1999). Variation in the echolocation calls of the hoary bat (Lasiurus cinereus): influence of body size, habitat structure, and geographic location. *Canadian Journal of Zoology*, *77*(4), 530-534.

Brigham et al. (1997) The influence of structural clutter on activity patterns of insectivorous bats. *Canadian Journal of Zoology*, *75*(1), 131-136.

Britzke, E. R. (2004). Designing monitoring programs using frequency-division bat detectors: active versus passive sampling. *Bat Echolocation Research: Tools, Techniques, and Analysis, RM Brigham, EKV Kalko, G. Jones, S. Parsons, and HJGA Limpens, eds. Austin, TX: Bat Conservation International*, 79-83.

Charbonnier, Y., Gaüzère, P., van Halder, I., Nezan, J., Barnagaud, J. Y., Jactel, H., & Barbaro, L. (2016) Deciduous trees increase bat diversity at stand and landscape scales in mosaic pine plantations. *Landscape Ecology*, *31*(2), 291-300.

Ciechanowski, M. (2002). Community structure and activity of bats (Chiroptera) over different water bodies. *Mammalian Biology-Zeitschrift für Säugetierkunde*, *67*(5), 276-285.

O'Donnell, C. F. (2000) Influence of season, habitat, temperature, and invertebrate availability on nocturnal activity of the New Zealand long-tailed bat (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology*, *27*(3), 207-221.

Crampton, L.H., & Barclay, R.M.R. (1996) Habitat selection by bats in fragmented and unfragmented aspen mixed wood stands of different ages. In: Barclay, R.M.R., & Brigham, R.M., (Eds.), *Bats and Forests Symposium*. British Columbia Ministry of Forests, Victoria, pp. 238–259.

Crampton, L.H., & Barclay, R.M.R. (1998) Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. *Conservation Biology*, 12: 1347–1358.

Downs, N. C., & Racey, P. A. (2006) The use by bats of habitat features in mixed farmland in Scotland. *Acta Chiropterologica*, 8: 169–185.

Erickson, J.L., & West, S.D. (1996) Managed forests in the western Cascades: the effects of serial stage on bat habitat use patterns. In: Barclay, R.M.R., Brigham, R.M. (Eds.), *Bats and Forests Symposium*. British Columbia Ministry of Forests, Victoria, 215–227.

Ezealor, A.U. (2002) Critical Sites for Biodiversity Conservation in Nigeria. Nigerian Conservation Foundation.

Findley, J. S. (1993) Bats: a community perspective. Cambridge University Press, Cambridge, United Kingdom.

Goodenough, et al. (2015) Later is better: optimal timing for walked activity surveys for a European bat guild. *Wildlife Biology*, 21: 323–328.

Grindal, S.D., & Brigham, R.M. (1998) Short-term effects of small-scale habitat disturbance on activity by insectivorous bats. *Journal of Wildlife Management*, 62: 996–1003.

Hein, C., Castleberry, S., & Miller, K. (2009) Site-occupancy of bats in relation to forested corridors. *Forest Ecology and Management*, 257: 1200-1207.

Hickey, M. B., & Neilson, A. L. (1995) Relative activity and occurrence of bats in southwestern Ontario as determined by monitoring with bat detectors. *The Canadian Field-Naturalist*, 109:413-417.

Humes, M. L., Hayes, J. P., & Collopy, M.W. (1999) Bat activity in thinned, unthinned, and old-growth forests in western Oregon. *Journal of Wildlife Management*, 63: 553–561.

Hutson, A. M., Mickleburgh, S. P., & Racey, P. A. (2001) Microchiropteran bats: global status survey and conservation action plan. IUCN/SSC *Chiroptera Specialist Group*. IUCN, Gland, pp 258.

Jones, G., Vaughan, N., & Parson, S. (2000) Acoustic identification of bats from directly sampled and time expanded recordings of vocalizations. *Acta Chiropterologica*. 2:155-170.

Jung, et al. 1999. Habitat selection by forest bats in relation to mixed-wood stand types and structure in central Ontario. *Journal of Wildlife Management*, 63: 1306–1319.

Jung, et al. (2012) Moving in three dimensions: effects of structural complexity on occurrence and activity of insectivorous bats in managed forest stands. *Journal of Applied Ecology*, 49: 523–531. doi: 10.1111/j.1365-2664.2012.02116.x.

Kalcounis, et al. (1999) Bat activity in the boreal forest: importance of stand type and vertical strata. *Journal of Mammalogy*. 80: 673–682.

Kanuch, P., & Kristin, A. (2006) Altitudinal distribution of bats in the Polana Mts area (C Slovakia). *Biologia*, 61: 605–610.

Kusch, et al. (2004) Foraging habitat preferences of bats in relation to food supply and spatial vegetation structures in a Western European low mountain range forest. *Folia Zoologica*, 53: 113–128.

Kuenzi A.J., & M. L. Morrison. (1998) Detection of bats by mist-nets and ultrasonic sensors. *Wildlife Society Bulletin*, 26:307-311.

Kunz, T. H., & Kurta, A. (1988) Methods of capturing and holding bats. In T. H. Kunz, (Ed). *Ecological and behavioral methods for the study of bats*. pp. 1-30, Smithsonian Institution Press, Washington, D.C.

Krusic, R. A., & Neefus, C. D. (1996) Surveying forest-bat communities with Anabat detectors. In R. M. R. Barclay & R. M. Brigham, (Eds), *Bats and forests symposium*, pp. 175-184. British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Lance et al. (1996) Surveying forest-bat communities with Anabat detectors. In R. M. R. Barclay & R. M. Brigham, (Eds), *Bats and forests symposium*, pp. 175-184. British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Murray, K. L., Britzke, E. R., Hadley, B. M., & Robbins, L. W. (1999) Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. *Acta Chiropterologica*, 1(1), 105-112.

Norberg, U. M., & Rayner, J. M. (1987) Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *316*(1179), 335-427.

O'Farrell, M. J., & Gannon, W. L. (1999a) A comparison of acoustic versus capture techniques for the inventory of bats. *Journal of Mammalogy*, *80*(1), 24-30.

O'Farrell, M. J., & Miller, B. W. (1999b) Use of vocal signatures for the inventory of free-flying Neotropical Bats. *Biotropica*, *31*(3), 507-516.

Parsons, S., & Szewczak, J. (2009) Detecting, recording and analysing the vocalisations of bats. *Ecological and Behavioral Methods for the Study of Bats [2nd. Ed.]*, 91-111.

Patriquin, K. J., & Barclay, R. M. (2003) Foraging by bats in cleared, thinned and unharvested boreal forest. *Journal of Applied Ecology*, *40*(4), 646-657.

R Core Team. (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/

Rachwald, A. (1992) Habitat preference and activity of the noctule bat *Nyctalus noctula* in the Białowiez a primeval forest. *Acta Theriologica*. 37: 413–422.

Rautenbach, I. L., Whiting, M. J., & Fenton, M. B. (1996) Bats in riverine forests and woodlands: a latitudinal transect in southern Africa. *Canadian Journal of Zoology*, *74*(2), 312-322.

Le Roux, D. S., Le Roux, N. N., & Waas, J. R. (2014) Spatial and temporal variation in long-tailed bat echolocation activity in a New Zealand city. *New Zealand Journal of Zoology*, *41*(1), 21-31.

Rydell, J., Bushby, A., Cosgrove, C. C., & Racey, P. A. (1994). Habitat use by bats along rivers in north east Scotland. *Folia Zoologica-Praha-*, *43*, 417-417.

Siemers, B.M., & Schnitzler, H. U. (2000). Natterer's bat hawks for prey close to vegetation using echolocation signals of very broad bandwidth. *Behavoural Ecology Sociobiology*, 47: 400–412.

Sierro, A. (1999) Habitat selection by barbastelle bats (*Barbastella barbastellus*) in the Swiss Alps (Valais). *Journal Zoology*. 248: 429–432.

Stebbings, R. E. (1988) The conservation of European bats. London: Christopher Helm, p. 246.

Vaughan, N., Jones, G., & Harris, S. (1997a) Habitat Use by Bats (Chiroptera) Assessed by Means of a Broad-Band Acoustic Method. *The Journal of Applied Ecology*, *34*(3), 716. doi:10.2307/2404918

VAUGHAN, N., JONES, G., & HARRIS, S. (1997). Identification of British bat species by multivariate analysis of echolocation call parameters. *Bioacoustics*, *7*(3), 189-207.

Walsh, A. L., & Harris, S. (1996). Foraging habitat preferences of vespertilionid bats in Britain. *Journal of Applied Ecology*, 508-518.

Walsh, A. L., Harris, S., & Hutson, A. M. (1995) Abundance and habitat selection of foraging vespertilionid bats in Britain: a landscape-scale approach. In *Symposia of the zoological Society of London* (Vol. 67, pp. 325-344). London: The Society, 1960-1999.