http://www.ajol.info/index.php/jfewr
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E-mail:jfewr@yahoo.com
ISBN: 2141 – 1778
Adeyanju et al., 2017

BAT DIVERSITY AND ABUNDANCE IN OMO FOREST RESERVE, NIGERIA

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ABSTRACT

Bats are yet to be incorporated in management plans in Nigeria. This is attributed to dearth in information as well as social stigma. This study was designed to determine bat species diversity, abundance and the relation of both indices to habitat structure. The survey was carried out in Omo forest reserve between May and June. Mist nets were deployed using stratified sampling method to place nets at 20 points. Netted points were set to be at least 200m apart. Total length of net averaged at 60 m, height ranged between 2-4m and set up after sunset from 1800-2300 hrs and before sunrise from 0400-0630 hrs. Sixty-four individuals were trapped belonging to 14 species in 8 genera and 6 families. Two other species were observed but not captured Eidolon helvum (Straw coloured fruit Bat) and Hypsignathus monstrosus (Hammer headed Fruit bat). Identification was based on Mammals of Nigeria and Mammals of Africa. Bat species diversity and bat abundance were higher in the forest compared to plantation but not significantly different. Bat species diversity decreased significantly as density of trees and litter cover increased while bat abundance decreased with increase in tree density but the relationship was not significant. Difference in diversity and abundance of bats is attributed to relative short distance between farmland and forest habitat types which provides easy access to bats for foraging. Habitat type and land usage influences the level of diversity and abundance of wildlife species for which bats are good indicators of habitat suitability.

Keywords: Bats, diversity, Omo forest reserve, deforestation, density of trees

INTRODUCTION

One of the major threats to bats and other organisms is the loss or destruction of their habitat due to increased demand on land resources caused by expanding human populations. Studies have shown that this pressure is more pronounced in tropical countries where larger percentages of the populace live in rural areas where livelihood opportunity and/or income are low (Mickleburgh *et al.*, 2002). Bats are an order of mammals that is abundant, species rich and biologically diverse. They are found virtually in all terrestrial biomes except the tundra and polar regions (Wang, 2004). The order Chiroptera, contains more than 1300 species (Fenton and Simmons, 2014) which are divided into two sub-orders, Microchiropterans and Megachiropterans (often known as old fruit bats) (Mickleburg *et al*., 2002); recent comparative and molecular studies have raised some questions about this suborder division. For example, Hutcheon and Kirsch (2004) concluded in their study that the new sub-order includes Vespertilioniformes and Pteropodiformes. Bats are important keystone species (Cox *et al*., 1992) and play major roles in ecological processes such as mediating links among habitat types (Arita, 1996; Weller and Lee, 2007) through seed dispersal, plant pollination and regulation of insect populations (Fleming, 1998; Medellin and Goana, 1999; Taylor, 2006). It is however sad but true that bats rank amongst the least known of any mammalian group; little information available on their diversity, distribution and ecological requirements (Lee *et al.*, 2007; Monadjem *et al*., 2010; Happold and Happold, 2013; Voigt and Kingston, 2016). More importantly, information is sparse on bats in Nigeria. The study provides a baseline data for bats species diversity and abundance in Omo forest reserve via mist netting technique. The authors also went a step further to determine how habitat variables affect bats abundance and diversity.

METHODOLOGY

Study Area

Omo FR was created in 1916, located 135km north-east of Lagos and 20km from the coast. The Omo River flows through the centre of the reserve. One of the tributary is a fast flowing stream (known as Erijah) and some creeks are reported to cease flowing during the dry season (including the creek within Erin Base Camp). An annual rainfall of 2,000 mm and a dry season from November to March with the rains falling almost every day during our survey. The terrain is undulating with an elevation of about 300 m on some rocky hills. The areas south of the reserve are at lower elevations than those to the north (Olmos and Turshak, 2009). The pockets of primary forests are around inaccessible areas where timber extraction is impossible (Ezealor, 2001). In the logged areas, vines are tangled with the secondary growth forest dominated by *Musanga cecropoides,* and a few oil-palm trees *Elaeis guineensis* compared to sites further west along the road to Lagos. Most remaining larger trees are the soft- wooded *Cieba pentandra* (Bombacaceae). Along the low-lying areas are drainages covered by tangled vegetation with few trees making access difficult. Cocoa farms now replace cleared areas of the forest (Olmos and Turshak, 2009).

Bat Census Techniques

Bats were captured using mist-nets within two habitat types (forest and plantation), using stratified sampling method to place nets at 20 points. Netted points were set to be at least 200m apart. All twenty points were surveyed at night and in some mornings (a total of 40 trapping days). Total length of net averaged at 60 m, height ranged between 2-4m and set up after sunset from 1800-2300 hrs and before sunrise from 0400-0630 hrs. Mist nets were set up along forest trails, across small streams and plantations (Cocoa and Teak plantations) and around identified roosts (Monadjem *et al*, 2007). The mist nets were first checked every 10 mins (Monadjem and Reside, 2008) and later every 3 mins to reduce net destruction and escape time. Identification of bats to species level was done with the aid of the mammals of Nigeria (Happold, 1987) and comparing with Mammals of Africa (Happold and Happold, 2013) as a means to confirm some species. On occasion where it was difficult to identify individuals to species level, photos have been taken and some confirmation on voucher specimens were carried out by the lead author with Iroro Tanshi. Morphological features such as body size, length of forearm, sex, age class (juvenile and adult) and reproductive class (breeding or non-breeding) was recorded for each individual bat. To avoid re-sampling of individuals, temporary ink markings were made (Medellin *et al*., 2000) on each individual using violet purple dye with the use of a spray bottle and or cotton wool swab so markings were visible on the top back (between the shoulders) of the bat before release. Trapping of bats were avoided when the weather was windy or while it was raining or threatening. Mist-nets adapted for wild birds were used for the survey. In general, only the micro-chiropterans were destructive while in the nets. Nets were shifted to new location each day to avoid easy detection of nets by the bats and improve capture.

Measure of Habitat Variables

We used a 10 x 10 m plot in each point and within the plot the following habitat variables were measured following Manu (2002). Tree density (number of trees in each plot (DBH>10 cm), number of snags (number of dead trees), litter cover (taken as the amount of dry litter on the ground) to the nearest 5% by eye, percentage canopy cover (to the nearest 5%) estimated by looking in the wrong side of the eyepiece of a pair of binoculars. This gives a small view area of the canopy allowing an assessment of cover to be made.

Statistical Analysis

All statistics were done using the software package R console 2.15.1 (2012) and Microsoft Excel spreadsheets. A Species-effort curve for the survey was plotted to determine if survey effort was sufficient. The data was subjected to one-sample Kolmogorov-Smirnoff test to determine normality in data distribution. General linear model was used to test for significance in mean diversity and mean abundance within site and also the effect of vegetation variables on mean diversity and mean abundance. Pearson's moment correlation was used to eliminate vegetation variable that could be represented by others (Test of association). Scatter plots was used to represent relationship between variables while bar charts with error bars were used to show summaries for group cases.

Bat species diversity was calculated using Shannon-Weiner diversity Index H, in the equation below

$$H = -\Sigma\ PiInPi$$

Where Pi is the proportion of individual species, and S is the total number of bat species capture (Number caught in the net).

Species Effort Curve

EstimateS (Version 8.2.0) was used to derive sample based asymptotic species richness estimate by the Chao 1 non-parametric species richness estimator for the bats captured in all points. The species effort curve (Figure 1) shows a quick climb in the number of species added at the beginning of the survey. More importantly, the curve does not reach asymptote meaning that more species could still be added with increasing number of points or effort.

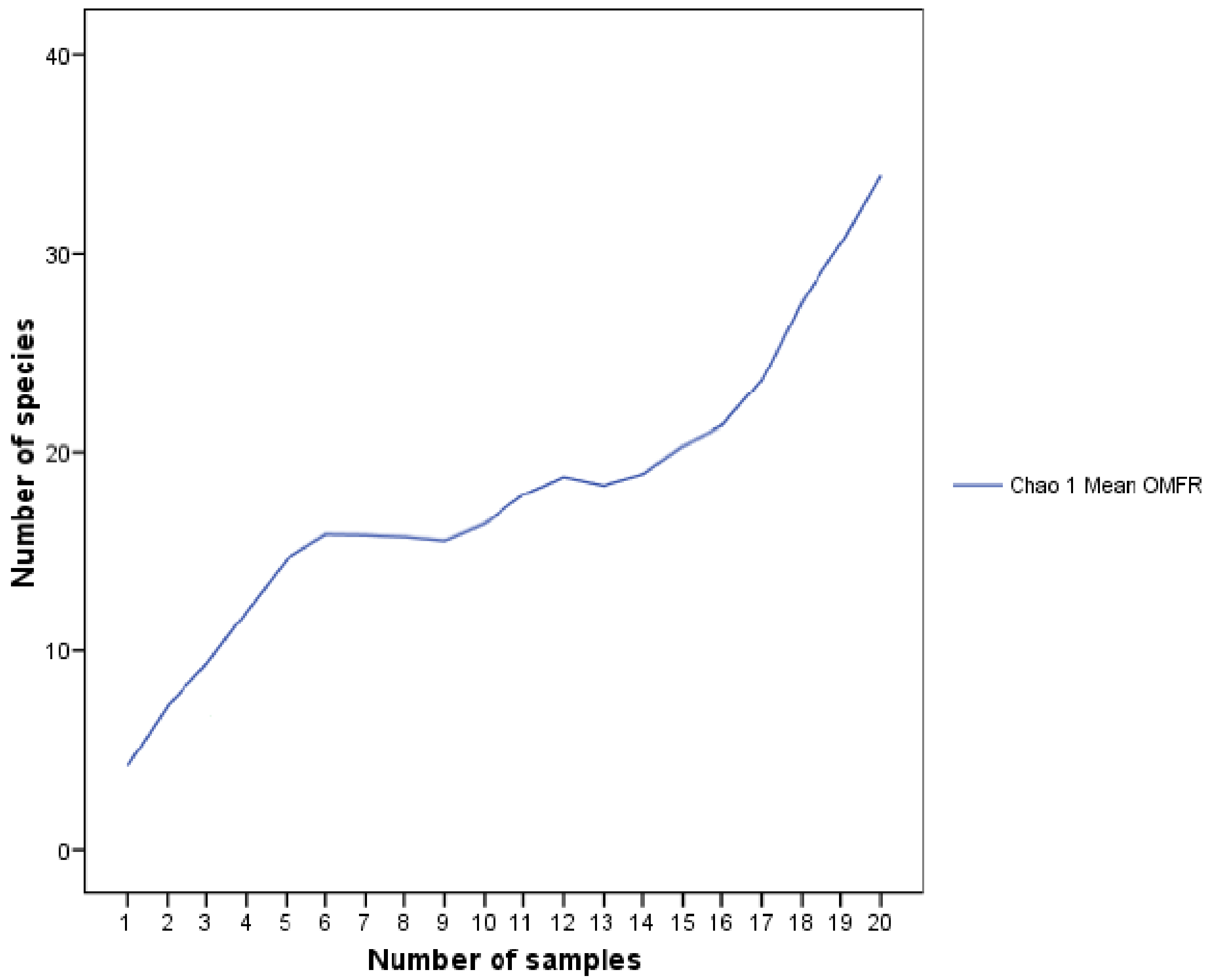

Figure 1: Sample based asymptotic species richness estimated by the Chao 1 nonparametric species richness estimator for the bats captured at OMFR.

RESULTS

A total of 64 individuals were trapped belonging to 14 species in 6 families and more species were detected in forest compared to plantation (Table 1). The total survey effort was 40 trap nights, covering a trap-length of 2400m within the forest and on adjacent cocoa farms. Diversity of bats was higher in the forest compared to the plantation but the difference in mean diversity between the two habitats was not significant (Figure 2). The abundance of bats captured was higher in the forest compared to the plantation but the difference in mean abundance between the two habitats was also not significant (Figure 3).

Effects of habitat variables on mean bat diversity

There was a significant relationship between mean bat diversity with density of trees and litter cover (Table 2), as density of trees and litter cover increased, diversity decreased respectively (Figure 4a and b). It was also observed that there w significant relationship between mean bat abundance with percentage canopy cover and litter cover (Table 3), as percentage canopy cover and litter cover increased, bat species abundance increased respectively (5a and b).

Table 1: A checklist of the number and species of bats captured at OMFR in south-west Nigeria.

Taxon	Forest	Plantation
Rhinolophidae		
Rhinolophus fumigatus	8	2
Rhinolophus alcyone	1	-
Nycteridae		
Nycteris hispidia	13	4
Nycteris macrotis	1	-
Nycteris grandis	3	-
Nycteris arge	9	-
Hipposideridae		
Hipposiderous caffer	1	-
Hipposiderous cyclops	3	-
Hipposiderous jonesi	3	-
Verspertilionidae		
Glauconycteris beatrix	1	-
Pteropididae		
Myonycteris torquata	2	-
Megaloglossus woermanni	6	5
Scotonycteris zenkeri	5	-
Megadermatidae		
Lavia fons	1	-

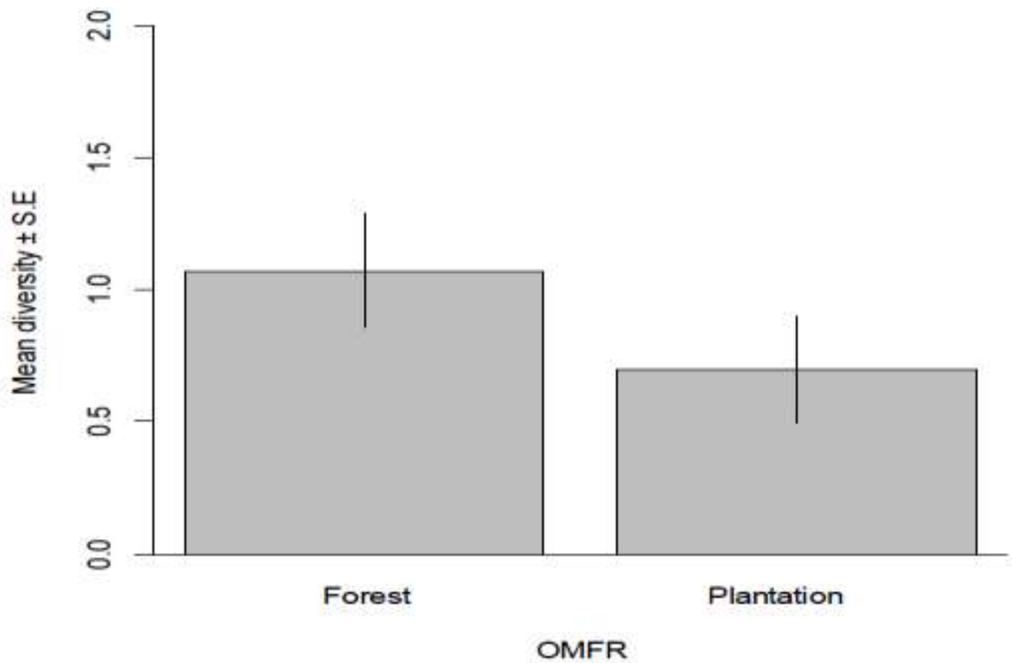

Figure 2: Mean diversity of bats in two habitats in OMFR. There is an observed difference in mean diversity which is not significant (P>0.05).

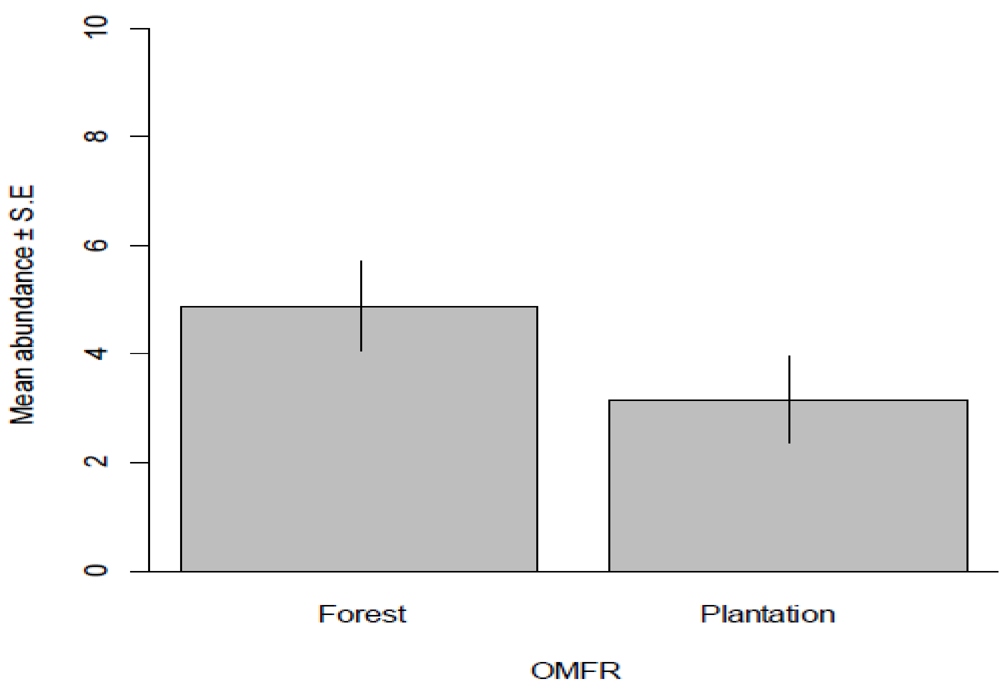

Figure 3: Mean abundance of bats in two habitats in OMFR. There is an observed difference in mean abundance which is not significant. (P>0.05)

Table 2: Analysis of variance test between density of trees, litter cover, number of snags and average bat diversity in OMFR.

Variable	Parameter estimate	df	Sum of Squares	F	P
Intercept	3.93	1			0.06
Number of trees	-0.27	1	1.79	7.42	0.02 *
Litter cover	-0.03	1	0.07	0.30	0.08
Number of snag	-0.09	1	0.16	0.67	0.20
Number of trees: Litter cover	0.002	11	0.89	3.69	0.08

R^2=0.35

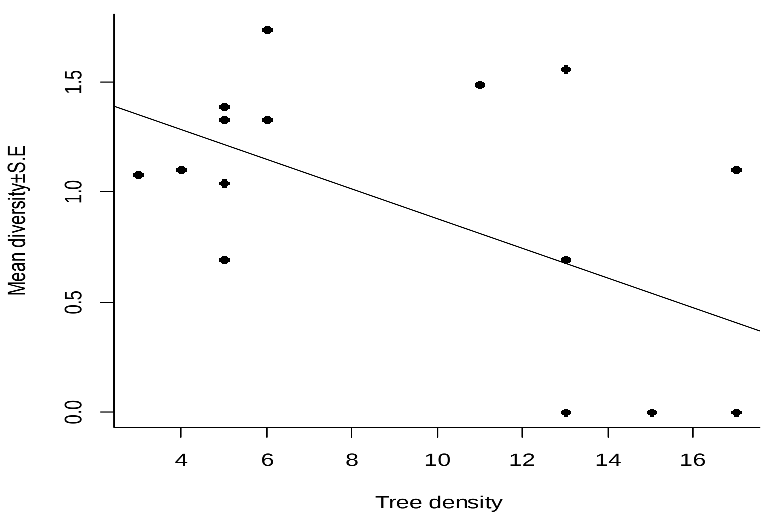

Figure 4a: Relationship between mean diversity of bats and tree density in OMFR.

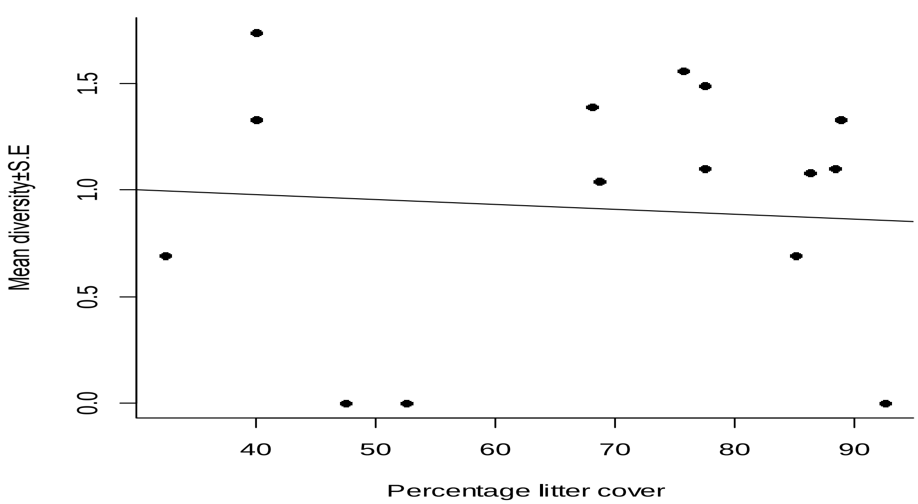

Figure 4b: Relationship between mean diversity of bats and percentage litter cover in OMFR

Table 3: Analysis of variance test between percentage canopy cover, percentage litter cover, number of snag and average bat abundance in OMFR.

Variables	Parameter	df	Sum of	F	P
Intercept	-22.00	1			0.03
Canopy cover	0.36	1	5.74	1.79	0.002**
Litter cover	0.36	1	0.47	0.14	0.005 **
Number of snags	-0.36	1	2.91	0.87	0.18
Canopy: Litter cover	-0. 004	11	42.09	12.41	0.004 **

R^2=0.43

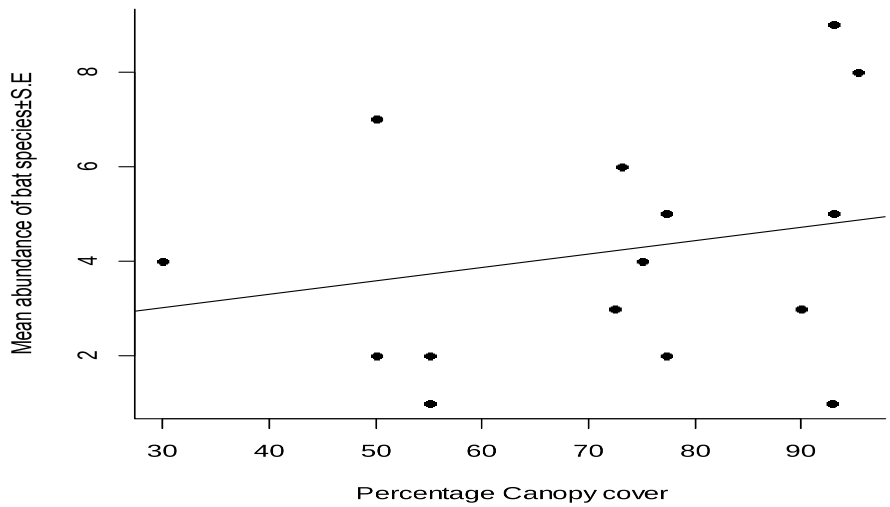

Figure 5a: Relationship between mean abundance of bats and percentage canopy cover in OMFR.

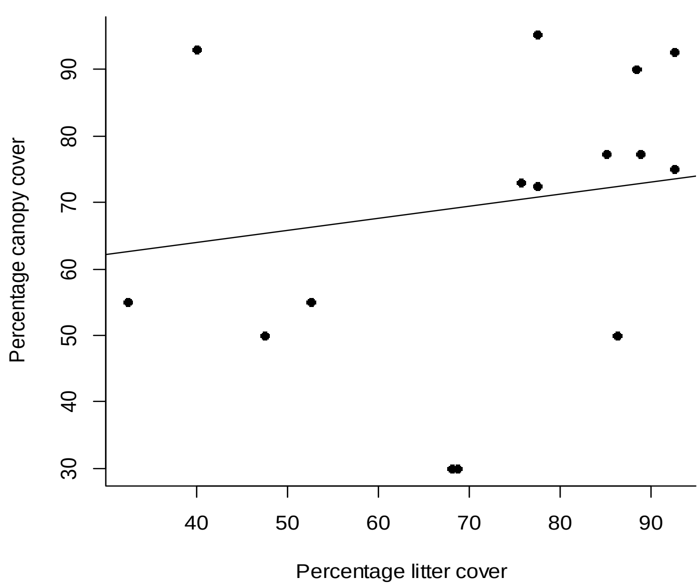

Figure 5b: Relationship between percentage canopy cover and percentage litter cover in OMFR.

DISCUSSION

Fourteen bat species belonging to eight genera and then six families were captured during our survey; *Rhinolophus fumigatus*, *R. alcyone*, *Nycteris hispidia*, *N. macrotis*, *N. grandis*, *N. arge*, *Hipposiderous caffer*, *H. cyclops*, *H. jonesi*, *Glauconycteris beatrix*, *Myconycteris torquata*, *Megaloglossus woermanni*, *Scotonycteris zenkeri* and *Lavia fons*. Two other species were observed but not captured *Eidolon helvum* and *Hypsignathus monstrosus*. The Chao 1 non parametric species richness estimator for bats captured predicts over 30 species, meaning that over fifteen more species could be captured with more points or effort given to capture.

The diversity and number of bats netted within the forest habitat was higher than that of the plantation but statistically, this difference was not significant. Though the statistics are interesting to see; the insignificant difference is consistent with past studies (Webala *et al*., 2004; Lee *et al*., 2007). The authors suggest this is an early warning of anthropogenic disturbances which involves clearing of the natural habitat by removing trees which hitherto provided shelter and snags (Wechuli *et al*., 2016). The use of artificial techniques such as pesticide application to advance food production is now prevalent as a short-run and cheaper alternative among cocoa farmers (ICCO, 2015). The application of pesticides if reduced is believed to lead to a general buildup of natural cocoa pod enemies and vice-versa improved conditions for natural controls to thrive (ICCO, 2015). Gradually, food bases are altered and micro nitches eroded, which in turn lead to loss of roosting sites closer to where feeding may occur (Medellin and Goana, 1999; Medellin *et al.*, 2000; Owens *et al.*, 2004; Webala *et al.*, 2004). Although the difference in diversity and abundance was not statistically significant and diverse species including other taxa respond differently to various habitat changes (Kunz *et al*., 1996), it is also probable that the relative short distance between the plantation and the forest habitat types has produced opportunity for ease of foraging with an added reduction of energy loss.

It is however important to note that the number of species captured in the forest area was generally much diverse than that captured in the plantations. Also the effort curve did not level off and predictors estimated more species to be added, showing that the area was still rich in many more species which could be added to captures or effort was increased. Nonetheless, bats are specialized with some occupying ground level, mid-storey and some others canopy (Meyer *et al*., 2011). Likewise the ability of different species to detect the nets vary while some carefree species contributed a much higher proportion of captures (*Nycteris* genera), some other species like *Lavia fons* are very good at evading nets. The latter can also be explained for in terms of rarity and commonness of individual species at the time of capture. Nonetheless, for all these species, higher proportions were trapped in the forest sites. Additionally, the use of pesticides in the protection of cocoa pods might also be indicted as a possible cause for the low level of bat captures experienced during our survey. During this study, logging activities was a common practice and this obviously will be an avenue for disturbance to bat activities (Olmos and Turshak, 2009). Forest clearing especially at the interior parts of the forest for cocoa plantation might also justify for the observed similarity in abundance and diversity between the two habitat types.

As observed from our results, bat species diversity and abundance decreased with increase in density of trees and that diversity decreased with increase in the amounts of litter cover. This is consistent with some studies (Tibbels and Kurta, 2003; Owen *et al*., 2004) though higher abundance of forest dwelling bats have been connected with greater availability of roosts (Crampton and Barclay, 1998). In addition, foraging opportunities are relatively higher in old grown forest due to reduced vegetation clutter and greater insect availability. Another factor may be that old grown forest will have more gaps due to reduced tree densities and more edges that aids in commuting and foraging of bats (Humes *et al*., 1999; Menzel *et al*., 2005). The timing of the capture in our study site suggests that some bats roosted in the forest and then foraged in the adjacent plantation. Although the reduction in the canopy trees in the plantation created fewer roosting sites for bats but it is assumed that this did not affect the availability of insects which led to increase in the number of insectivorous bats trapped.

CONCLUSION

This study has shown that habitat type affects species diversity and abundance significantly and the different vegetation variables of the different habitat types play a major role in determining the level of species diversity and abundance. Anthropogenic activities take a period before beginning to show grave consequences for wildlife. Efforts need to be put on deck to curtail anthropogenic activities in this Biosphere reserve before it gets to irreversible states. The effects of anthropogenic activities are differently observed on varying species as requirements for survival differ significantly. More species occur in the forest compared to the plantation where less food diversity, roosting or perching sites are present. Further study is needed to address seasonal effects on diversity indices of bats as our study was carried out during the rains; obviously some species would have been missed. Also, a need for an improved survey method such as the use of bat acoustic equipment to record echolocating bats, use of canopy nets and harp traps for upper and middle canopy bats that will not be found at the ground layer of the forest habitat. This will help proper documentation and also monitor bat activities especially insectivorous bats. Socio-economic surveys are also required to enable policy makers deter loggers from carrying out their illegal activities within the reserve.

ACKNOWLEDGEMENTS.

APLORI funded and provided logistic support for this survey as part of ATE Masters fieldwork. Mr. Nick, Mr. Omonu Clifford and Mr. Titus from Nigeria Conservation Foundation helped out with logistics, caring for our wellbeing and providing useful information. Prof. Ara Monadjem for his valuable contributions and encouragement during the survey and Iroro Tanshi for helping with confirmation of some voucher specimen. Anonymous reviewers for their constructive comments, which greatly improved this report. Stella Egbe and Crossby Omotoriogun for stimulating companionship and support during the field work. ATE and ATA collected, analyzed data and wrote the paper while ATA, MS and OU supervised the study.

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