The abundance and diversity of bird species in Logged Ehor Forest Reserve Edo state, Nigeria

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Abstract

The abundance and diversity of bird species were studied in Ehor Forest Reserve Edo state, Nigeria. The study area was divided into three compartments based on their different land-use types. The line transects method was used to collect bird species diversity and abundance in the study area. In all of 60 transect lines were randomly placed, measuring 1000 m. Each transect was divided into 200 m sections, with each block having 20 transects randomly placed. The site size determined the number of transect lines. Data were collected for six months (Dry and Wet seasons) in 20018. The quadrant method was used to determine plant species composition. This method involves a total enumeration count (TEC) of all trees above 1m in height and a Basal area of not less than 10cm from $25 \times 25m^2$ quadrant sample plot, which was randomly selected through balloting from each sampling compartments. Thirty-five (31) bird species were recorded in the Farmland, Forty-five (45) bird species in the Fallow Area, and sixty-seven (67) species encountered in the Undisturbed forest area. In all, a total of 143 bird species belonging to 43 families and 18 orders were recorded in the three study sites; the Order Passeriformes had the highest frequency (51 %) of the total number of birds recorded, while the dominant families were Cuculidae and Pycnonotidae, comprising (7.4 %) of the total species One endangered bird species, African Grey Parrot and 13 species cuculidae were encountered in the study area. A total of 117 tree species were enumerated in the study area, *Ficus exasperata* had the highest DBH, while Ceiba pentandra has the highest mean height. *Alchornea oppositifolia* has the highest frequency of occurrence in the study area.

Keywords: Agricultural intensification, Avian species, Habitat fragmentation, Home range

Introduction

Nigeria is endowed with a variety of flora and fauna species, including charismatic mammals such as Cross River Gorilla (*Gorilla gorilla diehli*) (Oates *et al.* 2008b), the West African chimpanzee (Pan troglodytes verus (Humle *et al.* 2008), the African bush elephant Loxodonta Africana) (Blanc 2008), white-bellied pangolin (*Phataginus tricuspis*) (Waterman *et al*. 2014), and beautiful avian species such as crowned eagle (*Stephanoaetus coronatus*) (BirdLife International 2012a) and Ibadan malimbe (*Malimbus ibadanensis*) (BirdLife International 2012b). However, biodiversity research and conservation efforts made during the last fifty years have mostly focused on the fauna that in habait southeastern regions further east of Lagos, north, south, or in the Niger Delta near the Cameroon border (Luiselli *et al*. 2015). This is partly because human population densities are lower, and forests are denser in these regions. For this reason, our knowledge of the fauna of south-western Nigeria west of Lagos is deficient (Koyenikan 2004).

Birds are among the best monitors of environmental changes and have been used to evaluate the environment throughout history as biomonitors and; the changes in their population, behavior patterns and reproductive ability have most often been used to examine the long-term effects of habitat fragmentation. Hence they are good indicators of the ecological status of any given ecosystem (Oates 2008a). Forests attract a large number of avifauna because of the habitat suitability for most of them. This mainly includes the birds associated with the vegetation, and for most, trees' existence is vital to their life cycle. Birds show different levels of interest in various stands depending on the age of the stands.

The bird species composition is positively related to the forest¨s vegetation structure. The diversity of birds and the native species is positively correlated with the vegetation's increasing structural complexity. Also, a seasonal change in species diversity of birds occurs in forests due to their foraging behavior (Oates 2008d). The present study was undertaken to assess the distribution and diversity of avifauna species abundance and diversity in Akure Forest reserve south-western Nigeria. These limited studies in Nigeria confirm that much more research needs to be carried out on tropical farmland biodiversity, and these have great potential to contribute to maintaining the populations of common and rare bird species through the well-informed management of agricultural development in Nigeria. The study areas are hotspots for birds in Africa as recorded by International Birdlife Fact. Hence, this research work will provide baseline information that will be of immense importance to other researchers in the management of birds

Materials and methods
Study Area

This study was carried out in Ehor forest reserve Edo state It covers an area of 69.93 km2. The three land uses selected for the study were present within this reserve. Ehor Forest Reserve is managed by the Department of Forestry, Edo State, Nigeria. The study site is situated on latitude 7°18'N and longitude 5°02'E. The three land uses were adjacent to each other. The climate is humid tropical with seasonal variation. The mean annual rainfall is about 4000 mm with double maxima in July and September and a short, relatively dry period in August. December through to February constitutes the major dry season while January and February are the driest months, with each having less than 30 mm rainfall (Ajiboye 2012). . The relative humidity at 15 hours Greenwich Mean Time (GMT) is highest in the maxima months of July and September (81%) and lowest in February (44%). Temperature ranges from about 20.6 °C to 33.5 °C. The monthly mean temperature is about 27 °C, a condition that is conducive to the development of tropical rainforests (Ajiboye 2012). Soils are predominantly ferruginous tropical, typical of the variety found in intensively weathered areas of basement complex formations in the rainforest zone of south-western Nigeria. The soils are well-drained, mature, red, stony, and gravely in the upper parts of the sequence. The texture of topsoil in the reserves is mainly sandy loam (Oksanen *et al.* 2013). The area's natural vegetation is tropical rainforest characterized by emergent with International Journal of Development and Sustainability multiple canopies and lianas. Some of the most commonly found trees in the area include *Melicia excelsa, Afzelia bipindensis, Antiaris africana, Brachystegia nigerica, Lophira alata, Lovoa trichiliodes, Terminalia ivorensis, Terminalia superba,* and *Triplochiton scleroxylon*. However, the area's natural vegetation except for the areas devoted to forest reserve has now been reduced to secondary regrowth forest thickets and fallow regrowth at varying stages of development or replaced by perennial and annual crops (Ogunsesan *et al.* 2012).
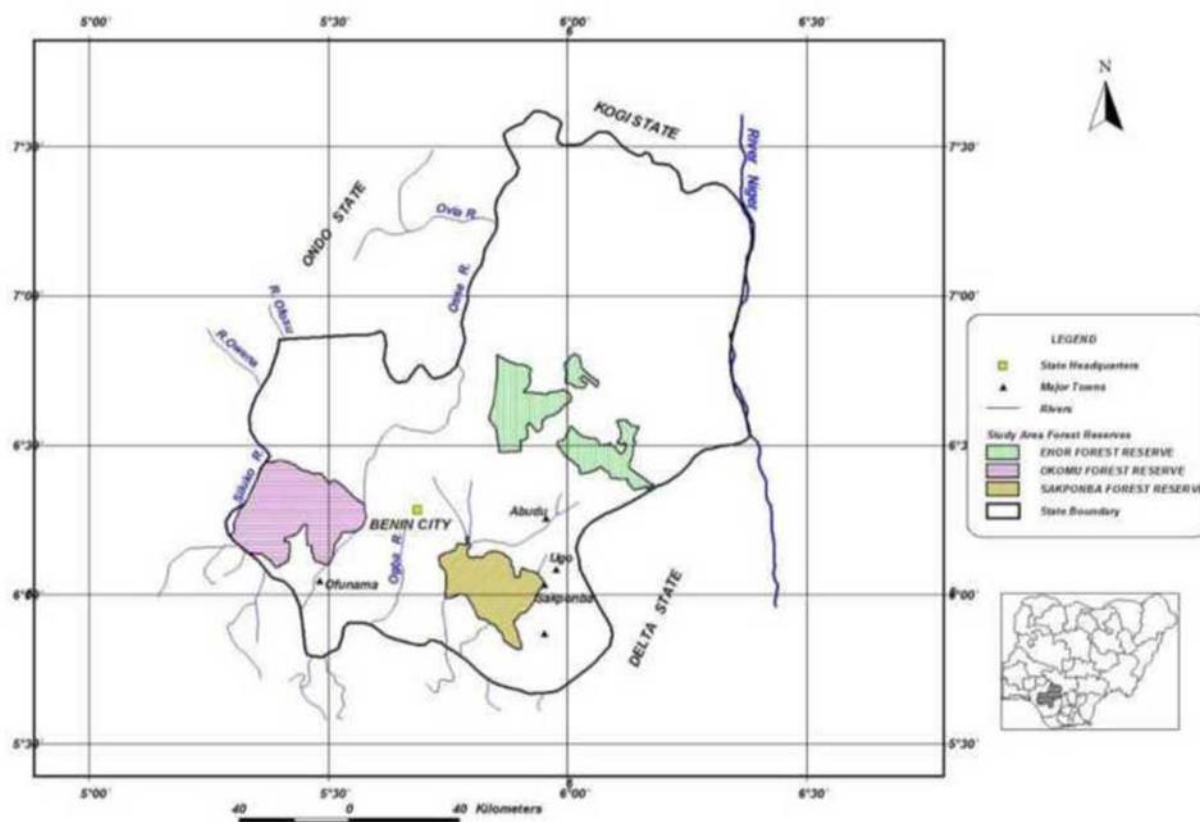
Figure 1: Map of the Study area (source: Aigbe *et al*. 2017)

Data Collection

The study area was divided into three compartments, which include the undisturbed forest area, Farmland and Secondary forest, for the purpose of this study. According to (Sutherland 2009), the line transects method was used to collect data on bird species diversity and abundance in the study area. In all of 60 transect lines were randomly placed, measuring 1000 m. Each transect was divided into 200 m sections with each block having 20 transects randomly placed. The program GPS 2011 Utility (GPSU 2012) was used to locate the starting and ending points of transects. Transect lines were walked three times a week for three months in both seasons (May, July, and September for the wet season and November, January, and March for dry season) of the year. The survey was conducted between 0.600hours and 10.00hours and 1600 hours to 1800 hours; the survey was not conducted beyond 10.00hours in the morning to reduce daylight effect. Transects were walked at an average speed of one kilometer per hour, depending on the terrain and the number of bird species recorded. All birds viewed on the ground or in the vegetation, as well as birds that are flying ahead, were identified and the number in the group recorded. Birds of the same species within 10m of each other were counted in the same group. A pair of binoculars with a magnification 7x 50 was used in the identification of bird species. Distance estimates were obtained by using a digital range finder. The side of the transect that the bird was recorded was also noted to

calculate the distance, for groups made up separately recorded individuals which may have been on different sides of the transect. If birds were in a tight group or recordings were to be made, the distance to the centre of the group was taken. Physical features of birds sighted but could not be identified immediately were taken and field guide book of West African birds (Burrow and Demey 2011) was used to identify the bird species and bird calls was used to confirmed the presence of nocturnal bird species within the study sites. Data was collected for six months three months in the dry season (November, February and March) and three months in the wet season (June, August, and September) in 2014 From the data collected, avian species diversity was calculated using Shannon diversity index, (Usher 1991) which is given as:

$H^i = - \Sigma Pi \ln Pi$

Where: $H^i = {}^{diversity}$ index

 Pi = is the proportion of the ith species in the sample

InPi = is the natural logarithm of the species proportion.

Species Relative Population Density

The relative population density of bird species at various sites and seasons were determined as outlined by Bibby *et al.* (1992) as follows:

$$D = \frac{n_1 + n_2}{\pi r^2 m} Log_e \frac{[n_1 + n_2]}{n_2}$$

where: D = density

r = radius of the first zone

n1 = number of birds counted within zone

n2 = number of birds counted beyond zone and m = number of replicate counts in such area.

Habitat analysis

The quadrant method (Ogunjiemitie *et al.* 2005) was used to determine plant species composition. This method involves a total enumeration count (TEC) of all trees above 1m in height and Basal area of not less than 10cm from $25 \times 25m^2$ quadrant sample plot, which was randomly selected through balloting from each sampling compartments. Three out of the 16 quadrants were randomly selected through balloting in each of the 5 sampling compartments giving 15 plots of a dimension of $25 \times 25m^2$. The following data was collected within each sampling quadrant. They include, the mean height of 22m and above was considered Tall Emergent Tree, 11m to 21m Middle layer and 1m to 10m Understorey. The tree species classification into different strata layers was carried using (Longman and Jennik 1987).

i   Total enumeration of all trees above 1m height and basal area ≥10cm.

ii   Total enumerations of all the tree species (s) and family to which they belong.

iii The diameter of all the plants above 1m in height ≥10cm.

Statistical Analysis

The field survey data were entered into Excel (version 15) spreadsheet prior to both descriptive (tables, frequency, and percentage frequency, graph, pie, and bar charts) and analytical statistics. Variables. Test

of homogeneity for the effect of logging and farming on the bird diversity was carried out using PAST Model.

Results

The result obtained from the research study indicates that the study area supports the diversity and abundance of birdlife. A total of 143 bird species belonging to 43 families and 18 orders were recorded in the study area. The Unlogged compartment has 47% of bird species, which is the highest in the study area, the logged compartment has 31%, and the Farmland has 22% bird species, which is the lowest in the study area (Figure 2). A total of 1131 individual bird species were recorded in the study area, and Farmland has the highest individual bird species (496) while Unlogged compartment has the lowest 274 individual bird species in the study area (Figure 3). The family composition result indicates that *cuculidae* has the highest number of bird species, klass cuckoo, and Dusky Long-Tailed and *Jacobin* Cuckoo have the highest frequency of occurrence during the study (Figure 4). The result of the diversity index indicates that it was higher in the unlogged compartment (4.406) than the rest other two compartments than the compartments Logged (3.341) and Farmland 2.962) Table 1. A total of 117 tree species were enumerated in the study area, *Ficus exasperata* had the highest DBH, while *Ceiba pentandra* has the highest mean height. *Alchornea oppositifolia* has the highest frequency of occurrence in the study area (Table 2). The land use impact on the bird species in linear regression is shown in Figure 6. The forest layers obtained show that the understory has the number of tree species (60), the middle layer 37 tree species, and Tall emergent layer 11 Figure 7. The result of bird species' habitat specialization in the study area indicates that understory has 64 bird species, wetland 11, Grassland 14, Middle layer 37, and tall emergent 17 bird species Figure 8. A checklist of the bird species in the study area is shown in Table 3
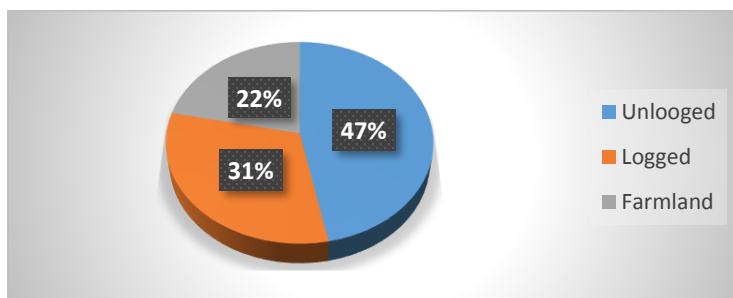

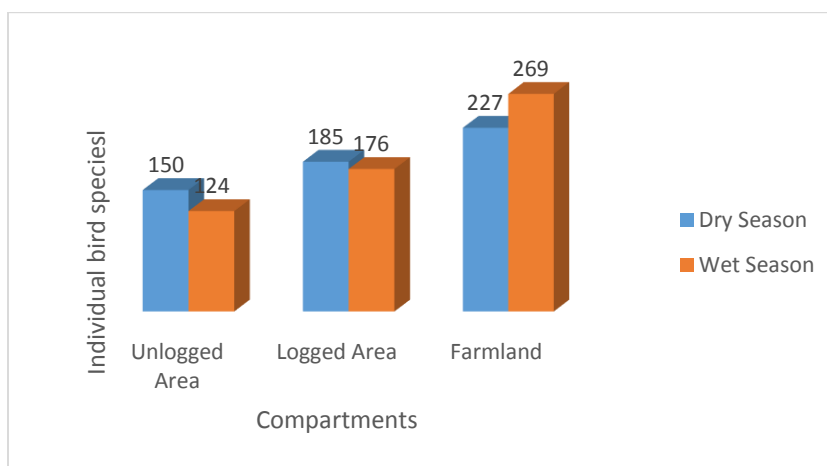**Figure 2:** Percentage of bird Species in each Compartment
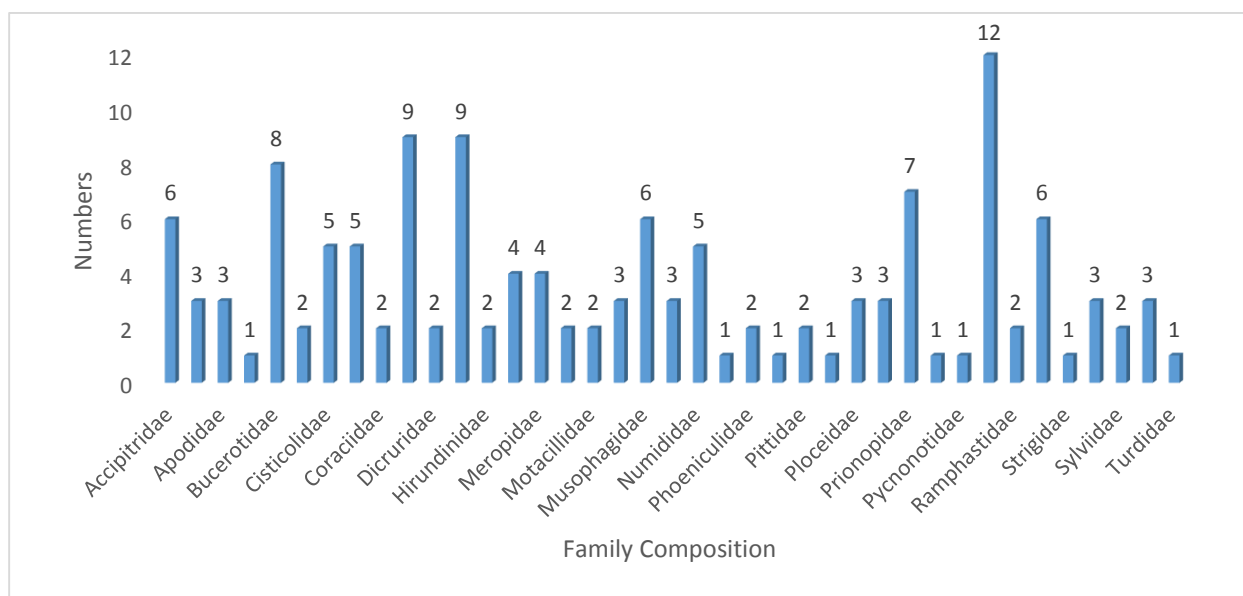
Figure 3: Individual Bird Species in Each Compartment

Figure 4: Family composition in the study area

Table 1: Diversity index of bird species in the study area

Diversity Index	Unlogged	Lower	Upper	Logged	Lower	Upper	Farmlands	Lower	Upper
Taxa_S	92	90	92	46	44	46	22	21	22
Individuals	272	272	272	175	175	175	49	49	49
Dominance_D	0.01349	0.01422	0.01698	0.02609	0.02753	0.03491	0.05789	0.05539	0.08205
Shannon_H	4.406	4.278	4.371	3.732	3.558	3.694	2.962	2.775	2.985
Evenness_e^H/S	0.8905	0.7901	0.8634	0.9075	0.7753	0.8785	0.8787	0.7505	0.9008
Brillouin	3.934	3.826	3.906	3.341	3.192	3.309	2.436	2.286	2.455
Margalef	16.23	15.88	16.23	8.713	8.326	8.713	5.396	5.139	5.396

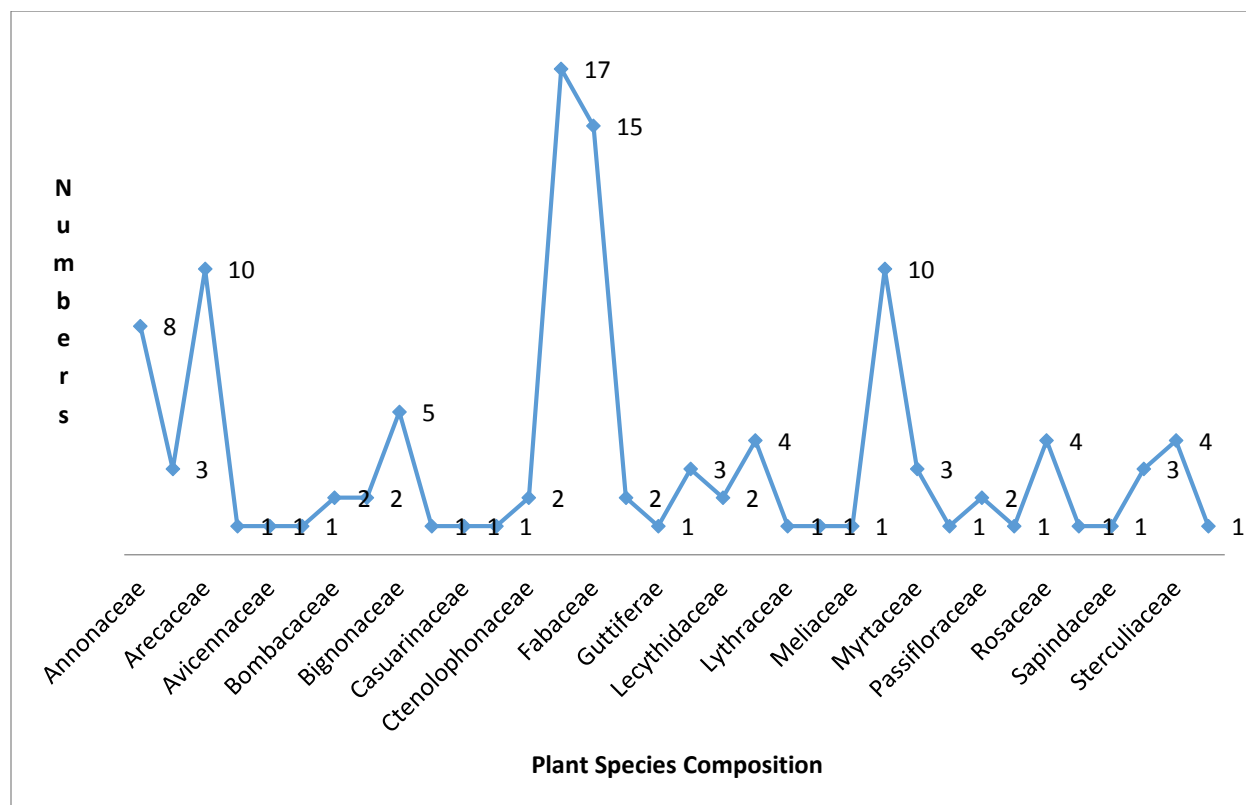| Equitability_J	0.9744	0.9478	0.9675	0.9747	0.9334	0.966	0.9582	0.9065	0.966
Fisher_alpha	48.9	46.99	48.9	20.33	18.9	20.33	15.35	13.92	15.35
Berger-Parker	0.02574	0.02574	0.04779	0.04571	0.04571	0.08571	0.102	0.08163	0.1837

Figure 5: Plant species composition in the study area

Table 2: Checklist of Plant species in the study area

Name of Tree species	Family	DBH (cm)	Mean height (m)	Frequency
Afrolicania elaeosperma	Rosaceae	21	12	1
Alchornea cordifolia	Euphorbiaceae	22	14	8
Alchornea oppositifolia	Euphorbiaceae	23	16	11
Alstonia congensis	Anacardiaceae	24	14	4
Anacardium occidentale	Annonaceae	12	21	2
Anonidium friesianum	Loganiaceae	13	21	3

Name of Tree species	Family	DBH (cm)	Mean Height (m)	Frequency
Anthocleista congonesis	Loganiaceae	23	18	4
Anthocleista nobilis	Loganiaceae	34	19	3
Anthocleista vogelii	Loganiaceae	23	21	4
Anthonotha macrophylla	Euphorbiaceae	45	22	5
Anthostema aubryanum	Moraceae	22	13	6
Artocarpus communis	Avicennaceae	32	17	7
Avicennia germinans	Meliaceae	21	15	5
Azadirachta indica	Balanitaceae	24	17	4
Balanites wilsoniana	Passifloraceae	23	15	7
Barteria nigritiana	Fabaceae	34	16	4
Bauhinia monandra	Fabaceae	30	23	3
Beilschmiedia mannii	Lauraceae	34	16	4
Beilschmiedia gaboonensis	Lauraceae	29	21	2
Beilschmiedia talbotiae	Sapindaceae	26	29	1
Blighia sapida	Bombacaceae	23	14	2
Bombax buonopozense	Euphorbiaceae	24	13	4
Bridelia micrantha	Calophyllaceae	23	12	2
Calophyllum inophyllum	Samydaceae	23	15	3
Casearia barteri	Casuarinaceae	23	29	2
Casuarina equisetifolia	Bombacaceae	34	14	2
Ceiba pentandra	Rutaceae	334	36	1
Chrysobalanus atacorensis	Rutaceae	22	12	2
Chrysobalanus ellipticus	Chrysophylloideae	34	11	3
Chrysophyllum albidum	Rutaceae	19	10	1
Citrus sinensis	Annonaceae	31	8	3
Cleistopholis patens	Arecaceae	13	9	2
Cocos nucifer	Sterculiaceae	14	8	1
Cola gigantea	Sterculiaceae	280	39	32
Cola nitida	Boraginaceae	17	8	3
Cordia abyssinica	Boraginaceae	12	9	2
Ctenolophon englerianus	Ctenolophonaceae	11	8	1
Ctenolophon englerianus	Ctenolophonaceae	14	10	2
Ctenolophon englerianus	Lecythidaceae	21	11	4
Crateranthus talbotii	Fabaceae	12	9	1

Continuted table 2: Checklist of plant species in the study area

Name of Tree species	Family	DBH (cm)	Mean Height(m)	Frequency
Delonix regia	Fabaceae	23	31	3
Dialium guineensis	Fabaceae	34	12	4
Dissomeria crenata	Euphorbiaceae	33	12	1
Drypetes principum	Arecaceae	32	33	2
Elaeis guineensis	Fabaceae	36	21	1
Erythrina senegalensis	Myrtaceae	39	31	2

Name of Tree species	Family	DBH (cm)	Mean Height(m)	Frequency
Eugenia malaccensis	Moraceae	40	22	3
Ficus congoensis	Moraceae	34	11	3
Ficus exasperata	Moraceae	336	35	3
Ficus sycomorus	Moraceae	22	11	4
Funtumia elastic	Tiliaceae	34	17	3
Grewia coriacea	Malvaceae	29	35	2
Holarrhena floribunda	Euphorbiaceae	28	12	4
Hura crepitans	Rosaceae	18	11	2
Hymenocardia heudelotii	Samydaceae	17	13	1
Homalium molle	Samydaceae	21	14	1
Homalium africanum	Flacourtiacea	21	11	1
Icacina trichantha	Bignonaceae	21	12	2
Jacaranda mimosifolia	Bignonaceae	21	12	2
Keayodendron bridelioides	Phyllanthaceae	37	21	2
Lagerstroemia speciosa	Lythraceae	28	11	3
Laguncularia racemosa	Flacourtiaceae	22	12	1
Lindackeria dentata	Euphorbiaceae	26	13	4
Macaranga barteri	Euphorbiaceae	29	14	2
Macaranga heudelotii	Euphorbiaceae	30	13	1
Maesobotrya barteri	Anacardiaceae	23	13	2
Mangifera indica	Moraceae	27	31	1
Milicia excelsa	Fabaceae	81	34	2
Millettia thonningii	Rubiaceae	33	27	3
Morinda lucida	Moraceae	35	16	1
Musanga cecropioides	Moraceae	37	33	2
Myrianthus preussi	Moraceae	38	35	1
Myrianthus arboreus	Lecythidaceae	31	13	2
Napoleona vogelii	Euphorbiaceae	34	12	1
Neoboutonia velutina	Annonaceae	30	23	3
Neostenanthera myristicifolia	Sterculiaceae	36	16	1
Nesogordonia papaverifera	Bignonaceae	41	15	2
Newbouldia laevis	Bignonaceae	44	27	2
Ochna multiflora	Ochnaceae	31	22	1
Ouratea calantha	Rosaceae	34	15	2

Continuted table 2: Checklist of plant species in the study area

Name of Tree species	Family	DBH (cm)	Mean Height(m)	Frequency
Parinari congensis	Rosaceae	31	17	1
Parinari robusta	Fabaceae	24	13	2
Peltophorum pterocarpum	Fabaceae	21	15	1
Pentadesma butyracea	Lauraceae	23	12	2
Persea americana	Arecaceae	22	11	1
Phoenix reclinata	Arecaceae	21	14	3

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Phyllanthus physocarpus	Fabaceae	26	14	3
Piptostigma pilosum Oliv	Fabaceae	10	9	3
Pithecelobium dulce	Fabaceae	12	9	2
Plagiostyles africana	Myrtaceae	7	10	1
Psidium guajava L	Annonaceae	6	4	2
Polyalthia oliveri	Arecaceae	13	11	3
Raphia hookeri	Apocynaceae	11	9	3
Rauvolfia vomitora	Arecaceae	10	8	2
Roystonea oleraceae	Arecaceae	21	9	1
Sacoglottis gabonensis	Flacourtiaceae	14	9	3
Scottellia mimfiensis	Fabaceae	16	8	2
Senna alata	Fabaceae	12	7	2
Senna fistula	Passifloraceae	25	11	3
Smeathmannia pubescens	Fabaceae	12	7	3
Senna siamea	Euphorbiaceae	16	9	1
Spondianthus preussii	Anacardiaceae	27	12	2
Spondias mombin	Sterculiaceae	29	11	2
Sterculia tragacantha	Guttiferae	23	12	3
Symphonia globulifera	Myrtaceae	24	10	2
Syzygium rowlandii	Bignonaceae	25	11	1
Tabebuia rosea	Moraceae	34	12	2
Treculia africana	Euphorbiaceae	27	11	1
Triumfetta cordifolia	Euphorbiaceae	23	10	2
Uapaca esculenta	Euphorbiaceae	29	12	7
Uapaca heudelotii	Euphorbiaceae	29	12	2
Uapaca paludosa	Euphorbiaceae	27	15	3
Uapaca vanhouttei	Euphorbiaceae	28	15	17
Urena lobate	Annonaceae	28	21	2
Uvariastrum insculptum	Annonaceae	27	16	1
Xylopia rubescens	Annonaceae	24	8	4
Xylopia stauditii	Annonaceae	29	11	2
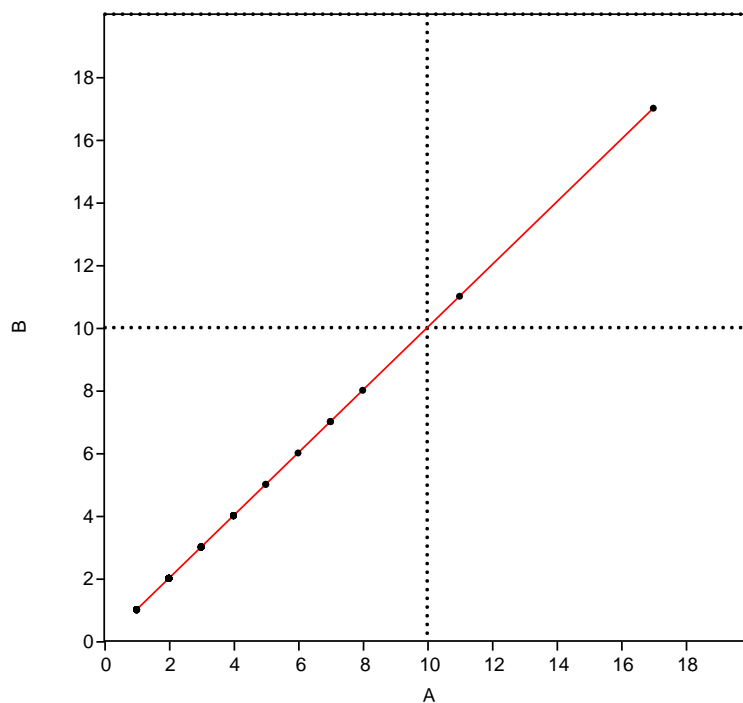
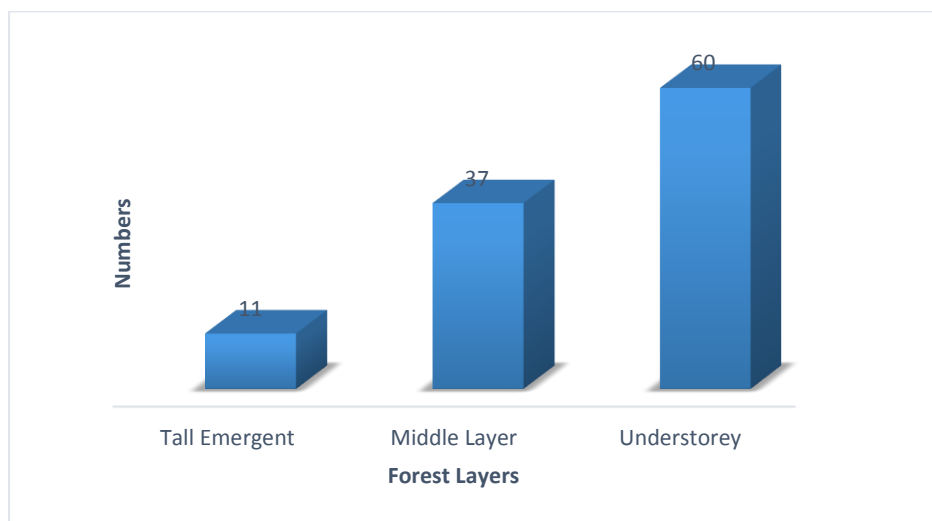**Figure 6:** Bird species diversity in the study area (generalized linear model)
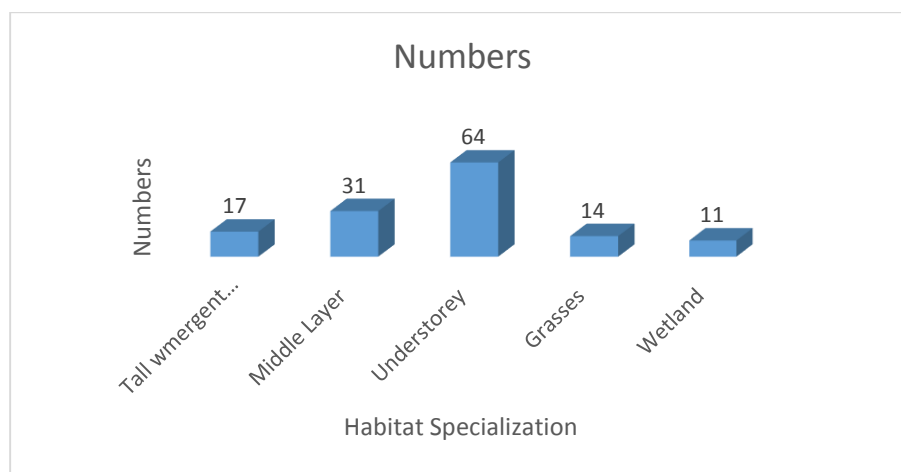

Figure 7: Forest layers in the Study Area

Figure 8: Habitat Specialization of Bird Species in the Study Area

Discussion

Our study showed that species diversity and richness of bird species in the study area were adversely affected by forest modification and land use. The result obtained bird species recorded in the undisturbed forest was higher than the rest two compartments, Fallow Area and the Farmland. The observed change in the species richness of several bird groups along the habitat gradient is remarkable because influences farms and deforestation in the study were large compared to the undisturbed area. This is consistent with (Petit and Petit 2003) that understory dwelling rather than canopy or edge-dwelling habit, specialized foraging strategies, and restricted geographic range could be responsible for this observation. Waltert *et al.* (2004) identified general characteristics of forest species sensitive to deforestation and land use, in addition, they suggested that resident birds, in contrast to nonbreeding visitors, mainly prefer forest habitats. Lindell *et al.* (2004) reported that resident forest species are often behaviorally inhibited from entering the open agricultural land, functioning as a barrier for dispersal. The Fallow compartment has fewer bird species than the undisturbed forest, which is consistent Turner *et al.* (1997) that secondary forest have a less complex vegetation structure and a lower species richness of larger trees compared to the near-primary forest (Turner *et al.* 1997), which in turn could lead to reduced variability in foraging substrates.

Indeed, the tree diameter distribution and mean high of tree species in the study sites showed that larger trees of certain size classes were reduced in the secondary forest sites than a primary forest, and the architecture of secondary forests was possibly more homogeneous than near-primary forest. The relative abundance of avian species in the study area was higher in the Farmland than in the rest study sites. This agrees with Kormar (2006) previous work, which also reported a high abundance of bird species in cultivated areas, which could be due to food availability. This is also consistent with the result obtained by Best *et al.*(1990) that the extent of change in bird species composition and abundance depends on the specificity of each bird species habitat requirement; in other words, the species tolerance to changes to its environment. Species with the restricted habitat changes pattern are more vulnerable to changes in land-use practices than those occupying a wider variety of environments. From the result of diversity bird

species, it was higher in the Unlogged Area (4.406) than the rest other two compartments logged Area (3.906) and Farmland (2.962). This result is supported by the previous work where (Kangah- Kesse *et al.,* (2008), who surveyed bird diversity in Abiriw sacred grove in Eastern Ghana and used the Shannon diversity index, recorded a value of 4.46 for the woods near the primary forest and 3.36 for the surrounding cultivated areas. The Undisturbed Area is a primary forest with three strata layers, bird species that utilize tall emergence trees such the (Black and White Casqued Hornbill and Great Blue Turaco) were encountered and bird species that utilize understory such as the (Little Greenbul, Common Bulbul, White-Tailed Aletheetc.) were also sighted.   This is consistent with MacArthur and MacArthur (2001), who reported that diversity increases with the vegetation number. Pearson (2001) reported that tropical wet evergreen forest supports more rare bird species than other habitats. Manu (2000) reported that birds select vegetation variables according to how an individual habitat affects access to food, mates or its vulnerability to predators. This is also in agreement with the report that altering habitats and changing population structure affects the avian population. The result also revealed the Shannon diversity index values, showing that there was no significant difference in bird species diversity between Farmland and Fallow Area; this is expected presumably because of the edge effect in farmland area. Previous studies support this; edge effects are described to be remarkably diverse, ranging from changes in species abundance (Manu, *et al.* 2007). Bird species are important indicators of environmental quality and ecological functionality. In this study, we provided data on the response of bird species to certain structural attributes of a natural forest, such as the presence of mature and heterogeneous forest stands (high level of DBH). This study shows that the Undisturbed Forest Area near the primary forest is the best habitats for the birds as far as the numbers and diversity are concerned. As the most severe loss of the biodiversity value occurs in the transformation of original landscapes to croplands due to human interference (Keith *et al.* 1992). Reduction in habitats quality is thought to be the main underlying causes of the declines in most farmland bird species (Newton 2004)

In the farmlands, we have few trees and less (DBH) resulting in the decline of bird species abundance and richness. This is supported by previous work of Donald *et al.* (2006) reported that the conversion of greater areas of land to farming has reduced habitat heterogeneity and led to reductions in species richness and declines in bird species which were once common forest species.

Conclusion

Bird species diversity was higher in the Undisturbed forest Area than the Fallow area and Farmland within the study area, which suggests that land-use change between the three blocks was responsible for this.   Large settlement camps are springing up in the study area, and these people are involved in logging, majorly cutting down commercial timber species such as *Ceiba pentandra*, *Alstonia congensis Cola gigantea, Daniella ogea; f*arming intensification is ongoing in the area, and compartments have been cleaved for the cultivation of cocoa and plantain farms. Government official allocates blocks to timber loggers without proper monitoring, and poaching is ongoing too. Deforestation and settlements by the local people should be discouraged. The sustainable harvest of tree species in this area should be managed appropriately to support avian habitats. Land conversion for agricultural purposes is very high in this region since most of the communities are agrarian. However, this may increase extinction risk for many threatened and endangered birds in the area, such as African Grey parrot, Black Casqued Hornbill,,

Great Blue Turaco and Crested Guinea fowl. The management of these areas should design programs to discourage bush burning, livestock grazing, deforestation, and illegal farming in the forest area.

As a result of urban settlement catching up with the study area from all directions, it is like an Island in trouble. This is why the management of this Ehor forest reserve should seek assistance from other conservation agencies that should come up with technical assistance that will further impact the management of the forest block within the study area.

Acknowledgments

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