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PATTERNS IN BIRD SPECIES RICHNESS AND ABUNDANCE IN THE UNIVERSITY OF LAGOS, AKOKA CAMPUS

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ABSTRACT

Biodiversity is declining globally partly due to urbanization which is often accompanied by habitat destruction, fragmentation and loss. In this study we investigated the factors influencing the patterns in bird species richness and abundance within an urban environment; the Akoka campus of the University of Lagos between July and August 2016 using the line transect method. A total of 34 transects of length 200 m were placed in a randomly stratified manner throughout the study area. The influence of habitat disturbance and habitat variables such as densities of large trees, small trees, shrubs and buildings as well as percentage ground cover on bird richness and abundance were tested using general linear models. Our results revealed that a total 1,927 birds belonging to 53 species and 32 families were encountered during the study period. Our best models retained time of day, percentage of ground cover, densities of shrubs and buildings as well as level of anthropogenic disturbance as significant predictors of bird richness and abundance. The magnitude of influence of the vegetation variables depended on the level of disturbance. On the whole, our result confirms the findings of previous studies that local vegetation and habitat characteristics such as densities of shrubs and buildings in urban areas influence bird species richness and abundance. In conclusion, although the University of Lagos, Akoka campus has a great potential for supporting avian species, increasing or retaining the existing vegetation cover will help mitigate the impact of anthropogenic disturbance on species richness.

Keywords: Bird species, species richness, urban biodiversity, University of Lagos

INTRODUCTION

Avian species patterns within urban areas have been the subject of many studies in recent time (e.g. Lim and Sodhi, 2004; Mckinney, 2008; Parker *et al.* 2014). This is largely due to the fact that birds are widespread, mobile and have been documented as good indicators of the health of the environment especially with the current spate of urbanisation and its accompanying habitat modification. The process of urbanization removes fragments and isolates natural vegetation, replacing it with roads and buildings while also introducing exotic plants, predators and competitors to the native wildlife (Chase and Walsh, 2006). Urbanisation has been shown to affect the abundance, diversity and composition of wildlife species through a reduction in the quantity and quality of available habitats (Mckinney 2008, Ferenc *et al.*, 2014; Sol *et. al.*, 2014). Birds are specifically sensitive to the environmental changes that follow processes such as urbanisation. This is because their densities and diversity changes as vegetation structure changes (e.g. Villegas and Garitano-Zavala, 2010; Parker *et al*. 2014). Further, the populations of many bird species have been declining as a result of insufficient adaptations to landscape changes that occur during urban expansion (Sol *et al*., 2014). Along a rural-urban gradient bird diversity reduces while abundance increases. Within urban areas, some species have been shown to exploit or even adapt to the urban habitats. For this group of species, food supplementation from human activities and reduction in predation pressure has been linked to their ability to maintain high densities (McKinney, 2002; Chase and Walsh, 2006).

In many urban areas there are often sparsely distributed green spaces which may be remnants of primary and secondary forests, managed vegetations such as parks and gardens or urban cemeteries (McKinney, 2002; Fontana *et al.,* 2011; Ferenc *et al.,* 2014). These habitats have the capacity to help maintain relatively high avian densities and diversities even in what seems like a sea of highly urbanised environment (Chase and Walsh, 2006). The quality and quantity of these green spaces can influence bird species composition within urban centres (Sandström *et al.,* 2006, Ferenc *et al.,* 2014). It is predicted that by 2050 about 70% of the world's population will live in cities (United Nations, 2008). This will likely put pressure on the available forest and influence the patterns in species composition across the world.

The University of Lagos, Nigeria is located in the densely populated and highly urbanised city of Lagos which was estimated to be home to over 9.1 million inhabitants as at 2006 (NBS, 2009). In many parts of the city, the original vegetation has been lost to buildings, road networks and concrete surfaces or has become fragmented and isolated. This can have a negative effect on the capacity of the city to support biodiversity and more specifically bird species. The university however still hold some of the natural mangrove vegetations of Lagos (Ogundele, 2012). Given that there is no documented survey of bird species of the University of Lagos, this study investigates the factors influencing bird species richness and abundance on the campus; an environment that is characterised by built habitats and green patches. The study also seeks to provide a checklist of bird species for the site. This information is vital for checking how developmental projects like the construction of buildings will influence the composition and densities of birds in the future.

MATERIALS AND METHODS

Study site

The study was conducted in the University of Lagos campus Akoka, Yaba Lagos, South western Nigeria (6° 32' N, 3° 24' E) from July to August 2016. The study area covers an approximate 802 acres (3.25km^2) of land area and is surrounded by the Lagos lagoon on two sides. The study area has an elevation of 40 - 90 m with an undulating terrain, half of which represents buildings, with mangrove swamp and creeks passing across at different locations (Nodza *et al.*, 2014). The vegetation is characterised by mangrove forest, secondary vegetations and introduced plants species (Adekambi and Ogundipe, 2009; Nodza *et al.*, 2014).

Bird Survey

Bird species were surveyed using the line transect method (Sutherland, 2006). Given that the University of Lagos is situated in an urban environment characterised by high human population and traffic density, we used vehicular traffic as a proxy for anthropogenic disturbance in this study. Hence we estimated vehicular traffic as the number of cars passing per minute on the major roads within the study site. Thereafter we categorized the habitat into two based on the volume of vehicular traffic on the major road traversing them: the Low disturbance habitat (vehicular traffic <10 cars/minute) and High disturbance habitat (vehicular traffic > 10 cars/minute). The mean traffic volume of the two categories differed significantly from each other (t-test: $t=-9.95$, $df=22$, $p<0.001$). To allow for sufficient coverage of the study site, 17 transects of length 200 m and at least 100 m apart, were placed in a stratified random manner in each of the habitat types. The length of transect was chosen due to the density of buildings and road networks within the study site. Birds were identified using a pair of binoculars (Lotus® 8 x 42) and following features described by Borrow and Demey (2001). All birds seen or heard along transects were recorded. All birds in flight were recorded only as part of the species checklist for the site. This category of birds was not included in the analysis. All transects were surveyed in the morning between the hours of 0630 – 0900 and in the evening between 1600 – 1800, to account for possible difference in detection probability that may occur due to time of day (Manu and Cresswell, 2007). Each transects was visited twice and a total distance of 6,800 m covered. The start and end points of all transect were marked with a GPS unit (Garmin®; GPSMAP 64).

Vegetation Assessment

For every transect surveyed, data on the influence of the vegetation structure and composition on bird species were collected. Hence at every 200 m of the transects a 10 x 10 m quadrat was randomly placed and within it we counted the number of large trees above 2 m in height (Manu *et al.*, 2005). In addition, we randomly placed four 2 x 2 m quadrats within the 10 x 10 m quadrat by throwing a stick over the shoulder. Within these quadrats the following measurement were taken:

1. Number of small trees above 1 m (trunk diameter >10 cm)
2. Number of shrubs (diameter 1-10 cm)
3. The percentage ground cover (estimated by eye to the nearest 5%)

In addition, we estimated the number of building within a radius of 50 m. This was used a measure of the influence of anthropogenic activity on the transect data.

Data Analysis

We estimated bird species richness and abundance as the total number of species and individuals respectively recorded per transect. We fitted General linear models in R statistical package version 3.1.3 (2015-03-09) (R Core Team 2015) with *bird species richness* and *abundance* entered as dependent variables in separate analyses. *Habitat* was included as a factor while *number of large trees, number of small trees, number of shrubs, percentage ground cover* and *number of buildings* were entered as covariates. In addition the two-way interactions between *Habitat* and the vegetation variables were included in the model. Using the stepwise backward elimination method (Crawley, 2012), variables with the highest P-values were removed starting with the non-significant interactions and the procedure repeated until the best model was attained. All the subsequent models were compared using the Akaike's Information Criteron (AIC; Burnham and Anderson, 2002) and the best model was selected as the model with the least AIC value. Statistical significance was considered at $p<0.05$. Bird abundance data was square root transformed to improve the normality of its residuals.

RESULTS

A total of 1,927 birds comprising 53 species and 32 families were recorded during this study (Table 1). Out of this number, only 49 species were recorded on transects whereas 4 species namely Black Kite *Milvus migrans*, African Openbill *Anastomus lamelligerus*, Palm-nut Vulture *Gypohierax angolensis* and the White-faced Whistling-duck *Dendrocygna viduata* were recorded in flight or off transects. Several individuals of the endangered Grey Parrot *Psittacus erithacus* (BirdLife International, 2017) were recorded during this survey. All other species recorded are currently categorised as Least Concerned under the IUCN Red List (IUCN 2018).

Bird species richness was significantly related to the percentage of ground cover and densities of shrubs and buildings in the study area (Table 2). The pattern of the relationship however differed between the two habitat categories (interaction terms Habitat*ground cover: $t=-2.36$, $p=0.022$; Habitat*shrubs: $t=2.1$, $p=0.040$; Habitat*buildings: $t=-2.91$, $p=0.005$, Table 2**)**. Whereas species richness increased with increase in the percentage of ground cover and the densities of shrubs and buildings respectively in the low disturbance habitat, it decreased with increase in ground cover and density of buildings in the high disturbance area. The magnitude of increase in bird richness in relation to increased shrub density was greater in the high disturbance area than the area with low disturbance (Fig. 2), even though shrub density was not significantly different between the two areas (t-test; $p=0.551$). On the overall, bird species richness was significantly higher in the morning (Mean=8.1, SE=2.26) than in the evening (Mean=3.6, SE=1.15).

Bird abundance was significantly influenced by time of survey ($t= -4.10$, $p<0.001$), Habitat type ($t= 2.29$, $p=0.025$), as well as the interactions of Habitat*ground cover ($t= -2.16$, $p=0.035$) and Habitat*buildings ($t= -2.55$, $p=0.013$). In both habitat types, a significantly higher bird abundance was recorded in the morning (habitat 1: mean=19.1, SE=0.32; habitat 2: mean=40.5, SE=2.06) than in the evening (habitat 1: mean=9.2, SE=0.06; habitat 2: mean=25.2, SE=1.23). Mean bird abundance was significantly higher in the morning (mean=19.1, SD=9.31) than in the evening (mean=11.55, SD=8.43). Bird abundance increased with increase in ground cover and density of buildings in habitat 1 whereas the relationship was negative in habitat 2 (Figs. 2 and 3).

Table 1: Checklist of bird species recorded during the study.

Family	Common name	*Scientific name*	IUCN Redlist status[†]
Columbidae	African Green Pigeon	*Treron calvus*	LC
Bucerotidae	African Grey Hornbill	*Tockus nasutus*	LC
Jacanidae	African Jacana	*Actophilornis africana*	LC
Apodidae	African Palm-swift	*Cypsiurus parvus*	LC
Turdidae	African Thrush	*Turdus pelios*	LC
Ardeidae	Black Heron	*Egretta ardesiaca*	LC
Accipitridae	*Black Kite	*Milvus migrans*	LC
Alcedinidae	Blue-breasted Kingfisher	*Halcyon malimbica*	LC
Columbidae	Blue-headed Wood Dove	*Turtur brehmeri*	LC
Coraciidae	Broad-billed Roller	*Eurystomus glaucurus*	LC
Estrildidae	Bronze Manikin	*Lonchura cucullata*	LC
Ardeidae	Cattle Egret	*Bubulcus ibis*	LC
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	LC
Falconidae	Common Kestrel	*Falco tinnunculus*	LC
Rallidae	Common Moorhen	*Gallinula chloropus*	LC
Platysteiridae	Brown-throated Wattle-eye	*Platysteria cyanea*	LC
Cuculidae	Diederik Cuckoo	*Chrysococcyx caprius*	LC
Hirundinidae	Ethiopian Swallow	*Hirundo aethiopica*	LC
Nectariniidae	Green-headed Sunbird	*Cyanomitra verticalis*	LC
Phoeniculidae	Green Wood-hoopoe	*Phoeniculus purpureus*	LC
Ardeidae	Grey Heron	*Ardea cinerea*	LC
Falconidae	Grey Kestrel	*Falco ardosiaceus*	LC
Psittacidae	Grey Parrot	*Psittacus erithacus*	EN
Picidae	Grey Woodpecker	*Dendropicos goertae*	LC
Cisticolidae	Grey-backed Camaroptera	*Camaroptera brevicaudata*	LC
Ardeidae	Intermediate Egret	*Ardea intermedia*	LC
Columbidae	Laughing Dove	*Spilopelia senegalensis*	LC
Ardeidae	Little Egret	*Egretta garzetta*	LC
Apodidae	Little Swift	*Apus affinis*	LC
Phalacrocoracidae	Long-tailed Cormorant	*Microcarbo africanus*	LC
Ciconiidae	*African Openbill	*Anastomus lamelligerus*	LC
Cisticolidae	Oriole Warbler	*Hypergerus atriceps*	LC
Corvidae	Pied Crow	*Corvus albus*	LC
Alcedinidae	Pied Kingfisher	*Ceryle rudis*	LC
Columbidae	Red-eyed Dove	*Streptopelia semitorquata*	LC
Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	LC
Cuculidae	Senegal Coucal	*Centropus senegalensis*	LC
Psittacidae	Senegal Parrot	*Poicephalus senegalus*	LC
Muscicapidae	Snowy-crowned Robin-chat	*Cossypha niveicapilla*	LC
Columbidae	Speckled Pigeon	*Columba guinea*	LC
Sturnidae	Splendid Starling	*Lamprotornis splendidus*	LC
Nectariniidae	Splendid Sunbird	*Cinnyris coccinigastrus*	LC
Charadriidae	Spur-winged Lapwing	*Vanellus spinosus*	LC

Nectariniidae	Variable Sunbird	*Cinnyris venustus*	LC
Viduidae	Village Indigobird	*Vidua chalybeata*	LC
Ploceidae	Village Weaver	*Ploceus cucullatus*	LC
Columbidae	Vinaceous Dove	*Streptopelia vinacea*	LC
Musophagidae	Western Plantain-eater	*Crinifer piscator*	LC
Alcedinidae	Woodland Kingfisher	*Halcyon senegalensis*	LC
Ardeidae	Western Reef-egret	*Egretta gularis*	LC
Anatidae	*White-faced Whistling-duck	*Dendrocygna viduata*	LC
Malaconotidae	Yellow-crowned Gonolek	*Laniarius barbarus*	LC
Accipitridae	*Palm-nut Vulture	*Gypohierax angolensis*	LC

*Species recorded in flight
[†]LC= Least Concern, EN = Endangered

Table 2: Summary statistics of variables retained in the final model for the relationship between bird species richness, abundance and Habitat variables. Habitat 1 and session (morning) were set as the intercept. Significant *P* values are in bold.

Adjusted R^2= 0.38, AIC=411.8				
	Estimate	**SE**	**t-value**	***P***
Species Richness				
Intercept	8.051	2.26	3.57	**<0.001**
Session (Evening)	-4.441	1.10	-4.03	**<0.001**
Small trees	0.111	0.38	0.29	0.772
Habitat2	7.070	3.57	1.98	0.053
Ground cover	0.051	0.03	1.50	0.139
Shrubs	0.660	0.95	0.7	0.489
Large trees	-0.021	0.63	-0.03	0.974
Buildings	0.994	0.3	3.35	**0.001**
Habitat2*Ground cover	-0.113	0.05	-2.36	**0.022**
Habitat2*Shrubs	3.071	1.46	2.1	**0.040**
Habitat 2*Large Trees	2.026	1.08	1.87	0.067
Habitat2*Buildings	-1.828	0.63	-2.91	**0.005**
Bird Abundance: R^2= 0.29, AIC=242.2				
	Estimate	**SE**	**t-value**	***P***
Abundance				
Intercept	4.369	0.57	7.71	**<0.001**
Session (Evening)	-1.340	0.33	-4.10	**<0.001**
Habitat2	1.994	0.87	2.29	**0.025**
Ground Cover	0.019	0.009	2.07	**0.043**
Buildings	0.214	0.08	2.82	**0.006**
Habitat2* Ground cover	-0.028	0.01	-2.16	**0.035**
Habitat2*Buildings	-0.333	0.13	-2.55	**0.013**

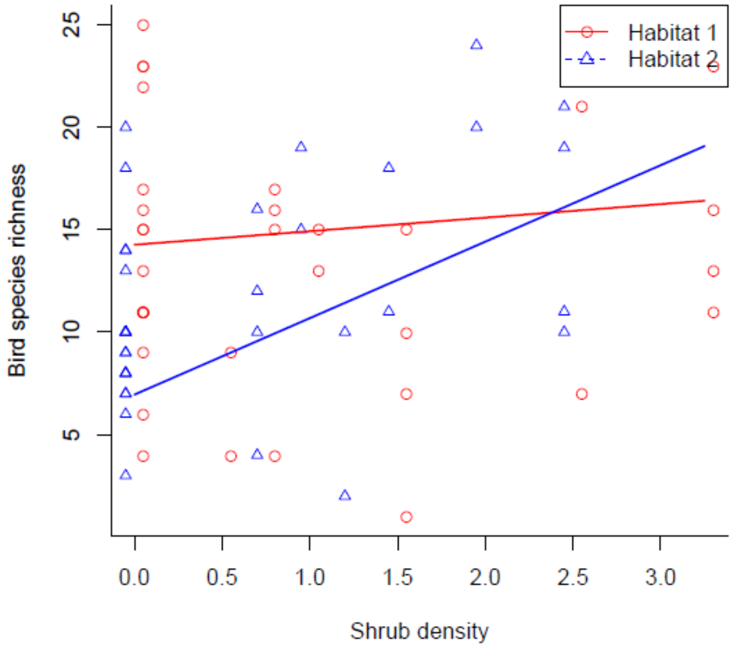

Figure 1: Predicted relationship between bird species richness and shrub density in areas with low disturbance (Habitat 1) and high disturbance (Habitat 2)

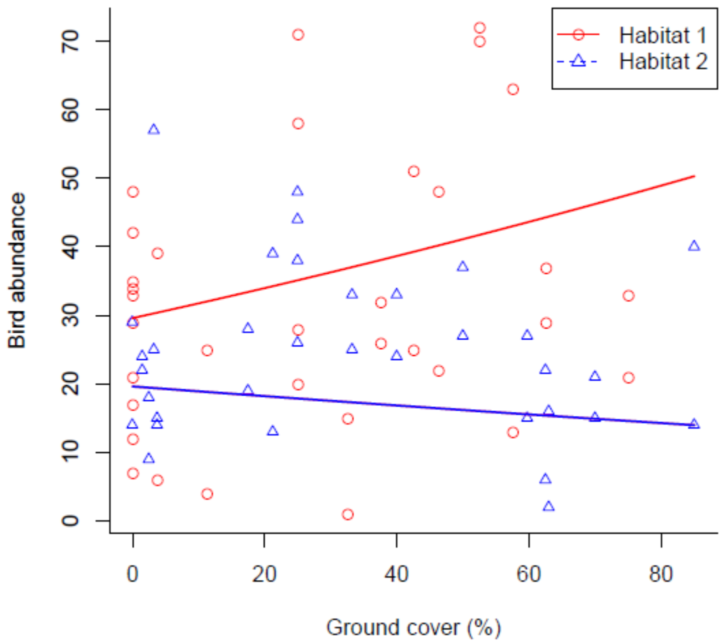

Figure 2: Predicted relationship between bird species abundance and percentage of ground cover in areas with low disturbance (Habitat 1) and high disturbance (Habitat 2)

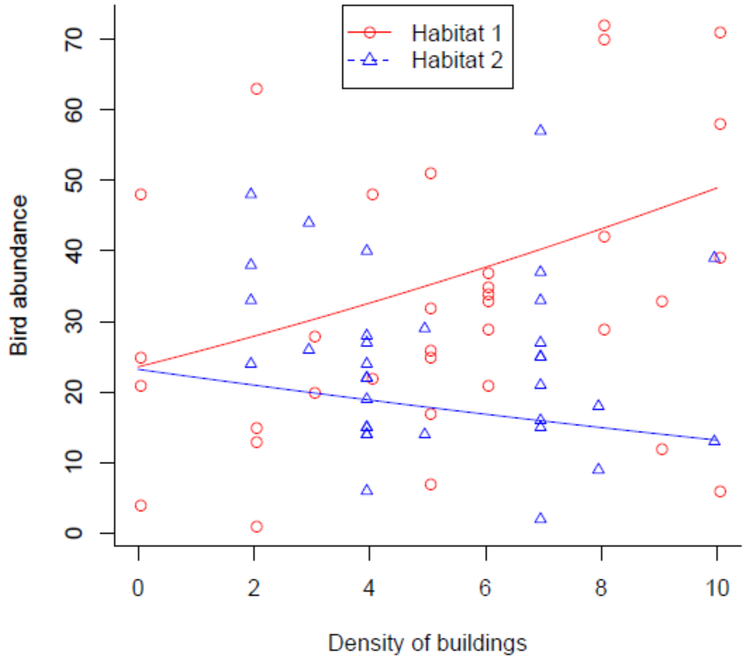

Figure 3: Predicted relationship between bird species abundance and density of buildings cover in areas with low disturbance (Habitat 1) and high disturbance (Habitat 2)

DISCUSSION

Our study reveals that the fifty three (53) species of birds representing 33 families were recorded in the University of Lagos within the period of this survey. Habitat modifications and loss have been documented to influence species richness and diversity. In urban areas, landscape characteristics and vegetation composition have been documented to have significantly impacts on the abundance, diversity and richness of many taxa. Our result confirms the findings of previous studies that local vegetation characteristics such as density of shrubs influence bird species richness (Parker *et al*., 2014). Summers *et al.* (2011) reported that although bird species richness reduces with decreasing distance from roads, the decrease is likely due to mortality arising from vehicular traffic rather than road traffic noise. In this study, bird richness declined as ground cover and building density increased in the high disturbance area. This is likely due to the effect of high volume of traffic which can negatively affect communication within species and consequently result in impaired breeding success; a plausible mechanism which has also been suggested by Villegas and Garitano-Zavala (2010). In spite of vehicular traffic disturbance in both areas, bird species richness increased with increase in shrubs. This shows that increase in vegetation cover can mitigate the negative effect of anthropogenic noise on bird species via the provision of nesting, foraging and roosting habitats for different bird species. In addition, Tratalos *et al.* (2007) reported that moderate housing density can have a positive effect on bird richness. Our result for the low disturbance area supports this finding. In this study we report that the volume of vehicular traffic did not result in a decline in bird species richness. This is likely due the urbanized nature of the study site and also the positive influence of shrub density on species richness via the provision of nesting, foraging and roosting habitats for different bird species. The patterns of change in bird species richness due to ground cover and building density however depended on the level of disturbance in the study areas.

In this study bird abundance was only significantly influenced by ground cover and density of buildings. Generally, bird abundance has been reported to increase in response to increase in urbanization (Chase and Walsh, 2006) and this increase has been attributed to the availability of food subsidies and the reduction of predation pressure (McKinney, 2002). Our results also showed that in the high disturbance area, bird abundance declined significantly with increase in ground cover and building density. This probably suggests that the disturbance level exceeds that which can maintain maximum abundance of bird species in the study area.

CONCLUSION

This study highlights the potentials of the University of Lagos, Akoka campus to support a relatively diverse number of bird species within the highly urbanized city of Lagos. Given the general scarcity of land in Lagos and the increasing pressure on available land by a growing human population for urban infrastructures, the challenge of retaining the remaining natural vegetations becomes more intense. Urban environments like the University of Lagos, can help maintain a rich diversity of fauna if development is properly planned and managed. As shown in this study, birds and other taxa of species will benefit from the retention of a matrix of vegetation cover which can have significant impacts on life history events.

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