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Impacts of plant functional traits and bird visitation on the abundance and diversity of birds in Zandama hill, Jigawa state, Nigeria

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Abstract

Understanding the link between bird community diversity and plant types, particularly in places with varied geographical and climatic gradients like the Zandama Hills Forest Reserve in Jigawa State of Northwestern Nigeria, where this study was conducted, is very crucial. This study aimed to assess the bird community and plant preference in Zandama Hill, one of the neglected Nigerian protected areas. Here, we examined the avian community and the selectivity of plants by birds using the line transect method across the wet and dry seasons of 2022. We also examined the impact of plant functional traits on the abundance and diversity of bird species. A total of 1657 individuals belonging to 82 bird species from 35 families were recorded on different plant species during the study period. Bird species were seen on 49 distinct plant species. There was a positive effect of the plant's functional traits on the abundance ($R^2 = 0.319$, $p<0.05$) and diversity of birds ($R^2 = 0.240$, $p<0.05$). Plant height and girth significantly predicted bird richness ($F(2, 45) = 7.09$, $p = 0.002$). Species diversity and high bird visitation were found to be higher on plants with greater height and larger plant girth. This research suggests that deforestation of taller native plants, particularly trees, should be discouraged as part of the conservation of bird species. Conservation measures should be employed to ensure the protection of the forest and its bird species.

key words: Plant traits; avian diversity; Zandama Hill; Avian bundance; Bird-plant interactions.

1. Introduction

Birds are the most researched taxon of all animal species (Gill, 2007). Birds offer ecological services such as pollination, pest control, seed dissemination, and seedling recruitment,

resulting in seedling recruitment and forest regeneration (Reid et al., 2012). A wide range of variables influences the spatial and temporal distribution of bird species. Seasonality in weather patterns is an important component in the formation of local bird groups. These might be due to indirect impacts from food availability or direct effects from an increase in metabolic needs in cold weather (Johnston et al., 2016; Abdul et al., 2024). Seasonal changes in resource availability are expected to influence varied responses according to feeding guild type (Mulwa et al., 2013).

Identification and analysis of ecological guilds have been critical in recognizing the mechanisms that determine the organization and structure of communities (Kornan and Kropil, 2014), and each species fits an ecological role based on its resource use within a community (Ricklefs, 2010). Season and landscape factors (vegetation type and location) were revealed to be key drivers in structuring bird assemblages (Muhammad et al., 2018; Abdul et al., 2024). Guilds are shaped by fluctuating ecological factors such as food availability, vegetation, predators, and diversity gradients (Katuwal et al., 2016). Although forests are biodiversity hotspots, the relative importance of tree diversity compared to other management factors in affecting forest-associated taxa remains unclear (Ampoorter et al., 2020).

Although studies have been conducted with questions related to the effects of trees on bird communities, no general consensus exists about how birds are affected by the densities and identities of plants. According to some studies conducted in Nigeria, human operations like cutting down trees, grazing, converting forests into farms, hunting, and other disturbances have resulted in habitat loss and a decrease in the populations of both resident (like the imperiled Beaudouin's Snake Eagle *Circaetus beaudouini*, according to BirdLife International 2017a) and migratory birds (e.g., the near-threatened Pallid Harrier *Circus macrourus*, BirdLife International 2017b).

However, the reasons for many bird reductions in West Africa, including Nigeria, remain unknown due to a paucity of data on habitat usage and feeding ecology for both resident and migratory birds (Vickery et al., 2014; Mallord et al., 2016). The forest specialists depend upon plant kind and structure (Gabbe *et al.*, 2002) for substrate for both nourishment and shelter (Lee and Rotenberry, 2005). Generalists are favored throughout the recolonization process (Newbold et al., 2014b), whereas specialists are more vulnerable to extinction in fragments of forest (Henle et al., 2004). This research provides information on the impact of plants' functional traits on the abundance and diversity of bird species in the Zandama Hills Forest Reserve.

2. Materials and methods

2.1 Study Area

This research was carried out in Zandama Hills (11°18'34.45"N and 9°43'49.55E). It is located 5 kilometers northeast of Kila town, in Jigawa State, Nigeria, with an elevation of 672 meters (Fig. 1). It was classified as a National Forest Reserve and has a total area of 23.16 square kilometers (UNEP-WCMC and IUCN, 2021). It has a 24.9°C mean temperature with a NE wind of 14 km/h and a humidity of 14%. The highest precipitation is recorded in August with 274.56 mm. The vegetation type is Sudan savanna. Just like many reserves in Nigeria, the Zandama Hills Forest Reserve is poorly managed with a high level of deforestation and other anthropogenic disturbances, which might have a cascading effect on other species, especially the avian community.

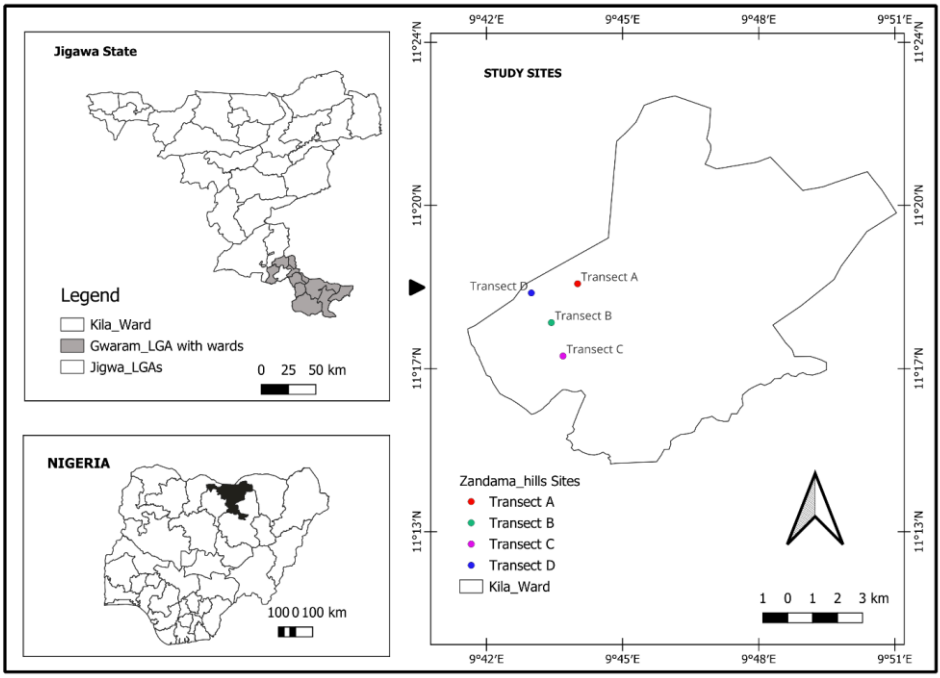

Figure 1. Map of Nigeria Showing Jigawa State and the Study Area

Study Design and Bird Count

Bird surveys were conducted using the line transect method as described by Bibby *et al.* (2000) to assess bird species diversity and abundance in the Zandama Hills Forest Reserve. Surveys were carried out across both the dry season (March–May) and wet season (June–August) of 2022 to capture seasonal variations in avian communities.

Four transects, each measuring 2 km in length and 200 m in width, were established across representative habitats within the reserve. Each transect was surveyed three times weekly (Saturday, Sunday, and Monday) during peak activity periods between 06:30 a.m. and 11:00 a.m. to maximize species detection (Abdullahi et al., 2025). All birds observed perching, foraging, or interacting with plants within the transect boundaries were recorded.

Each transect required approximately one hour per session, resulting in a total sampling effort of 72 survey days (approximately 576 person-hours) over the six-month study period. This approach ensured repeated sampling, minimized temporal bias, and provided robust data on bird abundance and species composition across seasons.

Birds and Plants Identification

Bird identification was carried out using Borrow and Demey's (2014) *Birds of Western Africa* field guide. Birds that were difficult to identify in the field were photographed using a Canon digital camera, and their calls were recorded with Merlin and BirdNET mobile applications. Observations included birds' behaviors such as perching, feeding, and other interactions with plant species.

All surveys were conducted by a single experienced observer to maintain consistency and reduce observer bias. 8×40 binoculars were used for visual observations, while vocalizations were employed to identify cryptic or canopy species.

Plant species associated with bird visits were photographed, collected, and identified at the Department of Biological Sciences, Federal University Dutse. The IUCN Red List of Threatened Species (version 3.1, 2023) and the BirdLife International database were used to determine the conservation status, residency, and population trends of both bird and plant species recorded during the study.

Plants Functional Traits

Plant functional traits were measured to evaluate their influence on bird species abundance and diversity within the Zandama Hills Forest Reserve. Two primary traits were considered, plant height and stem girth (circumference), following standardized protocols outlined by Perez-Harguindeguy et al. (2016).

Plant height was measured as the vertical distance from the ground at the base of the main stem to the highest photosynthetic tissue using a graduated measuring pole, and values were recorded to the nearest centimetre (cm). Stem girth was measured using a flexible fibreglass tape. For trees and large shrubs, girth was recorded at diameter at breast height (DBH; 1.3 m above ground level), while for smaller shrubs and herbs, measurements were taken 10 cm above the root collar.

All girth measurements were recorded to the nearest millimetre (mm) and converted to diameter ($D = C/\pi$) where appropriate. In the case of leaning or multi-stemmed plants, measurements were adjusted according to the recommendations of Perez-Harguindeguy *et al.* (2016) to ensure standardization and accuracy.

The data collected on plant functional traits were later used in correlation and regression analyses to determine their predictive effects on bird abundance and species richness across the study area.

Data Analyses

The Microsoft Excel Pivot table function was used to arrange and organize the data. The Shannon-Wiener Index was used to determine the diversity of birds across sites and seasons using PAST software (version 4.03). Correlation and regression were used to determine the relationship between bird species and plants, as well as the effects of plants' functional traits on birds' species richness and abundance, using SPSS software (version 20). Statistical analyses were conducted at a significance level of $p \leq 0.05$, while for correlation, a $p \leq 0.01$ significance level was used, where there is significance at $p \leq 0.05$.

3. Results

Bird species composition at Zandama Hills

During the study, 1656 individuals from 82 bird species across 35 families were recorded on various plant species (Tables 1 & S1). The families Estrildidae and Ploceidae had the highest bird species richness (7 species each), followed by Muscicapidae, Nectariniidae, and Sturnidae with 5 species each (Tables S2a & 2b). The most abundant feeding guild was Insectivore (21 species), followed by Granivore (20), Omnivore (12), and Carnivore (12), where some species recorded had multiple guilds (Table S1). Table 1 below represents the most abundant and least abundant bird species recorded within the study period.

Table 1. Bird Species Composition and Abundance in Zandama Hill Protected Area, Jigawa State, Nigeria

Family	Bird species	Scientific name	Species Abundance
Nectariniidae	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	248
Estrildidae	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	132
Cisticolidae	Senegal Eremomela	*Eremomela pusilla*	90
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	88
Cisticolidae	Grey-backed Camaroptera	*Camaroptera brachyura*	87
Columbidae	Vinaceous Dove	*Streptopelia vinacea*	86
Cisticolidae	Tawny-flanked Prinia	*Prinia subflava*	83
Ploceidae	Village Weaver	*Ploceus cucullatus*	80
Columbidae	Laughing Dove	*Spilopelia senegalensis*	70
Estrildidae	Lavender Waxbill	*Estrilda caerulescens*	58
Cuculidae	African Cuckoo	*Cuculus gularis*	1
Picidae	Grey Woodpecker	*Dendropicos goertae*	1
Alaudidae	Chestnut-backed Sparrow Lark	*Eremopterix leucotis*	1
Falconidae	Red-necked Falcon	*Falco chicquera*	1
Falconidae	Common Kestrel	*Falco tinnunculus*	1
Alcedinidae	Grey-headed Kingfisher	*Halcyon leucocephala*	1
Accipitridae	Lizard Buzzard	*Kaupifalco monogrammicus*	1
Sturnidae	Chestnut-bellied Starling	*Lamprotornis pulcher*	1
Passeridae	Sudan Golden Sparrow	*Passer luteus*	1
Accipitridae	Bateleur	*Terathopius ecaudatus*	1

Utilization of plants by birds and the Effect of plant species on different birds' visitation

Birds were recorded utilizing 49 plant species; however, the number of individual plants used by the birds varied between plant species (Tables S2-3). *Parkia biglobosa* (266 visits), *Anageisus leiocarpus* (135 visits), *Tamarindus indica* (98 visits), and *Sterculia setigera* (80 visits) were the plants with the greatest number of visits, with *P. biglobosa*, *A. leiocarpus,* and *S. setigera* being visited by 48, 38, and 29 different bird species, respectively (Table 2). Results from correlation (Table S3) and regression analysis (Table S5) showed the significant effect of plant abundance and bird visit count on bird species richness ($r = 0.903$, $R^2 = 0.914$, $P<0.05$). The result further showed a positive effect of the plant's abundance on the abundance of bird species ($r = 0.882$, $P<0.01$).

Table 2. Some plants species and their number of bird species and visit count in Zandama hills forest reserve

Scientific name	Plants Abundance	Number of birds visiting	Birds Richness	Birds Abundance	Height(m)	Girth(m)
Parkia biglobosa	70	266	48	411	6.2	2.4
Anageisus leiocarpus	30	135	38	207	6.9	2.8
Tamarindus indica	8	98	18	194	11.2	3.3
Sterculia setigera	32	80	29	113	5.3	1.9
Combretum molle	23	51	27	76	4.0	0.6
Commiphora africana	22	34	21	78	1.7	0.6
Acacia ataxacantha	26	32	15	43	1.8	0.3
Entada africana	8	27	16	38	4.3	0.7
Dioscorea praehensilis	19	24	20	39	1.7	0.2
Mangifera indica	6	23	11	52	6.2	2.0

4. Discussion

Effects of different plant species on different birds' visitation preference

The rate of bird visiting varies between plant species, with *P. biglobosa, A. leiocarpus, and S. setigera* being visited by 48, 38, and 29 bird species, respectively. The study conducted found a significant positive relationship between the abundance of plant species and bird species richness (Spearman's rho = 0.932, one-tailed p = 0.001, N = 49). These findings imply that the greater the number of individual plants, the greater the number of individual birds and the number of distinct species that came. A comparable substantial positive association was discovered between bird visitation counts and bird species richness (Spearman's rho = 0.977, one-tailed p = 0.001, N = 49), demonstrating that both abundance of plants and bird visitation counts are strongly related to increased bird species richness.

General vegetation structure positively influences species diversity, particularly for birds (Tews *et al.*, 2004). Regression analysis revealed a strong correlation between plant abundance/bird visit count and bird species richness (r = .945, R^2 = .892, adjusted R^2 = .888, F (2, 47) = 194.800, p < .001), with the model explaining 88.8% of the variance in bird species richness. High plant abundance and bird visitation, particularly of *P. bilobosa*, significantly predicted high bird species richness. Consistent with Mason *et al.* (2007), adult trees and heterogeneous plant layers correlate positively with bird diversity in the USA. A similar result was reported in Nigeria by Buba and Jaafar (2021).

Effects of plants' functional traits on birds' abundance and diversity

Results from the regression equation significantly predicted bird species richness (F (2, 45) = 7.090, p = .002) and bird abundance (F (2, 45) = 10.534, p = .000), indicating that the combined effect of plant height and girth significantly contributed to explaining the variance in bird species richness and abundance.

Many studies have shown that many plant communities support a higher diversity of other taxa cohabiting the same ecosystem (Schuldt et al., 2019). For instance, Zhang et al. (2013) opined that bird diversity was lower in stands dominated by many functionally similar tree

species and that a high functional diversity of trees is important to maintain high bird diversity. These impacts on birds are probably going to be indirect, and they might happen if there is a low diversity and activity of defoliating insects as a result of reduced tree functional diversity. If the food habits of different species of birds vary, this might have detrimental domino consequences on bird diversity and abundance (Charbonnier et al., 2016). Multiple levels of plant diversity are vital for promoting total forest biodiversity, as demonstrated by the significance of both the number of individual plants as well as their functional diversity. The impacts of functional composition and variety of trees outweighed the effects of forest structure (Ampoorter et al., 2020). Tree functional composition, i.e. the particular functional trait values found in a stand, could affect forest-associated taxa as well (Rowe et al., 2006). The result obtained from this study also agrees with the work of Buba and Jaafar (2021) conducted at Ngel Nyaki forest reserve in Nigeria, where they reported that tree height, crown width and crown density positively affected avian species diversity and their visit.

5. Conclusion

The study provided quantitative ornithological data and plant utilization by birds in Zandama Hills Forest Reserve. The high bird diversity, including birds of conservation concern, highlights the importance of this area as a key bird habitat in the region. Similarly, there was also a strong relationship between bird species richness, plant abundance and bird visitation. Therefore, the higher the abundance of plant species, the higher the birds that visit and birds species richness. Government and conservation bodies should prioritise the protection of tall native trees, thereby controlling deforestation.

Supplementary Materials

The following supporting information can be downloaded at:
https://jfaunab.com/index.php/jfb/libraryFiles/downloadPublic/379

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Conflict of interest

The authors declare that they have no competing interests.

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