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Research Article

Variations in Avian Species and Functional Diversity in Different Habitat Types in a Vulnerable Savannah Ecosystem in Ghana

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Most research on avian functional diversity in the tropics is focused on forest and agroecosystems, leaving a gap in knowledge about the effects of habitat types on functional diversity in savannah landscapes. Savanna ecosystems are fragile and are under threat of anthropogenic destruction, particularly in developing Sub-Saharan Africa and could be eliminated in the face of the ever-increasing human population exacerbated by the changing climate. This study investigated the influence of the three major habitat types (grassland, riparian forest, woodland) on bird species and functional diversity in the Mole National Park (MNP) in Ghana. We used the line transect method to survey birds along 39 transects, each 1 km in length, and collected data on environmental variables along the same transects. Data from these surveys was used to estimate species and functional diversity indicators. We found significant variations in species and functional diversity measures between the three habitat types in the MNP. These variations were significantly influenced by species abundance and environmental covariates. Diversity measures were particularly higher in the riparian forest habitats compared to the woodland and grassland, with the latter being the least diverse habitat both functionally and species wise. The results of this study suggest that the avifauna assemblages in MNP are largely influenced by the riparian forest and are important for ecosystem function and stability. We recommend management efforts to intensify the protection of such vital habitats of the Mole National Park from illegal human activities, especially the rising removal and export of rosewoods (*Dalbergia nigra*) around the park. Further research on the avian community composition and structure in the MNP is recommended.

1. Introduction

Birds are effective bioindicators of environmental change [1–3] because they occur in nearly all climatic zones and habitat types worldwide [4]. Their community composition is primarily determined by the structure and complexity of the habitats they occupy [5–7]. As such, heterogeneous habitats could harbour more resources that could support higher species abundance than homogeneous ones [8–10]. Moreover, changes and variations in habitat types can influence changes in species population dynamics and assemblages [11, 12]. However, the influence of changes in habitats would vary depending on the ecosystem type and would be more severe for vulnerable ecosystems. It is thus critical to understanding how these changes can structure avian communities to develop conservation strategies (such as effective management and protection of PAs, incentives for fringe communities, and law enforcement) in vulnerable ecological systems such as the savannahs.

Several studies have reported the variabilities in avifaunal diversity indices and the influence of different habitat types on bird community structure. For instance, Watson et al. [13] found increases in avifaunal species richness with increasing remnant area and habitat complexity in south-eastern Australia. They suggested that about 71% and 65% of resident woodland birds were significantly affected by decreasing woodland patch size and loss of habitat complexity, respectively. Moreover, high species diversity in woodlands can be attributed to the availability of breeding sites and protection from predators [14]. Hovick et al. [15] found that greater heterogeneity across experimental landscapes in grassland communities resulted in increased avian diversity and stability over time. Their work established that bird species responses were consistently positively associated with increased heterogeneity in modified grasslands.

However, the rising global temperatures could lead to the homogenization of plant community structure [16–18] and in effect increase the range of generalist species [19] in the ecosystems. Thus, drastic changes in plant diversity may be severe on bird communities that are primarily determined by the structural complexity of plant communities [7, 20–22]. As such, conservation ecologists are concerned about the consequences of habitat modification on biodiversity loss and ecosystem functioning [23]. These concerns have led to an increased interest in the concepts of guilds and functional groups [24–26], and the emergence of functional diversity as a unit of biodiversity measurement [27–29].

Functional diversity indices complement the traditional taxonomic approach, as they quantify the differences between species using functional traits [30]. Functional traits can be morphological, physiological, reproductive, or behavioural that could affect the performance or fitness of an individual [28, 30]. Yet there is evidence of rapid population declines of many avian functional groups due to habitat modification and change globally [8, 31–33].

Functional diversity is projected to decline at higher rates in disturbed habitats [34], disrupting some key ecological processes within those ecosystems [31]. For instance, a decline in pollinator-disperser services could negatively affect the long-term regeneration of plant communities [35], especially in vulnerable ecosystems like the savannah that are already experiencing the impacts of anthropologic activities and severe weather conditions [36, 37]. Although it remains unclear what factors will determine the severity of the impact of habitat modifications on species and functional diversity in the savannah ecosystem, understanding the variations in species and functional diversity in different habitats could inform conservation plans and actions including the formulation of enforceable policies that could result in the protection of these ecosystems.

The growing number of studies on avian functional diversity in the tropics are focused on forest and agroecosystems [34, 38–40], leaving a gap in knowledge about the ecological services birds provide in savannah landscapes, especially within protected areas. With the growing trends of anthropogenic activities on ecosystems globally [41–45], arid and savannah ecosystems are predicted to be the hardest hit in terms of the impacts of human population growth and climate change [46–48]. Northern Ghana, where the Mole National Park is located, is predominantly a savannah ecosystem, and challenges such as illegal logging of rosewood, charcoal production [49, 50], water stress, reduced food security, and other socio-ecological issues associated with weather variability have been drastic [36, 37, 51, 52]. In such ecosystems, projected changes in habitat heterogeneity are expected to drive changes in avian community assemblages and their respective functional roles [47, 53–55].

Although protected areas are expected to be more resilient to change than ecosystems already damaged by human impact [23, 56, 57], little is known about the avian community structure and functional diversity in many tropical protected areas within savanna landscapes and how they respond to changes in habitat type and structure, particularly in sub-Saharan Africa. Most studies on avian community ecology in sub-Saharan Africa have concentrated largely on species diversity and population trends of individual species. Yet the potential effects of habitat variability on avian functional diversity and the responses of functional groups to changes in biotic interactions are often overlooked. In West Africa and Ghana, in particular, it remains unclear how habitat variability influences the avifaunal assemblages and community structure in the vulnerable savannah ecological zone. This study, therefore, highlighted the avifauna functional diversity in a savannah ecosystem and the importance of habitat variability to sustaining avifaunal community structure and ecosystem functioning at large.

In this study, we investigated the influence of three major habitat types (grasslands, riparian forests, and woodlands) on avifauna assemblage structures in the Mole National Park (MNP) in Ghana. We predicted that avian species and functional diversity indicators of bird assemblages will vary significantly due to variability in the three main habitat types within the study area and that these variations are predicted by the variabilities in the influences of sets of vegetation and environmental variables in those habitat types.

2. Materials and Methods

2.1. Study Area. Mole National Park is Ghana's largest protected area (PA), covering an area of about 4,577 km^2 and located in West Gonja District (N 9° 30′ 0″, W 2° 0′ 0″) [58] of the Savanna region (Figure 1). Apart from the severe weather conditions experienced in recent times, probably due to climate change, the increase in encroachments and the massive logging of rosewood and charcoal production in and around the MNP [49, 50], including the intermittent poaching activities [59], has degraded portions of the park. The level of illegal logging of the precious rosewood for export has posed a major threat to the savannah ecosystem, especially the riparian and woodland forests within that ecosystem including the constituent fauna.

The park receives an average annual rainfall of about 1100 mm, 90% of it falls from April to October [59]. The dry season, which is mostly characterised by harmattan dry winds, occurs between December and March with an annual mean temperature of 28°C. The MNP has different habitat types, namely, open savanna woodland, bovals (open areas dominated by grass), riparian forest, swamps, and floodplain grasslands.

Most of the park is dominated by open savanna woodland [59], interspersed with grasslands and riparian forests. Trees that are relatively widely spaced with patches of grasses and shrubs dominate the woodland habitats. The riparian (gallery) forest consists of forested areas associated with streams and rivers that have complex ecosystems and

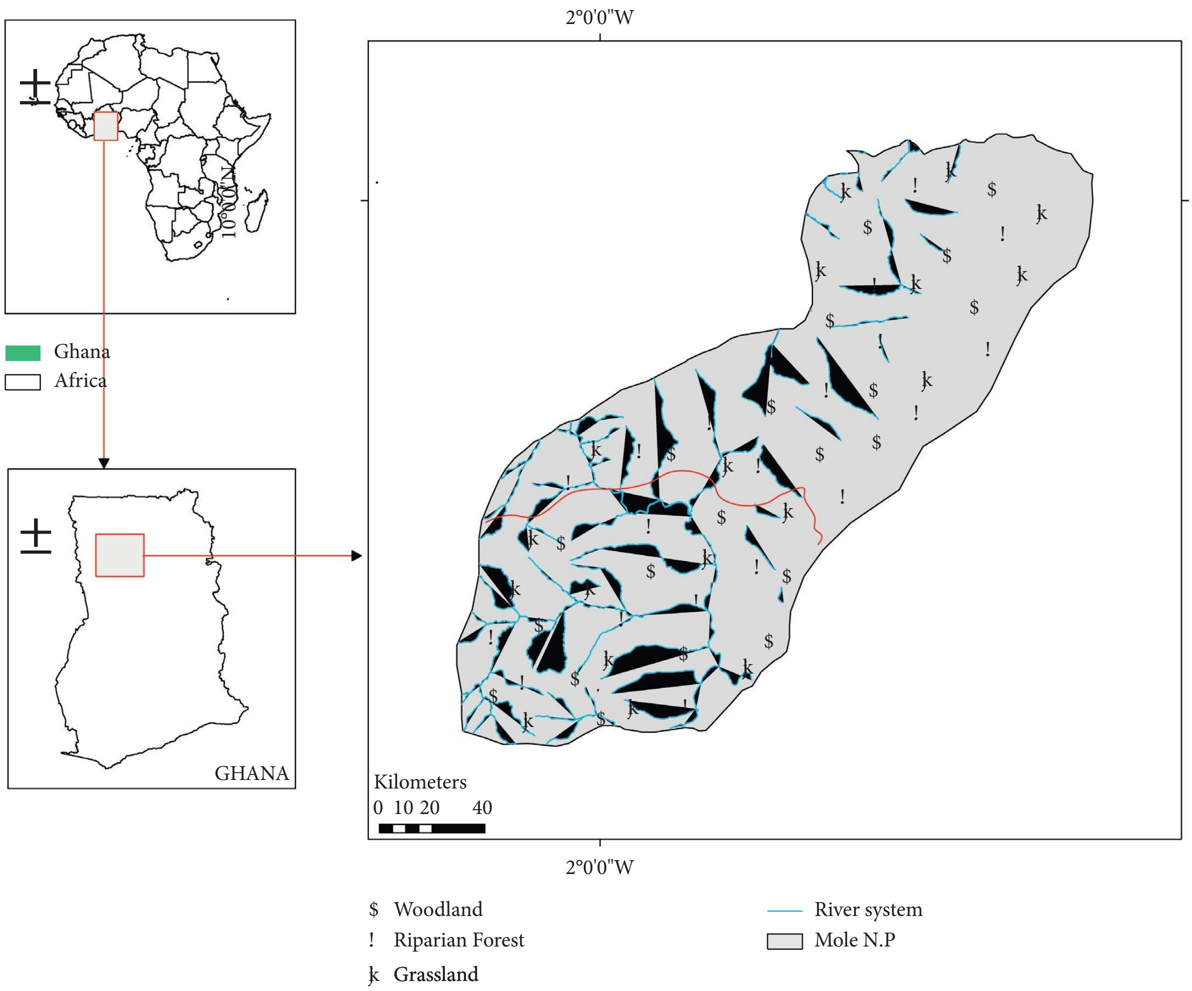

Figure 1: Map of mole national park showing habitats that were surveyed (insert top left is Africa map showing the location of Ghana and down left is Ghana map showing the location of the MNP).

provide food, lodging, and travel corridors for both aquatic and terrestrial species in the park [60]. The grassland is mainly dominated by grasses and sedges, with small trees and shrubs scattered all around [61].

Mole National Park holds rich biodiversity, comprising about 94 mammal species and over 300 bird species [61]. Aside from conserving biodiversity, MNP serves as a major source of headwater for the surrounding communities. Most of the streams and rivers either take their source from within or drain through the park and empty into the White Volta [58, 59].

2.2. Survey Design. The three dominant habitat types within the Mole National Park were selected for this study (Figure 1). A line transect sampling technique was used to survey the birds. Line transects are often used to collect data in large, open areas [62]. It is more efficient in covering more ground quickly and recording more birds than point counts [62, 63]. Within each of these habitats, three transects each 1 km in length were selected either along existing trails or created where possible with the aid of a Garmin GPS device (Garmin Terex 10). Each transect was located at least 500 m away from the other. A flowchart summarising the methodology is shown in Appendix 1.

2.3. Bird Survey. Bird surveys were carried out along each transect at 13 random locations, with each location having three transects. Surveys took place between August and November 2019, coinciding with the breeding season, and between December and March 2020, which coincided with the nonbreeding season in Ghana [64, 65]. Bird surveys were conducted twice daily from 06:30 hrs to 09:30 hrs and 15:00 hrs to 18:00 hrs coinciding with peak bird activities in the MNP. Along each transect, the researcher (SA) walked and maintained an average speed of 2 km/hr and recorded all bird contacts (sighted or heard), including the number of individuals of each species. Flyovers were identified, and the number of individuals was also recorded, but was not used in the final analyses. These data, however, enriched the species list of the study area. Along the same transects, vegetation and other environmental variables were estimated.

Each transect was visited twice in both the breeding and nonbreeding seasons, making four visits per transect and eight visits per habitat type over the entire study period. Bird identification was aided by a pair of binoculars (Olivon 8×42) and the field guides of birds in Western Africa [66]. Unfamiliar bird calls were taped and sent to the experts for identification. Surveys were not conducted on days with severe weather conditions. Data collection was largely restricted to the southern half of the park (which has an estimated area of about 1,700 km^2, ~ 40% of the total land area) due to logistical and accessibility constraints.

2.4. Functional Trait Classification. All bird species recorded were grouped into two main functional traits: feeding guilds (predominant diet); (carnivores, frugivores, granivores, insectivores, nectarivores, omnivores, piscivores, and scavengers) [66–69] and foraging behaviour; (dabbling, gleaning, hawking lunging, plunge-diving, probing, sallying, scanning, scavenging, scratching, stooping, and swooping) [70]. The classification of birds into predominant diet and foraging behaviour constituted the functional traits from which avian functional diversity indices were estimated [3].

2.5. Vegetation and Microclimatic Variables. A 20×20 m quadrat was systematically placed at the beginning and the end of each transect, and the number of trees within each quadrant was estimated. Within the same 20×20 m quadrant, a 10×10 m quadrant was placed, and the number of shrubs and percentage of grass cover were estimated. The percentage of grass cover was estimated by the eye to be the nearest 5% [71].

The average temperature was also recorded at the start and finish of each transect using a kestrel meter (Kestrel 3000). The average temperature was measured by holding the Kestrel meter at arm length from the body and waiting for about two minutes to allow the kestrel to rest. This allows the kestrel sensor to measure the air temperature rather than the temperature of the case. This measurement was conducted in both morning and afternoon sessions in each season. The vegetation and temperature variables were measured to predict their influence on functional groups in the MNP.

2.6. Data Exploration and Statistical Analyses. All data were organised in Microsoft Excel and imported to *R* statistical software (version 4.0.2) for analysis [72]. Species/functional richness and abundance per habitat were estimated as the total number of species/functional traits and the total number of individuals of those species/functional traits in each habitat, respectively. Avian species diversity (α-diversity) and functional diversity were calculated using the Shannon–Wiener diversity index as follows:

$$H' = -\sum\left(\frac{n_i}{N} x \operatorname{In} \frac{n_i}{N}\right), \quad (1)$$

where n_i is the number of individuals of each of the i species/functional groups and N is the total number of individuals for the study area. The values of H' usually range from 0 to 5 although they typically range from 1.5 to 3.5. Species and functional evenness were estimated using Simpson's Index (D^S). These estimations were carried out using the vegan package in *R* statistical software [73]. Beta (β)-diversity was estimated between habitat types using the beta part package, an *R* package for computing total dissimilarity as Sørensen or Jaccard indices, as well as their respective turnover and nestedness components. The package provides two basic analytical functions (beta.multi and beta.pair), which calculate the multiple site and pairwise partitions of beta diversity [74]. The result from the beta diversity analysis was plotted using a principal coordinate analysis (PCoA), boxplots, and a PERMANOVA to test if treatments were significantly different.

Functional evenness measures the regularity of the distribution of species abundances and dissimilarities in functional space [75]. We compared the overall species diversity and functional diversity among all three habitat types in MNP using two-factor analyses of variance (ANOVA). A Tukey's test was used to further examine where differences in species diversity and functional diversity lie.

We used general linear models (GLMs) to examine the relationship between functional diversity measures and species abundance. We also examined the relationship between species and functional diversity measures (as responses) and the estimated environmental explanatory variables (average temperature, % grass cover, shrub, and tree densities), with habitat types and season as the major predictors. A Pearson correlation test was conducted on all explanatory variables, and for any strongly correlated pairs of variables, one was eliminated and the variable with the most plausible ecological importance relative to the particular response was maintained in the final model (Appendix 2). Model residual plots from general linear models (GLMs) were used to check whether the model assumptions were met (Appendix 3).

3. Results

3.1. Overview of Bird Surveys. Overall, 6,530 individual birds comprising 180 species from 63 families were detected during the survey period in the Mole National Park (Appendix 4). These included 156 residents, 10 intra-African migrants, 10 partial migrants, and 4 Palearctic migrants (*Phoenicurus phoenicurus, Actitis hypoleucos, Upupa epops,* and *Ficedula hypoleuca*). The highest number of individuals, 956 (15%), were recorded from the family Columbidae, whereas only one individual (0.02% each) was recorded from 25 families during the study. Out of the total number of birds recorded, two are critically endangered (*Necrosyrtes monachus, Trigonoceps occipitalis*), one each is endangered (*Gyps africanus*), vulnerable (*Polemaetus bellicosus*), and near threatened species (*Terathopius ecaudatus*) and the rest are in the least concern category of the IUCN.

3.2. Variations in Species Diversity Measures. The estimated mean ± (SD) species diversity for the entire survey was 3.10 (±0.30). Species diversity differed significantly among habitat types and with the season ($F_{5,212.5} = 2665$, $p < 0.001$). The riparian forest was most diverse in both seasons

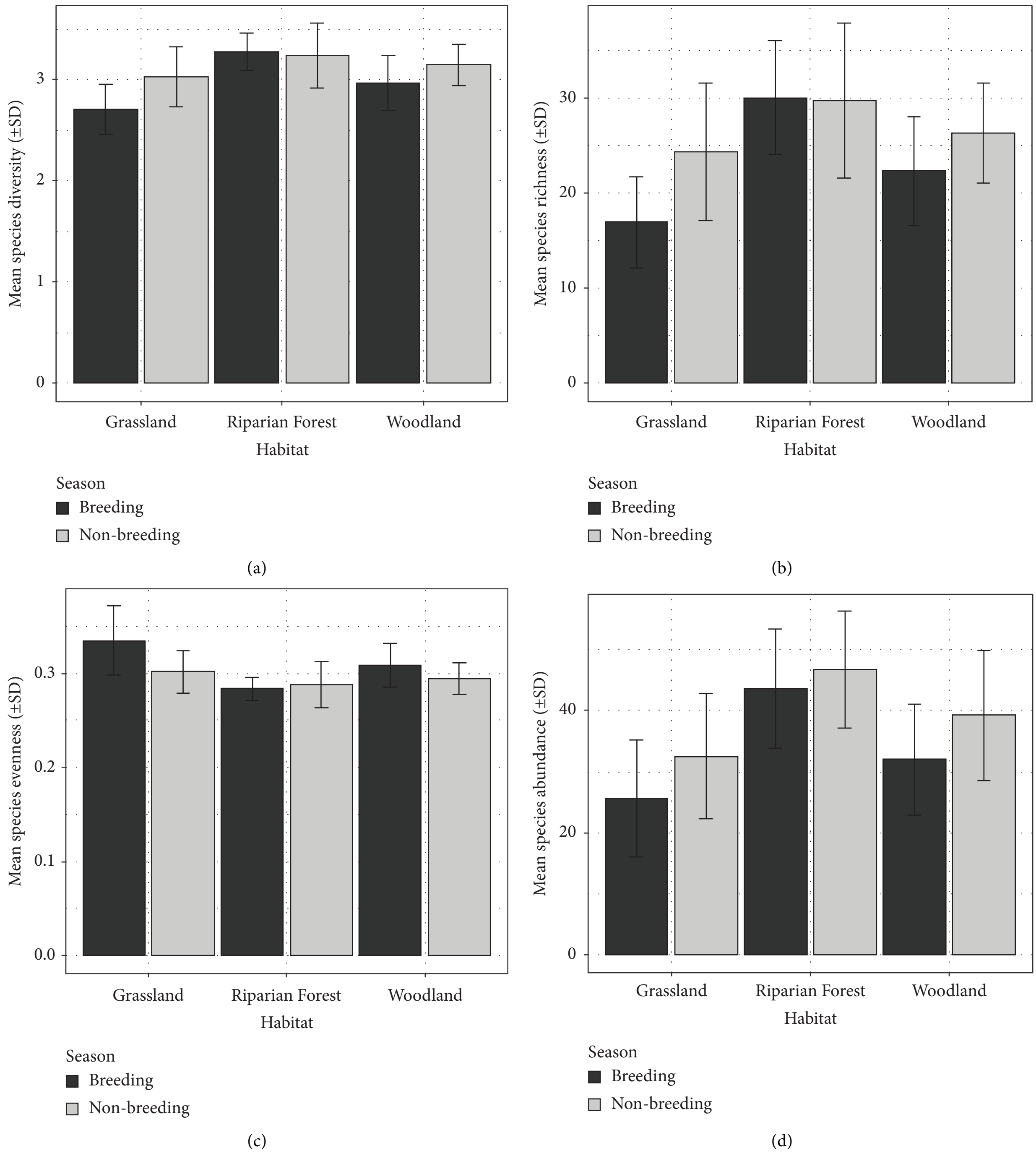

Figure 2: Variations in overall mean avifaunal diversity indices among habitat types in the MNP ((a) Shannon–Wiener diversity, (b) species richness, (c) evenness, and (d) abundance).

compared to the grassland and woodland habitats although a Tukey's test showed no significant difference in species diversity between the two seasons within the riparian forest ($F_{5,211.7} = 2665$, $p > 0.05$) (Figure 2(a)).

Similarly, mean species richness was estimated at 26 (±7.50) and varied significantly among habitat types and between seasons ($F_{5,203.8} = 2665$, $p < 0.001$), with the riparian forest being the most species-rich habitat in both the nonbreeding and breeding seasons compared to the woodland and grassland. The mean species richness in the grassland increased from 17 The mean species in the breeding season to 24 in the nonbreeding season (Figure 2(b)). Similar to species diversity, species richness did not differ significantly within the riparian forest in both seasons ($F_{5,203.8} = 2665$, $p > 0.05$).

Overall, mean evenness varied significantly among the three habitat types and seasons ($F_{5,215.4} = 2665$, $p < 0.001$). Contrary to the trend observed in species diversity and

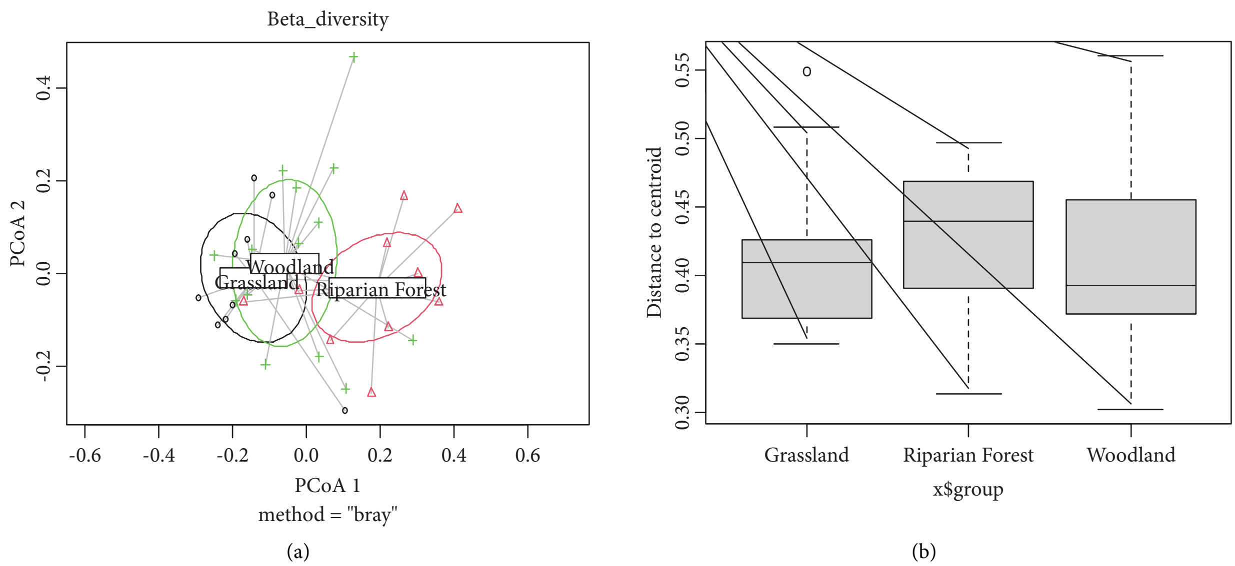

Figure 3: (a) A principal coordinate analysis (PCoA) plot showing that the first two axes explained 60% of the variation among the habitats. (b) Boxplot of the variations in species composition among the three habitat types in MNP.

richness values, species evenness was highest in the grassland in both the nonbreeding and breeding seasons and lowest in the riparian forest. A Tukey's test showed that the overall species evenness in the riparian forest did not differ significantly between the breeding and nonbreeding seasons ($F_{5,215} = 2665$, $p > 0.05$) (Figure 2(c)).

The mean abundance was estimated at 37.92 (±11.89) and varied significantly among the three habitat types ($F_{6,490.9} = 2665$, $p < 0.001$) and seasons ($F_{6,220.5} = 2665$, $p < 0.001$). Species abundance was generally higher in the riparian forest in both nonbreeding and breeding seasons with the grassland recording the least number of individuals. However, Turkey's test showed that species abundance did not vary significantly between the woodland and grassland in the breeding season and nonbreeding season, respectively ($p > 0.05$) (Figure 2(d)).

With regards to the dissimilarities in species composition, (β-diversity), a Principal Coordinate Analysis (PCoA) of the three habitats showed that the first two axes explained 60% of the variation among the habitats (Figure 3(a)). However, a PERMANOVA test showed no significant variations among the three habitats ($F_{2,0.2146} = 37$, $p = 0.808$) although their medians visibly differ (Figure 3(b)).

3.3. Variations in Functional Diversity Measures. Overall mean functional diversity was significantly different among the three habitat types ($F_{5,322.5} = 2665$, $p < 0.001$) but did not significantly differ between seasons ($F_{5,322.5} = 2665$, $p > 0.05$) except for the interaction between habitat and season ($F_{5,322.5} = 2665$, $p < 0.001$). The riparian forest was still the most functionally diverse habitat in both the nonbreeding and breeding seasons compared to the woodland and grassland (Figure 4(a)).

Overall, mean functional richness was significantly different among the three habitat types ($F_{8,1302.7} = 2665$, $p < 0.001$). Functional richness, however, did not differ significantly between seasons ($F_{8,1302.7} = 2665$, $p > 0.05$). Similar to functional diversity, the highest mean functional richness occurred in the riparian forest, whereas the lowest mean functional richness occurred in the grassland (Figure 4(b)). The mean functional evenness was significantly different among the three habitats ($F_{2,\ 1349} = 2668$, $p < 0.001$) but did not differ significantly between seasons ($F_{2,1349} = 2668$, $p > 0.05$). Functional evenness was highest in the grassland but lowest in the riparian forest (Figure 4(c)).

The mean functional abundance (the number of individuals in a functional group) was estimated at 114.00 (±36.00) and differed significantly among the three habitat types and between seasons ($F_{13,738.4} = 2665$, $p < 0.001$). However, the pairwise comparison of the functional abundance values between woodland in the breeding season and grassland in the nonbreeding season did not differ significantly ($F_{13,738.4} = 2665$, $p > 0.05$). Functional abundance was highest in the riparian forest in both seasons but was particularly higher in the nonbreeding season. The least functional abundance was recorded in the grassland (Figure 4(d)).

3.4. Relationship between Species Abundance and Functional Diversity Measures in the MNP. Avian functional diversity increased with an increase in species abundance between the riparian forest and grassland but declines marginally in the woodland habitats ($F_{5,394.7} = 2665$, $p < 0.001$). When mean abundance approaches 26 individuals, functional diversity in the riparian forest and woodland overlapped (Figure 5(a)).

Similarly, mean functional richness related positively with mean species abundance among the habitat types

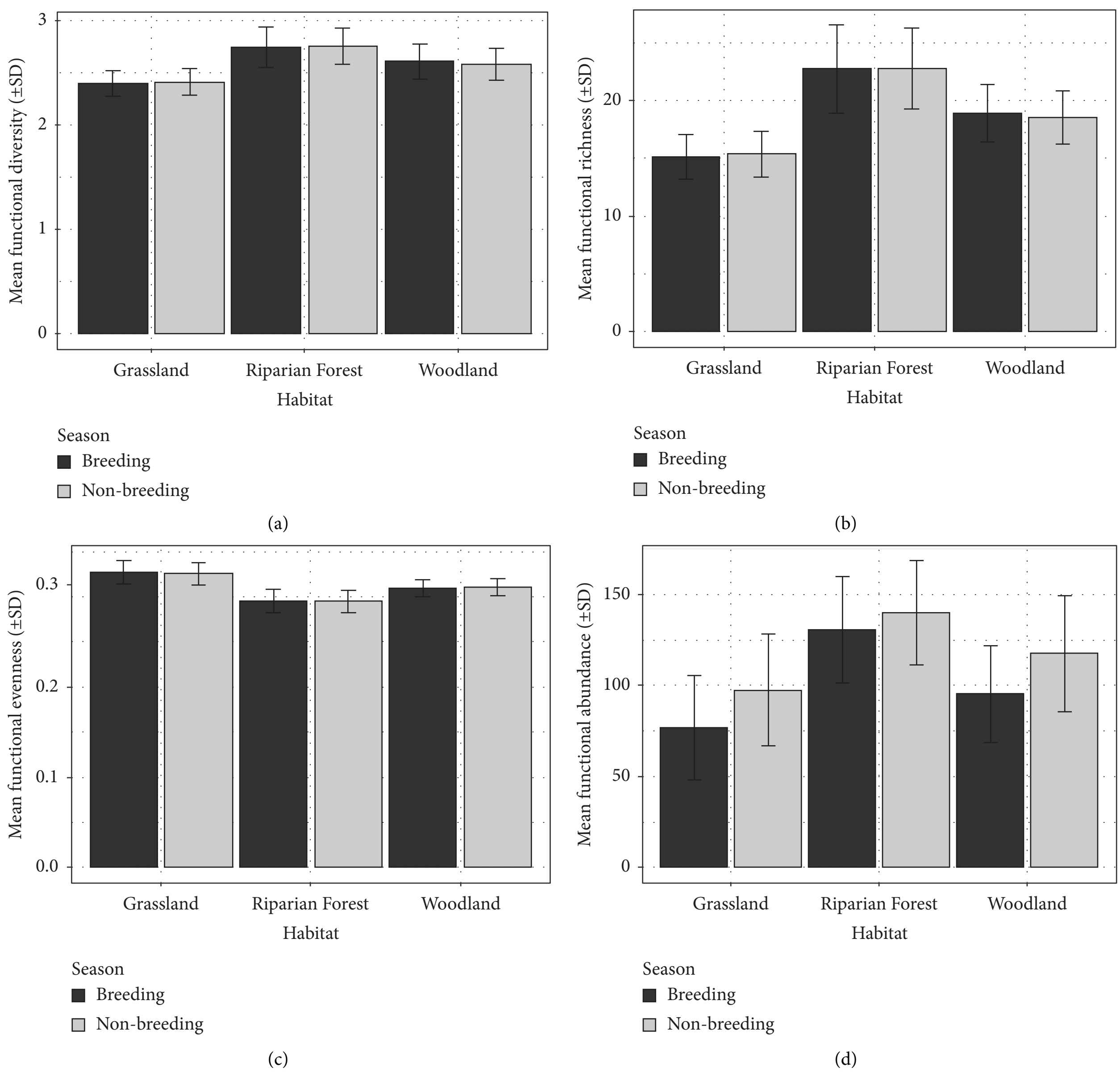

FIGURE 4: Mean variations in avifaunal functional diversity indicators among three habitat types in the MNP. ((a) Functional diversity, (b) functional evenness, (c) functional richness, and (d) functional abundance).

($F_{5,704.8} = 2665$, $p < 0.001$). As mean abundance increased, functional diversity increased sharply in the riparian forest and slowly in both the woodland and grassland (Figure 5(b)). On the other hand, mean functional evenness correlated negatively with mean abundance, increasing with a decline in species abundance ($F_{5,735.1} = 2665$, $p < 0.001$). Mean functional evenness declined sharply in the grassland and riparian forest as the mean abundance increased (Figure 4(c)).

3.5. The Relationship between Avian Functional Diversity Indicators and Environmental Variables. Environmental variables (% grass cover, tree, and shrub densities) showed a significant relationship with functional diversity ($F_{7,348.5} = 2663$, $p < 0.001$) and functional richness ($F_{7,872.5} = 2663$, $p < 0.001$) among the three habitat types and seasons. Functional diversity and richness increased with tree density and percentage of grass cover but decreased in the nonbreeding season and with increasing shrub density (Table 1). On the other hand, functional evenness declined with an increase in tree density and grass cover but increased with an increase in shrub density ($F_{8,492.4} = 2655$, $p < 0.001$). The average temperature did not influence functional diversity measures significantly (Table 1).

4. Discussion

Emerging from this current study is the fact that the composition of avian communities measured by species and functional diversity indicators in the MNP differs among the three habitat types. An important innovation in our study

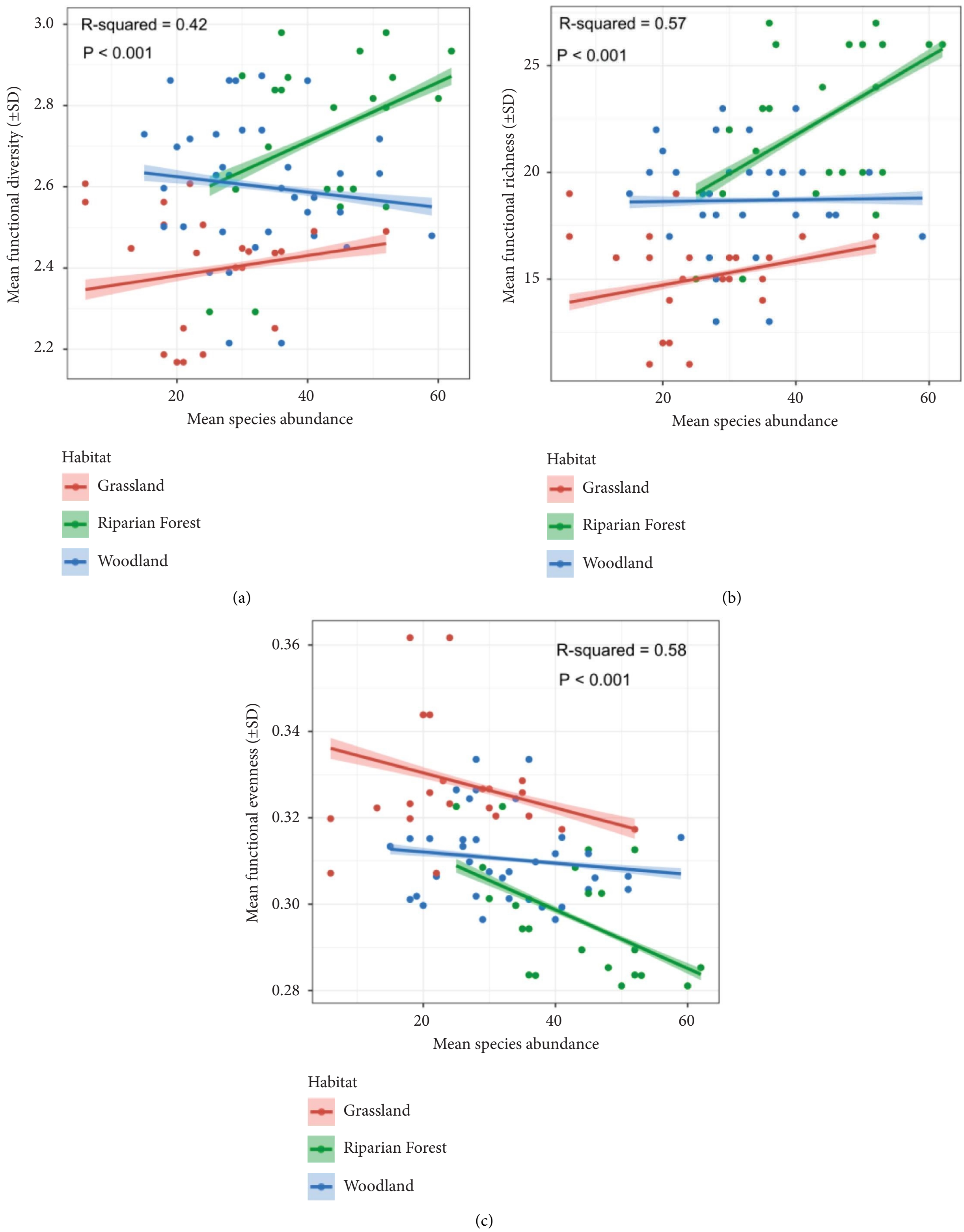

Figure 5: Relationships between overall avifaunal abundance and those of functional diversity measures in the MNP. ((a) mean functional diversity versus mean species abundance, (b) mean functional richness versus mean species abundance, and (c) mean functional evenness versus mean species abundance).

Table 1: Summary table of model estimates of avian functional diversity measures versus temperature and vegetation variables.

	Functional diversity		Functional richness		Functional evenness	
	Estimate	p value	Estimate	p value	Estimate	p value
(Intercept)	2.25 ± 0.02	0.001	2.61 ± 0.03	0.001	0.33 ± 0.00	0.001
Riparian forest	0.33 ± 0.01	0.001	0.38 ± 0.01	0.001	-0.03 ± 0.00	0.001
Woodland	0.20 ± 0.01	0.001	0.21 ± 0.01	0.001	-0.02 ± 0.00	0.001
Nonbreeding	-0.03 ± 0.01	0.001	-0.04 ± 0.01	0.001	0.00 ± 0.00	0.001
Temperature*	0.00 ± 0.00	0.101	0.00 ± 0.00	0.688	0.00 ± 0.00	0.066
Tree density	5.81 ± 0.26	0.001	5.54 ± 0.39	0.001	-0.44 ± 0.02	0.001
Shrub density	-1.82 ± 0.25	0.001	-1.78 ± 0.38	0.001	0.14 ± 0.02	0.001
% grass cover	0.00 ± 0.00	0.001	0.00 ± 0.00	0.005	-0.00 ± 0.00	0.008

*Average temperature not significant.

was the closer examination of functional diversity, which provides a surrogate measure of ecosystem function by capturing the range of species functional traits. Although such innovation has not been conducted for a Guinea Savannah Wildlife Protected Area (WPA), there are some parallels with studies like [76–78]. The habitat composition and structure cannot be ignored in developing effective management tools and strategies for protecting the avifauna.

4.1. Variations in Species and Functional Diversity Measures. This study found significant differences in avian species and functional diversity measures among the dominant habitat types in MNP. The riparian forest harbour more species than the other two habitats, and this could be attributed to its structural complexity and composition [5–7, 79]. The riparian forest in MNP is highly heterogeneous with streams, wetlands, shrubs, and tall grasses well interspersed, hence playing a crucial role in the production of food and other habitat resources [80]. We believe that the greater structural heterogeneity in the riparian forest provided diverse resources to support a higher number of species to coexist and perform their ecosystem roles. During the dry season, the riparian forest retains more vegetative cover and water compared to the grassland and woodland habitats in the MNP. Whilst the vegetative cover serves as refugia for stressed mobile organisms, the availability of water in riparian forests influences species distribution and trophic interaction of terrestrial food webs [81].

Research by Agyei-Ohemeng et al. [82] and Nsor et al. [83] in the MNP found similar results that are corroborated by our current study in further assessment of the functional diversity of the avifauna community in the park. Elsewhere in Africa, Mengesha et al. [84] recorded the highest bird species diversity in the riverine woodland habitats during the wet season, attributing it to the availability of water and food variety.

Woodland, being the dominant habitat in the MNP, was the second most diverse habitat both functionally and species wise. This finding could be attributed to the fact that woodlands are known to be more stable environments than grasslands, thus having a greater number of potential niches, allowing for the co-occurrence of species [78]. Just like the riparian forest, the woodland habitat provides more resources to avifauna communities and other wildlife, thereby accounting for the relatively higher number of species and functional groups. High species diversity in woodlands has been attributed to the availability of breeding sites and protection from predators [14].

Our study revealed that, although the distribution of species and functional groups was most even in the grassland, this habitat type was rather the least diverse of species and in their functional traits but also with the lowest abundance of birds. The grassland habitats in the MNP undergo annual fire management, and during our survey, some parts of the park were either burnt or had already been burnt, particularly in the nonbreeding season. This could have led to a loss in breeding grounds, food, and cover, thereby restricting birds to the riparian forest and woodland habitats. We also observed higher numbers of post-fire specialists (mostly northern carmine bee-eater and some raptors like grasshoppers and lizard buzzards, among others) and other generalist species, suggesting that many savanna species can tolerate and utilize burned areas [85]. Though the attraction of generalist species to the burnt site could lead to increase in avian species richness [86], our study found otherwise. In contrast, Docherty et al. [85] found a positive association between species richness and newly burned habitats in the Pilanesberg National Park, South Africa [85].

Having established that habitat structure is an important predictor of bird diversity and composition, it is not surprising that the largely homogenous grasslands in the MNP would record a less diverse avifauna community. Our findings corroborate research in north-eastern Oklahoma, USA, which has shown that greater heterogeneity across managed landscapes in grasslands led to increased avian diversity and stability over time [15].

Rather surprisingly, this study found no significant differences in species and functional diversity measures within the riparian habitat between the breeding and nonbreeding seasons in the MNP. The retention of most resources (food, water, nesting materials, nesting grounds, and cover from predation) in the nonbreeding season (dry season) attracts more wildlife to the riparian forest compared to the woodland and grassland. The shortage of food resources and nesting grounds in the grassland, for instance, may have forced some species and functional groups to use the riparian habitat, hence accounting for the higher diversity and abundance of avifauna communities in the riparian forest, as found in other studies [87–89]. A study by de Deus et al. [78] made similar observations in which the diversity of functional groups varied between two habitat types (forests and savannas) but did not significantly vary across the seasons.

Despite the significant variation in species diversity among the three habitats in the MNP, the variation in species composition (β-diversity) among those habitats was not significant. This suggests that most avian species in the park may have at best low habitat specificity, even with the differences in vegetation structure and complexity. A variation in habitat resources and conditions can affect birds' fitness and influence their reproduction and survival [90]. Beta diversity is a useful tool for understanding the responses of communities to the variations in environmental conditions and their consequences on ecological functions [91].

4.2. Relationship between Species Abundance and Functional Diversity Measures in the MNP. Our study found a positive correlation between bird abundance and functional diversity in the MNP. This positive relationship was most influenced by riparian habitats. This finding is consistent with earlier studies (see [9, 10]). Our study further found an overlap of functional diversity between the riparian habitats and the woodland habitats when bird abundance averaged 30 individuals. This finding suggests habitat complementarity within the MNP, a phenomenon that could promote critical ecosystem processes and help sustain the wildlife diversity in the MNP [92]. Higher functional diversity and abundance in the riparian habitat and woodland is an indication of increased ecosystem services and functioning that could result in improved ecosystem health. This could further result in the long-term regeneration of plant communities through improved pollinator services as well as seed and fruit dispersal [8, 68]. According to Cadotte et al. [93], for functional diversity to be relevant, it should be correlated with ecosystem function because it measures those aspects of diversity that potentially affect community assembly and function. In similar research, Luck et al. [94] recorded a positive linear relationship between species richness and functional diversity measures and cautioned against its interpretation as the likelihood of functional redundancy in a community. Bu et al. [95] and Biswas and Mallik [96] found positive correlations between species diversity measures and functional diversity in plant communities.

In contrast to functional diversity and richness, bird abundance declined among the three habitat types with increasing functional evenness. This could lead to low functional diversity and has the potential to reduce the rate of ecosystem services and function [97]. These findings are consistent with studies that found a direct correlation between species richness, abundance, and functional diversity [93, 98].

4.3. The Relationship between Avian Functional Diversity Indicators and Environmental Variables. Our study found a significant relationship between functional diversity measures and environmental covariates among habitat types and seasons. Functional diversity indices increased in habitats with more trees and grass cover but reduced with increasing shrub density. The riparian forest and woodland habitats in the MNP are characterised by higher tree density, thus supporting our earlier finding of higher species and functional diversity within those habitats. These patterns have been observed in similar research where functional diversity and richness increased with increasing vegetation structure [99]. This finding emphasised the point that avian communities are primarily determined by the structure and complexity of the habitats in which they occur [5, 79].

The observed decline in functional diversity and richness in the nonbreeding season among habitats could be attributed to reduced resource availability in the park. The nonbreeding season coincided with the dry season, a period in which the most essential resources (water, food, nesting sites) are limited and competition for those resources is high among birds and other fauna in the savannah [65]. Apart from the annual fire management in the MNP, most plant species either dry up or shed off their leaves during the nonbreeding season except for the riparian habitat, which still holds a good amount of water in streams. This perhaps has resulted in the shift of avifauna communities toward the riparian forest and interior woodland habitats where water remains available.

Though rising temperatures are expected to have negative effects on bird distribution and diversity [100], this study did not find a significant influence of average temperature on bird functional diversity. As expected, functional evenness declined in habitats with a higher tree and grass cover but increased marginally with shrub density. Communities with low functional evenness could result in homogenization and further lead to under exploitation of resources [19, 101]. Homogenisation of avifauna communities could also have important implications for ecosystem function and services and further reduce the resilience of ecosystems to future environmental changes [102].

5. Conclusion

Expansion of the understanding of bird presence is important for forecasting future population trends and assessing regular habitat management in light of in-house disturbances such as intentional or accidental fires and the illegal human destruction of portions of the MNP. The environment has restricted resources in certain seasons, benefiting species with specific functional traits. Though habitat turnover is an important factor that influences bird species composition across seasons, the changes in species composition still allowed the maintenance of certain functional characteristics. This study thus suggests that the vulnerable savannah in MNP may show some resilience to changes in the ecosystem for now, given the high species and functional diversity; however, this observation could change if the anthropogenically-induced changes that have engulfed the immediate surroundings of the MNP are not controlled.

It is recommended that MNP management commit more logistics to protect the park from poachers and illegal chainsaw operators while developing strategies to maintain the structural complexity of the riparian habitats within the ecosystem. Further studies to understand how the avifauna community would respond to anthropogenic habitat disturbances in synergy with natural changes in habitats in the face of global climate change are recommended.

Data Availability

Upon acceptance, the data on this research will be deposited in the archives of Dryad upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

The supplementary material contains an appendix with information on the Pearson correlation test, model residual plots from regression models, and the Bird inventory list. (*Supplementary Materials*)

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