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Bird composition and feeding guilds interactions across heterogeneous habitats in Mikumi national park, Tanzania

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ABSTRACT

Birds serve as environment health indicator, pollinators, scavengers, seed dispersers and predator while providing recreational services. This study investigated the current species distribution, diversity, richness, abundance and feeding guilds interaction in different habitats. Bird fauna was recorded using ground transect surveys in different habitat types identified. A total of 5,404 individuals of bird species were recorded in Mikumi National Park comprising of 237 species belonging to 71 families and 27 orders were observed in the study area. Red-billed Quelea (*Quelea quelea*) was frequently observed (1115 individuals, 20.63%). Overall, grassland supported higher abundance of bird species. Similarly, vachellia woodland supported the highest bird richness and diversity. Interestingly, although grassland accounted for the highest total abundance, it supported a moderate richness species. Grassland and shrubland supported significantly more granivorous bird species. Habitat heterogeneity in vachellia woodland, which also provide critical habitats for the 8 species of global conservation concern such as endangered vulture species contributed to overall bird richness and diversity. These findings provide baseline data to inform conservation planning, ecological monitoring, and avitourism development within the park. Further long term study is necessary in the park to compare information of temporal and spatial that will assist in conservation of birds and also improve avitourism planning, designing and implementation.

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INTRODUCTION

Globally, there is significant interest in quantifying the distribution, diversity and abundance of indigenous biodiversity in different protected and non-protected areas. It has been recognized that biodiversity can be conserved through the designation, establishment, and management of protected areas (Naughton-Treves *et al.,* 2005; Venter *et al.*, 2014; Asaad *et al.*, 2017; Visconti *et al.,* 2019). Documentation of biological resources, are very important for considerate of ecological characteristics and ecosystem functions, making them crucial for effective ecosystem management (Brussard *et al.*, 1998; Venter *et al.*, 2014; Asaad *et al.,* 2017; Baskent, 2020).

Birds' communities in the Mikumi National Park are the most species-rich group and form the source of food for predators of medium-sized carnivores and birds of prey. Observing feeding guilds tells more about how ecosystems stay stable than just looking at a list of species names (Sebastián-González *et al.*, 2025). Guilds like insectivores or granivores shows how resources are shared. In unpredictable savannas, sharing resources this way reduces competition, allowing many different birds to survive even when food becomes scarce during the dry seasons (De León *et al.*, 2014; Zwarts *et al.*, 2015).

Mikumi National Park in Tanzania is covered with different vegetation types divided into two main different environments (Northern and Southern sector) with different vegetation zoning.

According to the Habitat Heterogeneity Theory (MacArthur and MacArthur, 1961), structurally complex ecosystems provide a greater diversity of ecological niches, thereby accommodating higher species coexistence and partitioning. In East African savannas, this vertical and horizontal structural complexity is primarily dictated by vegetation architecture and woody plant cover (Lyaruu, 1997; Mligo, 2017; Sherry *et al.,* 2020; Bukombe *et al.,* 2023). Because Mikumi National Park features a transition between open grasslands and dense woodlands, evaluating how this structural variation alters bird's community assembly rules is critical to understanding savanna biodiversity dynamics. Such habitat type variation created favorable area for birds to survive. Presence of diverse habitats enabled the park to support a wide range of resident, migratory birds as well species of conservation concern (Cunningham and Johnson, 2019; Chefrour *et al.,* 2026). It is possible that vegetation structure and food availability in such vegetation are the main factors determining the pattern of distribution of birds. Apart from birds being distributed in the park, also other animal species that can be found in the park include large and small mammals such as wildebeest, giraffes, zebras, hippos, wild dogs, lions and elephants (Venance, 2010; Magige *et al.*, 2025), also the park has invertebrates, fish, amphibians and reptiles.

Birds serve as environment health indicator, pollinators, scavengers, seed dispersers and predator while providing recreational services (Whelan *et al.,* 2008; Mariyappan *et al.,* 2023; Sebastián-González *et al.,* 2025). Birds respond rapidly to environmental changes, occupy diverse trophic and functional niches, and are closely associated with habitat structure and resource availability (Van Strien *et al.,* 2012; Barbet-Massin and Jetz, 2015). In savanna ecosystems, bird's community composition is strongly influenced by vegetation structure and heterogeneity, rainfall patterns, habitat complexity, and disturbance regimes (Bender *et al.,* 2017; Sherry *et al.*, 2020). Despite ecological social and economical roles played by birds in the Mikumi National Park, systematic baselines investigating the effects of habitat heterogeneity on bird community structure across the entire park remain scarce. Most of the studies conducted focuses on other taxa including small mammals (Stanley *et al.*, 2005; Venance, 2010; Kisanga *et al.,* 2019; Magige *et al.,* 2025), baboon community (Rhine *et al.,* 2000; Mayengo *et al.*, 2017; Kitegile *et al.,* 2022; Manyama, 2026), large mammals (Newmark *et al.,* 1996; Caro *et al.,* 1998), and plants of Mikumi National Park and their surroundings (Lyaruu, 1997; Mligo, 2017; Bukombe *et al.,* 2023). This study aimed to document how habitat

types and feeding guilds influence bird species richness, abundance, and diversity in Mikumi National Park.

MATERIALS AND METHODS

Study area description

The study was conducted in Mikumi National Park (MINAPA) which is located in central-eastern of Tanzania. The park is found in the Kilosa District, within the Morogoro Region and lies between 7° 00'-7° 45' S and 37° 00'-37° 30'. In extraordinary of Malundwe Hill which is a situated in a windward site receiving higher amount of annual rainfall of about 1500 to 2000 mm (Lovett and Norton, 1989), although the rainfall pattern is very unpredictable. However, there is always a definite dry period between January E (Fig. 1). The park was established in 1964 with an area of 3,230 km². The park has a bi-modal rain season, characterized by short rain in October to early November, followed by long rain lasting for five/six months and annual average rainfall is about 860 mm (Bukombe *et al.,* 2023) and February, with a mean annual temperature of 25-5°C (Lovett and Norton, 1989).

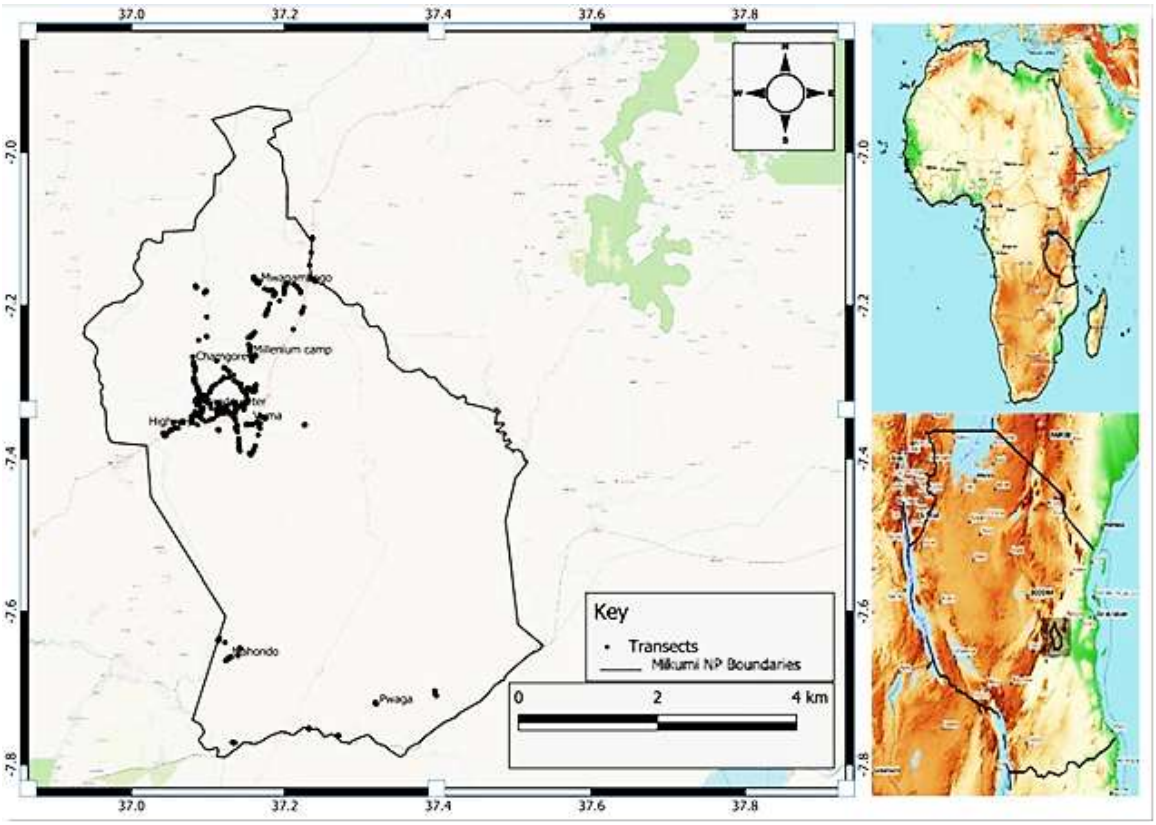


Fig. 1. Location of Mikumi National Park in Tanzania, showing sampling points in different areas

MINAPA has diverse in habitat types; include flood plain and riverine vegetations; grassland, forest, woodland (miombo and vachellia) and shrushland (Lyaruu, 1997; Bukombe *et al.,* 2023). These habitats classification was adopted from Lyaruu (1997) and Bukombe *et al.* (2023). Floodplain and grassland are dominated by *Borassus aethiopum, Themeda triandra, Panicum maximum* and *Hyperrhenia* spp., and trees such as *Vernonia glabra, and Lonchocarpus cappasa*. Shrubland and woodland are dominated with *Dalbergia* spp., *Tamarindus indica Albizia* spp., Balanites spp., miombo and vachellia spp. (Lyaruu, 1997; Bukombe *et al.*, 2023). Riverine and forest are normally associated with *Sclerocarya caffra, Terminalia kilimandscharica, Ficus sppand Haplocoelum inoploeum*.

Survey methods

The survey of bird species in Mikumi National Park was conducted in November 2020, repeated in March

2021and April 2025. Following the method of Baker and Baker (2020) and Werema (2017), we created line transects and attended by Driving vehicles at speed of 20km/h. using existing roads in the area, Also, we created several transects of 1km in the park and was attended by walking. The transects were established perpendicular to road transects to complement the effects of roads. Driving line transects for birds' observations and counts were done at 5 km, and separated with a length of 2 km. In the stretch of the length of 2 km, no records were made to allow scared birds to settle. In order to maximize observations/ encounters, the vehicle was driven at a speed of 20 km/h with two observers (2 rear seats observers left/right) and one person as data recorder (Tiwari *et al.,* 2021).

A one Kilometer walking transect was also created, this 1km transects were placed after every 5 km in each road existed in the park, birds' observation was within 50m on either side of the transect. During walking in a 1km length observers maintain a straight line, the direction of the transect was guided using a handheld GPS depending on the terrain and vegetation cover of the area. Birds were identified by sight (direct observation) and call, and numbers were recorded using a Smartphone Bird a\Lasser Application (Lee and Nel, 2020). Birds identification was facilitated with the aid of binoculars which helps to identified colour patterns of the species and field guide books. Birds flying overhead were included if they were specifically associated with the habitat (e.g., swallows and birds of prey actively foraging along transects). These transects aimed to document bird's species inhabiting different habitat types in the Mikumi National Park.

For species which were not directly identified in the field, brief notes describing them was recorded to allow for later identification. Administrative and patrol roads were used to assess bird's species' distribution patterns and habitat occupancy in the park. Birds sighting relied on both direct sightings with assistance of binoculars and indirect observations using calls. The distance of 50 m was maintained on either side of a transect to record birds; although, sometimes length was increased depending on visibility. The observers' experience and field guide books were used to identify birds (Stevenson and Fanshawe, 2020). Birds observations were grouped in a trip card, once created per sampling transect. Observations of birds were added in a trip card as described by Lee and Nel (2020).

Data analysis

Data were cleaned in Microsoft Excel, followed by data analysis in R Statistical Software, descriptive statistics were conducted to show number of species, total abundance and richness in Mikumi National Park. To evaluate the composition and habitat-specific dominance patterns of the avian community, the Index of Relative Abundance (IRA) was calculated for each recorded bird species within each distinct habitat type. The IRA standardizes the presence of a species by calculating its percentage representation relative to the entire local community, IRA provides a robust proxy for community structure and relative dominance across varying habitat types, minimizing potential biases introduced by absolute density variations or differing sampling conditions between open grasslands and dense woodlands (Van Heezik and Seddon, 2012; 2017), furthermore diversity indices such as Shannon (H′), Simpson (1-D) and Evenness were computed via vegan package in R (Oksanen *et al.*, 2001).

Inferential statistics were conducted to check the statistically significant differences among habitats in Mikumi NP and investigations on how habitats interact with feeding guilds where Generalized Linear Mixed Model using Template Model Builder (glmmTMB) package were used to account for hierarchical structure and non-normal distributions inherent in biodiversity datasets. For count-based metric such as species richness and abundance, a Negative Binomial distribution was employed to address overdispersion, where variance typically exceeds the mean in biological populations (Brooks *et al.,* 2017; Douma and Weedon, 2019; Nakagawa *et al.*, 2026). For Shannon diversity, we employed a

Gaussian distribution while Simpson Index which is bonded between 0 and 1 was analyzed using a Beta distribution (Geissinger *et al.,* 2022). On both model log-abundance was included as covariate to account for the effect of individual density on diversity estimates (Gooriah *et al.,* 2020).

Statistical significance for the fixed effects was assessed using Type II Wald Chi-square tests which is preferred for models with interaction terms as it tests each main effect after accounting for others at the same level (Fox and Weisberg, 2019) where P-values less than 0.05 were statistically significant. All pairwise comparisons among habitats as well as between habitat and guilds were adjusted using Tukey HSD method to maintain a stringent family-wise error rate and minimize the risk of Type I errors (R core Team, 2024).

RESULTS

Bird species composition and abundances

A total of 5,404 individuals of bird species were recorded in Mikumi NP comprising of 237 species belonging to 71 families and 27 orders. The most abundant species in Mikumi NP was *Quelea quelea* (1115, 20.63%) followed by *Hirundo rustic*a (608, 11.25%) and *Quelea erythrops* (299, 5.53%). The bird community showed habitat specific dominance. grassland and Shrubland were characterized by high dominance of species like *Quelea quelea* (IRA = 45.07% on grassland) and *Hirundo rustica* (IRA = 39.5% on shrubland) while riverine forest and vachellia woodland dominated by various species with the most abundant species representing less than (IRA = 12%) of the total community.

Species abundance varied significantly across habitats (χ^2 = 222.18, df = 5, P < 0.001). Post-hoc pairwise using Tukey's HSD adjustment revealed a clear gradient of birds' abundance across habitats. Grassland and shrubland both supported significantly high abundance than all wooden habitat types. Specifically, grassland supported higher abundance than in miombo woodland (Ratio = 3.805, Z = 10.492, P < 0.001) and then vachellia woodland (Ratio = 2.325, Z = 7.098, P < 0.001). Similarly, shrubland bird's abundance were greater than vachellia woodland (Ratio = 2.325, Z = 7.098, P < 0 .001) and Pond (Ratio = 0.596, Z = -3.024, P = 0.03). Similar patterns were observed for riverine forest, which showed marked lower abundance compared to pond (Ratio = 2.874, Z = 5.873, P < 0.001) and shrubland (Ratio = 0.207, Z = -9.948, P < 0.001).

Miombo woodland showed significantly lower abundance than Vachellia Woodland (Ratio = 0.611, Z = -4.103, P = 0.0006) and Pond (Ratio = 0.375, Z = -6.017, P < 0.001).

Species richness and diversity across habitats

Vachellia Woodland supported the highest bird richness with 86 species followed by Miombo Woodland (74 species) and riverine forest (70 species). Interestingly, although grassland accounted for the highest total abundance, it supported a moderate richness of 62 species and Shrubland (43 species), pond supported richness of 37 species.

A clear gradient in community complexity was observed through the Shannon-Winner (H′) and Simpson (1 – D) indices. Riverine forest, miombo woodland and vachellia woodland emerged as the most ecological diverse habitats with highest mean Shannon values (H′ ≈ 2.49, H′ ≈ 2.02 and H′ ≈ 2.14 respectively) and Simpson values (1 – D ≈ 0.80). Conversely, shrubland and pond exhibited lowest diversity scores (Fig. 2). The evenness index (E) highlights that riverine forest and iombo woodland demonstrated most equitable distributions with mean evenness scores exceeding (E ≈ 0.93, E ≈ 0.89). While grassland, vachellia woodland and shrubland maintained relatively high mean even scores (Fig. 2), pond displayed the lowest mean evenness (E ≈ 0.68).

Statistical analysis revealed the existence of significant difference on richness among habitats (χ^2 = 17.925, df = 5, P = 0.003), also it indicated that Shannon diversity varied significantly by habitat type (χ^2 = 19.415, df = 5, P = 0.0016), with log-abundance as strong positive predictor of diversity (χ^2 = 72.07, df

= 1, P < 0.001). Consistent with these findings, the beta regression model revealed overall significant difference of Simpson Index across different habitat types (χ^2 = 14.695, df = 1, P = 0.0117). Log-abundance remained a significant covariate (χ^2 = 31.578, df = 1, P < 0.001).

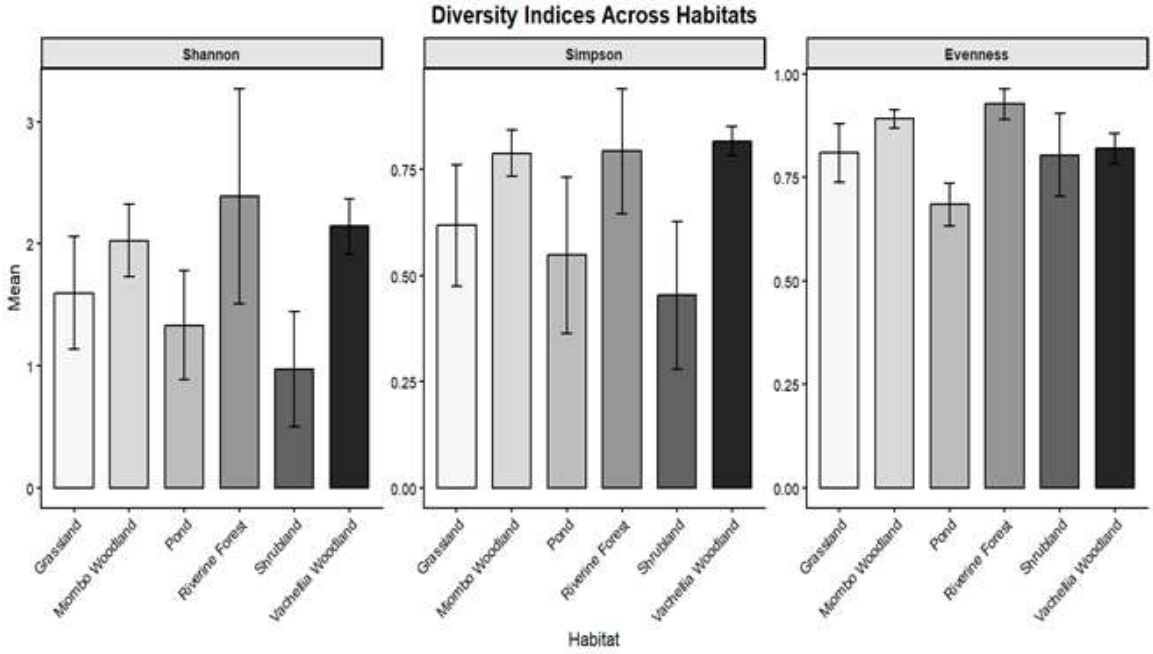


Fig. 2. Mean diversity indices across different habitats in Mikumi National Park with standard error bars

Table 1. Significant feeding guilds interaction across heterogenous habitats in Mikumi NP

Habitat	Feeding guild		Ratio	Z-Value	P-Value
Grassland	Granivorous	Carnivorous	3.27	3.592	0.0044
		Insectivorous	3.71	7.1	< 0.001
Pond	Herbivorous	Carnivorous	12.13	4.564	0.0001
		Granivorous	16.67	2.971	0.0352
	Insectivorous	Carnivorous	4.22	4.128	0.0005
Shrubland	Granivorous	Carnivorous	7.55	2.957	0.0259
		Nectivorous	7.576	2.957	0.0259
		Omnivorous	6.41	5.026	< 0.001
	Insectivorous	Omnivorous	4.08	4.579	< 0.001

Interaction between habitat types and feeding guild

A significant interaction on birds' abundance between habitat type and feeding guild was observed (χ^2 = 81.294, df = 22, P < 0.001). Post-hoc pairwise comparison revealed several habitat-specific differences in feeding guild composition (Table 1). In grassland habitat supported significantly more granivorous species than carnivorous and insectivorous species. Pond habitat significantly supported herbivorous species than carnivorous and granivorous guilds as well as more insectivorous than carnivorous. Furthermore, shrubland habitat significantly supported granivorous species than carnivorous, nectivorous and omnivorous species while also it supported more insectivorous species than omnivorous species.

Bird species of conservation importance (endangered and threatened)

Eight threatened species including vultures were recorded in different habitat types of Mikumi National Park (Table 2). The recorded species categorized by an International Union for Conservation of Nature (IUCN) as critically endangered (CR) including Hooded Vulture *Necrosyrtes monachus*, White-backed Vulture *Gyps africanus*, and White-headed Vulture *Trigonoceps occipitalis*. During the survey, White-backed Vulture

was frequently sighted (63.801%), Hooded Vulture and White-headed Vulture both possessed equal frequencies of observation having 1.357% each (Table 2). More threatened bird species were recorded along vachellia woodland habitats with overall of abundance of 154 (69.683%), and least in Pond areas having abundance of 6 (2.715%; Table 2).

Three species characterized by IUCN as endangered (EN) were recorded in the study areas (Table 2). Bateleur *Terathopius ecaudatus* was the most frequent recorded endangered species with abundance of 20 (9.050%) individuals recorded along grassland, Miombo woodland, pond areas, and vachellia woodland (Table 2). Lappet-faced Vulture *Torgos tracheliotus* (4 (1.810%)), and Martial Eagle *Polemaetus bellicosus* (1 (0.452); Table 2). Also, we documented a single species in Vachellia woodland and five individuals of Saddle-billed Stork *Ephippiorhynchus senegalensis* in ponds habitat (6 (2.715%)) a species categorized by IUCN as Near Threatened (NT; Table 2). We also recorded Southern Ground-hornbill *Bucorvus leadbeateri* (43 (19.457%)) a species categorized by IUCN as vulnerable (VU; Table 2). Therefore, the results obtained from statistical tests using ANOVA at a 5% level of confidence comparing diversity, richness and abundance of birds of IUCN concern across habitat types of Mikumi National Park showed that there was no significant difference ($p<0.05$).

Table 2. Bird species of conservation importance observed in Mikumi National Park in different habitats

Sl	Common name	Scientific name	IUCN status	Habitat					
				Grassland	Miombo Woodland	Pond	Vachellia woodland	N	%N
1	Hooded Vulture	*Necrosyrtes monachus*	CR		3			3	1.357
2	White-backed Vulture	*Gyps africanus*	CR	15	20		106	141	63.801
3	White-headed Vulture	*Trigonoceps occipitalis*	CR				3	3	1.357
4	Bateleur	*Terathopius ecaudatus*	EN	5	13	1	1	20	9.050
5	Lappet-faced Vulture	*Torgos tracheliotos*	EN		4			4	1.810
6	Martial Eagle	*Polemaetus bellicosus*	EN	1				1	0.452
7	Saddle-billed Stork	*Ephippiorhynchus senegalensis*	NT			5	1	6	2.715
8	Southern Ground-hornbill	*Bucorvus leadbeateri*	VU				43	43	19.457
Grand Total (N)				21	40	6	154	221	
%N				9.502	18.100	2.715	69.683		

NT= Near Threatened, VU= Vulnerable, EN= Endangered, CR= Critically Endangered

DISCUSSION

Bird species composition, abundances between habitat types and feeding guild

There was a significant difference between species composition and abundance of birds across the different habitats and feeding guilds within Mikumi National Park. Presence of higher number of granivorous species in grassland habitat supported more significantly results.

Therefore, seed eating guilds in different habitat types can be explained by the presence of a high proportion of *Quelea quelea* species among bird communities. grassland habitats possessed more grass seeds which attracted granivorous birds to forage and concentrated in large assemblages, this dynamic is common for heterogenous savanna grassland habitats (Tews *et al.*, 2004). This observation contradicts the finding by Nkwabi *et al.* (2025) who conducted the study in Ruaha National Park, recorded more *Quelea quelea* in *vachellia* woodland habitats. Similarly, Werema (2017) recorded higher abundance of birds in Acacia/Vachellia habitat of Burunge Wildlife management area in northern Tanzania. Such habitat types in Mikumi National Park, environmental variation might affect either species richness or the total number of individuals causing a substantial shift in the composition of species in communities due to the ability of most species to thrive in diverse habitat conditions. Grassland habitats in the park are a result of water lodged areas (Lyaruu, 1997; Bukombe *et al.*, 2023), producing heterogenous grass habitats with

plenty of seeds for birds to interact and forage (Abdulwahab *et al.*, 2019; Murray *et al.,* 2016; Sam *et al.,* 2019).

Occurrence of higher number of insectivorous bird species in shrubland habitat produced more significantly results. Bird species that feed on insects showed habitat specific dominance with Barn Swallow (*Hirundo rustica)* occurring in higher numbers in shrubland habitats. The *H. rustica* is an extensive aerial insect feeder that breeds across North America and East Asia (Kusack, 2018; Boynton *et al.,* 2020; Tian *et al.,* 2024) and winters in Eastern, Central and Southern African landscapes (Ambrosini *et al.*, 2011; Underhill and Remisiewicz, 2025).

Presence of *H. rustica* in Mikumi National Park could be due to availability of higher proportion of aerial invertebrates in shrubland than in other habitats. Globally, the population size of Barn Swallow has shown a moderate decline due to reported of human activities which resulted into decline of their aerial insect prey, on which be subject to at all stages of their wandering lifespan (Dean and Milton, 2001; Underhill and Remisiewicz, 2025). Therefore, higher distribution of this species in Mikumi National Park will flourish well and increase population size during their wintering in Africa.

The results obtained from this study have presented that bird's dispersal occur in all habitats together with areas where during rainy season flooding making the Mkata floodplains inaccessible. Large percentage of grassland in Mikumi National Park is covered by wetland grassland in turn providing refugee for birds preferring to forage in such areas. This study proved the status of grassland habitats, which has provided range of diverse vegetation types enabling favorable environment for diverse birds' communities to nest, stay in shade, forage and discharge from predator (Watters *et al.,* 2002; Okafor *et al.,* 2025). For example, *Quelea quelea* was frequently observed along Mkata floodplain contributing higher abundance of birds in grassland habitats. From the results obtained therefore, grassland habitats in Mikumi National Park can be important areas for establishing avitourism. Documenting of the bird's status (species richness, abundance, diversity and distributions) in different habitats of the park can be beneficial effort for development and ranking different conservation activities by advising for avitourism attractions in the park.

Bird species of conservation importance (endangered and threatened), richness and diversity across habitats

The current survey findings presented higher species richness and diversity in vachellia woodland habitats than in other habitats. Vachellia woodland possess variety of habitat requirements for birds including shading, nesting, feeding and protection cover. Results from this survey were consistent with the observation by Muhammad (2018) who observed acacia/vachellia woodlands habitat to accommodate more species richness and diversity of avifauna than other habitats. Results from this survey were not consistent with the observation by Dean and Milton (2001) who observed higher species richness and diversity in shrubland habitats in the southern Karoo, South Africa. Similarly, Werema (2017) documented higher species richness and abundance in shrubland habitat when compared to other habitats in semi-arid East-Central Tanzania. Also, Mangewa *et al.* (2025) documented higher species richness and diversity in shrubland than in other habitats. Birds in Mikumi National Park choose habitats with woodlands because they provide them with enough resources for to forage and achieve survival of the species.

We spotted some birds that are at risk of extinction, according to the IUCN Red List. Three scavengers' vultures were classified as Critically Endangered included the Hooded Vulture, White-headed Vulture, and White-backed Vulture. The presence of birds' species of IUCN conservation concern in the park need special attention to conserve the species, there should be consideration in habitats they inhabit (e.g. for nesting and roosting). Human activities surrounding protected areas they cause threats and therefore are critical in conservation for enhancing

their population recovery (Jha and Jha, 2021; Lobello *et al.*, 2025). We also recoded two endangered birds of prey – the Bateleur and the Martial Eagle. Noticing these birds emphasizes how crucial it is to protect old-growth *Vachellia* trees. These trees provide essential habitats for the big birds to nest and rest. To help these species bounce back, managers need to tackle local threats like poison from illegal carcass dumping, pesticide run-off, and the removal of large trees.

CONCLUSION

Bird species were observed in each habitat types surveyed, bird inhabiting both terrestrial and aquatic areas is available in the Mikumi National Park. Prominently, the park area has the necessary life supporting resources in terms of forage, shelter and nesting for birds that provides survival of bird species. The information obtained from this survey will guide future conservation planning and research; as well improve tourism circuit/pattern in different habitats of the park. The collected information has further added understanding of the different bird species occurring in different habitat types for improving conservation and diversifying tourism activities in the park. The actions/activities would be geared towards to improve road network and hotspot areas for avitourism, habitats management and improvements for the species distribution. The generated information of birds in the entire areas of the park had increased an existing baseline data for ecological monitoring and future research works. Finally, we encourage the development of comprehensive studies that consider a broader range of factors influencing bird's abundance, diversity and richness in the park. Further studies may account for disturbance as a continuous variable for ongoing multi-infrastructure development occurring in the southern circuit of Tanzania, or include additional design factors such as flooding intensity, landscape connectivity, to provide a more complete understanding of the factors structuring birds' communities across national parks of southern circuit of Tanzania to enhance avitourism development.

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REFERENCES

Abdulwahab UA, Osinubi ST, Abalaka J. 2019. Risk of predation: A critical force driving habitat quality perception and foraging behavior of granivorous birds in a Nigerian forest reserve. Avian Research **10(1)**, 33.
DOI: 10.1186/s40657-019-0173-6.

Ambrosini R, Rubolini D, Møller AP, Bani L, Clark J, Karcza Z, Vangeluwe D, du Feu C, Spina F, Saino N. 2011. Climate change and the long-term northward shift in the African wintering range of the barn swallow *Hirundo rustica*. Climate Research **49**, 131–141.
DOI: 10.3354/cr01025

Asaad I, Lundquist CJ, Erdmann MV, Costello MJ. 2017. Ecological criteria to identify areas for biodiversity conservation. Biological Conservation **213**, 309–316.
DOI: 10.1016/j.biocon.2016.10.007

Baker NE, Baker EM. 2020. A large concentration of Allen's gallinules *Porphyrio alleni* in Ruaha National Park, Tanzania and other interesting observations of the species in Tanzania. Scopus: Journal of East African Ornithology **40(2)**, 80–81.

Barbet-Massin M, Jetz W. 2015. The effect of range changes on the functional turnover, structure and diversity of bird assemblages under future climate scenarios. Global Change Biology **21(8)**, 2917–2928. DOI: 10.1111/gcb.12905

Baskent EZ. 2020. A framework for characterizing and regulating ecosystem services in a management planning context. Forests **11(1)**, 102. DOI: 10.3390/f11010102

Bender IM, Kissling WD, Böhning-Gaese K, Hensen I, Kühn I, Wiegand T, Dehling DM, Schleuning M. 2017. Functionally specialised birds respond flexibly to seasonal changes in fruit availability. Journal of Animal Ecology **86(4)**, 800–811. DOI: 10.1111/1365-2656.12683

Boynton CK, Mahony NA, Williams TD. 2020. Barn swallow (*Hirundo rustica*) fledglings use crop habitat more frequently in relation to its availability than pasture and other habitat types. The Condor **122(2)**, duz067. DOI: 10.1093/condor/duz067

Brooks ME, Kristensen K, Van Benthem KJ, Magnusson A, Berg CW, Nielsen A, Skaug HJ, Mächler M, Bolker BM. 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling.

Brussard PF, Reed JM, Tracy CR. 1998. Ecosystem management: What is it really? Landscape and Urban Planning **40(1–3)**, 9–20. DOI: 10.1016/S0169-2046(97)00094-7

Bukombe J, Kavana P, Marealle W, Nkwabi A, Leweri C, Makongoro R, Kimaro J, Mwita M, Kija H, Okick R, Kohi E. 2023. Flora resources of Mikumi National Park (MINAPA): An insight for enhancing strategic management and conservation of protected areas (PAs) in Tanzania. Taxonomy and Biosystematics **15(57)**, 1–42. DOI: 10.22108/TBJ.2023.138616.1237

Caro TM, Pelkey N, Borner M, Campbell KI, Woodworth BL, Farm BP, Ole Kuwai J, Huish SA, Severre EM. 1998. Consequences of different forms of conservation for large mammals in Tanzania: Preliminary analyses. African Journal of Ecology **36(4)**, 303–320. DOI: 10.1046/j.1365-2028.1998.00147.x

Chefrour R, Guelati K, Menaa M, Aouadi A, Mederbal KE, Boutabia L, Bouderbaia A, Toumi A, Maazi M, Telailia S. 2026. Habitat preferences of bird communities across woodland types in Mount Tiffech, northeastern Algeria. Applied Ecology and Environmental Research **24(3)**, 4487–4505. DOI: 10.15666/aeer/2403_44874505

Cunningham MA, Johnson DH. 2019. Narrowness of habitat selection in woodland and grassland birds. Avian Conservation and Ecology **14(1)**, 522. DOI: 10.5751/ACE-01372-140114

De León LF, Podos J, Gardezi T, Herrel A, Hendry AP. 2014. Darwin's finches and their diet niches: The sympatric coexistence of imperfect generalists. Journal of Evolutionary Biology **27(6)**, 1093–1104. DOI: 10.1111/jeb.12383

Dean WRJ, Milton SJ. 2001. The density and stability of birds in shrubland and drainage line woodland in the southern Karoo, South Africa. Ostrich: Journal of African Ornithology **72(3–4)**, 185–192. DOI: 10.2989/00306520109485315

Douma JC, Weedon JT. 2019. Analysing continuous proportions in ecology and evolution: A practical introduction to beta and Dirichlet regression. Methods in Ecology and Evolution **10(9)**, 1412–1430. DOI: 10.1111/2041-210X.13234

Fox J, Weisberg S. 2019. An R companion to applied regression. 3rd ed. Sage.

Geissinger EA, Khoo CL, Richmond IC, Faulkner SJ, Schneider DC. 2022. A guide to second-order effects in ecology: Beta regression for bounded ecological data. Ecosphere **13(3)**, e3967.

Gooriah LD, Davidar P, Chase JM. 2020. Species–area relationships in the Andaman and Nicobar Islands emerge because rarer species are disproportionately favored on larger islands. Ecology and Evolution **10(14),** 7551–7559
DOI: 10.1002/ece3.6480

Jha KK, Jha R. 2021. Study of vulture habitat suitability and impact of climate change in Central India using MaxEnt. Journal of Resources and Ecology **12(1)**, 30–42.

Kisanga AC, Nyahongo JW, Mtemi WM, Roskaft E. 2019. Influence of multiple linear infrastructure on diversity of small mammals in Mikumi National Park, Tanzania. Environment and Natural Resources Research **9(3)**, 1–8.
DOI: 10.5539/enrr.v9n3p41

Kitegile A, Hassan SN, Norton GW. 2022. A road traversing a protected area has little effect on feeding and foraging behaviour of yellow baboons. Ecology and Evolution **12(12)**, e9405.

Kusack JW. 2018. Landscape-level effects of agricultural intensification on the condition and diet of nestling barn swallows (*Hirundo rustica*). Master's thesis, The University of Western Ontario, Canada.

Lee ATK, Nel H. 2020. BirdLasser: The influence of a mobile app on a citizen science project. African Zoology **55(2)**, 155–160.
DOI: 10.1080/15627020.2020.1717376

Lobello M, Bava R, Castagna F, Sotgiu FD, Berlinguer F, Tilocca B. 2025. The role of vulture (Accipitriformes) cutaneous microbiota in infectious disease protection. Microorganisms **13(4)**, 898.
DOI: 10.3390/microorganisms13040898

Lovett JC, Norton GW. 1989. Afromontane rainforest on Malundwe Hill in Mikumi National Park, Tanzania. Biological Conservation **48(1)**, 13–19. DOI: 10.1016/0006-3207(89)90056-6

Lyaruu HVM. 1997. Plant community structure and land degradation in Mikumi National Park, Tanzania. Medd. Växtbiologiska Institutes, Uppsala **1**, 1–35.

MacArthur RH, MacArthur JW. 1961. On bird species diversity. Ecology **42(3)**, 594–598.
DOI: 10.2307/1932254

Magige FJ, Kilwanila SI, Bukombe JK, Malleale WN, Sabuni CC. 2025. Diversity of small mammals in Mikumi and Udzungwa Mountains National Parks, Tanzania. Journal of East African Natural History **114(9)**, 80–93.
DOI: 10.2982/028.114.0901

Manyama FF. 2026. Effects of seasonality on baboons' (*Papio cynocephalus* and *Papio anubis*) daily movement patterns and group sizes in semi-arid environment at Swagaswaga Game Reserve, Tanzania. Discover Conservation **3(1)**, 21.
DOI: 10.1007/s44353-025-00058-8

Mariyappan M, Rajendran M, Velu S, Johnson AD, Dinesh GK, Solaimuthu K, Kaliyappan M, Sankar M. 2023. Ecological role and ecosystem services of birds: A review. International Journal of Environment and Climate Change **13(6)**, 76–87.
DOI: 10.9734/IJECC/2023/v13i61800

Mayengo G, Bwagalilo F, Kalumanga VE. 2017. Human wildlife conflicts to communities surrounding Mikumi National Parks in Tanzania: A case of selected villages. International Journal of Environment, Agriculture and Biotechnology **2(4)**, 1777–1784. DOI: 10.22161/ijeab/2.4.40

Mligo C. 2017. Diversity and distribution pattern of riparian plant species in the Wami River system, Tanzania. Journal of Plant Ecology **10(2)**, 259–270.

Muhammad SI. 2018. The effects of seasonality, landscape variables and anthropogenic activities in structuring bird community in Dutse, Nigeria. Doctoral dissertation, University of Malaya, Malaysia.

Murray C, Minderman J, Allison J, Calladine J. 2016. Vegetation structure influences foraging decisions in a declining grassland bird: The importance of fine-scale habitat and grazing regime. Bird Study **63(2)**, 223–232.
DOI: 10.1080/00063657.2016.1180342

Nakagawa S, Ortega S, Gazzea E, Lagisz M, Lenz A, Lundgren E, Mizuno A. 2026. Location–scale models in ecology and evolution: Heteroscedasticity in continuous, count and proportion data. Methods in Ecology and Evolution **17(2)**, 554–566.
DOI: 10.1111/2041-210x.70203

Naughton-Treves L, Holland MB, Brandon K. 2005. The role of protected areas in conserving biodiversity and sustaining local livelihoods. Annual Review of Environment and Resources **30**, 219–252.
DOI: 10.1146/annurev.energy.30.050504.164507

Newmark WD, Boshe JI, Sariko HI, Makumbule GK. 1996. Effects of a highway on large mammals in Mikumi National Park, Tanzania. African Journal of Ecology **34(1)**, 15–31.
DOI: 10.1111/j.1365-2028.1996.tb00590.x

Nkwabi AK, Mangewa LJ, Marealle WN, Makongoro R, Leweri C, Efraim J, Kija HK, Keyyu JD, Mwita MN, Kimaro JG, Mjingo EE. 2025. Avifauna diversity and occupancy in different habitat types: Key updates for biodiversity conservation in the Ruaha National Park, Tanzania.
DOI: 10.5897/IJBC2024.1638

Norton GW. 1989. National Park, Tanzania. Biological Conservation **48**, 13–19.

Okafor NM, Iwajomo SB, Azaki BD, Shiiwua MA. 2025. The number of human-simulated predators influences the escape behaviour of bird species in a West African protected area. Ostrich **96(2)**, 94–102.
DOI: 10.2989/00306525.2025.2510458

Oksanen J, Simpson GL, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'Hara RB, Solymos P, Stevens MHH, Szoecs E, Wagner H. 2001. vegan: Community ecology package. R package version 2.6–8.

R Core Team. 2024. R: A language and environment for statistical computing. Version 4.4.1 [computer program]. R Foundation for Statistical Computing, Vienna, Austria.

Rhine RJ, Norton GW, Wasser SK. 2000. Lifetime reproductive success, longevity, and reproductive life history of female yellow baboons (*Papio cynocephalus*) of Mikumi National Park, Tanzania. American Journal of Primatology **51(4)**, 229–241.

Sam K, Koane B, Bardos DC, Jeppy S, Novotny V. 2019. Species richness of birds along a complete rain forest elevational gradient in the tropics: Habitat complexity and food resources matter. Journal of Biogeography **46(2)**, 279–290.
DOI: 10.1111/jbi.13482

Sebastián-González E, Carrión S, Pérez-Granados C, López-Iborra GM, Botella F, Pérez C, Rocher G, Pérez-García JM, García-Rodríguez J, Sánchez-Zapata JA, Orihuela-Torres A. 2025. Servibirds: Quantitative assessment of the ecosystem services provided by native birds in Spain. Ardeola **73(1)**, 43–66.

Sherry TW, Kent CM, Sánchez NV, Şekercioğlu ÇH. 2020. Insectivorous birds in the Neotropics: Ecological radiations, specialization, and coexistence in species-rich communities. The Auk **137(4)**, ukaa049.
DOI: 10.1093/auk/ukaa049

Stanley WT, Gunn J, Kihaule P. 2005. Results of a preliminary small mammal survey of Malundwe Mountain, Mikumi National Park, Tanzania. Journal of East African Natural History **94(1)**, 213–222.

Stevenson T, Fanshawe J. 2020. Field guide to the birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi. Bloomsbury Publishing.

Tews J, Brose U, Grimm V, Tielbörger K, Wichmann MC, Schwager M, Jeltsch F. 2004. Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. Journal of Biogeography **31(1)**, 79–92.
DOI: 10.1046/j.0305-0270.2003.00994.x

Tian L, Liu Y, Wu Y, Feng Z, Hu D, Zhang Z. 2024. Migration pattern of a population of barn swallows (*Hirundo rustica*) breeding in East Asian tropical region. Avian Research **15**, 100192.
DOI: 10.1016/j.avrs.2024.100192

Tiwari G, Pandey P, Kaul R, Lee H, Singh R. 2021. Comparison of point and roadside transect methods to evaluate the abundance and richness of diurnal raptors in the arid region of Rajasthan. PLoS ONE **16(12)**, e0259805.

Underhill LG, Remisiewicz M. 2025. Arrival and peak abundance of barn swallows *Hirundo rustica* in three regions of South Africa in relation to climate indices, deduced from bird atlas data. Birds **6(3)**, 48.
DOI: 10.3390/birds6030048

van Heezik Y, Seddon PJ. 2012. Accounting for detectability when estimating avian abundance in an urban area. New Zealand Journal of Ecology **36(3)**, 1–7.

van Heezik Y, Seddon PJ. 2017. Counting birds in urban areas: A review of methods for the estimation of abundance. In: Ecology and conservation of birds in urban environments, pp. 185–207.
DOI: 10.1007/978-3-319-43314-1_10

Van Strien AJ, Soldaat LL, Gregory RD. 2012. Desirable mathematical properties of indicators for biodiversity change. Ecological Indicators **14(1)**, 202–208.
DOI: 10.1016/j.ecolind.2011.07.007

Venance J. 2010. Small mammal communities in the Mikumi National Park, Tanzania. Hystrix, the Italian Journal of Mammalogy **20(2)**.
DOI: 10.4404/hystrix-20.2-4439

Venter O, Fuller RA, Segan DB, Carwardine J, Brooks T, Butchart SH, Di Marco M, Iwamura T, Joseph L, O'Grady D, Possingham HP. 2014. Targeting global protected area expansion for imperiled biodiversity. PLoS Biology **12(6)**, e1001891.

Visconti P, Butchart SH, Brooks TM, Langhammer PF, Marnewick D, Vergara S, Yanosky A, Watson JE. 2019. Protected area targets post-2020. Science **364(6437)**, 239–241.

Watters ME, McLash TL, Aldridge CL, Brigham RM. 2002. The effect of vegetation structure on predation of artificial greater sage-grouse nests. Ecoscience **9(3)**, 314–319.
DOI: 10.1080/11956860.2002.11682718

Werema C. 2017. Preliminary comparison of birds inhabiting exotic *Acacia* and native bushland habitats in semi-arid East-Central Tanzania. Scopus: Journal of East African Ornithology **37(2)**, 32–37.

Whelan CJ, Wenny DG, Marquis RJ. 2008. Ecosystem services provided by birds. Annals of the New York Academy of Sciences **1134(1)**, 25–60.
DOI: 10.1196/annals.1439.003

Zwarts L, Bijlsma RG, Van Der Kamp J, Sikkema M, Wymenga E. 2015. Moreau's paradox reversed, or why insectivorous birds reach high densities in savanna trees. Ardea **103(2)**, 123–144.
DOI: 10.5253/arde.v103i2.a2