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Avian species composition, distribution and abundance in selected habitat types in Lake Manyara National Park, Northern Tanzania

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The study conducted at Lake Manyara National Park (LMNP) in 2021, covering both wet and dry seasons in aquatic, forest and woodland habitats, utilized the point count method to collect data on bird species composition, abundance and distribution. The results revealed a total of 171 identified bird species belonging to 52 families and 17 orders. Significant differences in species abundance were observed between woodland and forest ($z = 4.32$, $p < 0.001$), aquatic and woodland ($z = 5.89$, $p < 0.001$), and aquatic and forest habitats ($z = 2.43$, $p = 0.015$). The majority of bird species were recorded in the woodland (105), followed by the forest (69) and aquatic (38) habitats. These findings highlight the diverse bird species present in the selected habitat types of the park, emphasizing its significance as an important conservation area for birds. Detailed studies are recommended to further enhance our understanding of bird life in LMNP.

Key words: Bird species, biodiversity, conservation, environment, seasons.

INTRODUCTION

The variations in bird diversity within any ecosystem are crucial components of biodiversity conservation, carrying significant ecological, economic, and aesthetic values (Rajashekara and Venkatesha, 2011; Girmay et al., 2020). Ecologically, bird species play a vital role in pollination and seed dispersal (Bibi and Ali, 2013), as well as in controlling insect pests of agricultural crops, managing rodents, and acting as scavengers of carcasses (Briggs et al., 2012; Ramchandra, 2013). Additionally, their vibrant colors, attractive displays, songs, and calls contribute to the aesthetic enjoyment of our lives (Amare and Girma, 2021) and generate significant economic benefits in various countries through ecotourism, marking a new era in tourism (Nicolaides, 2014).

Given the importance of birds in environmental assessments, there is a critical need for a better ecological understanding of bird distribution patterns and community structures to inform conservation decision-making in specific areas (Kati and Sekercioglu, 2006). The distribution patterns of bird species typically align with the spatial structure of the environment and habitat requirements (Storch et al., 2003; Buckley and Freckleton, 2010). Habitat type and structural complexity influence species diversity and the interrelationship between vegetation and avian populations (MacArthur and

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MacArthur, 1961). For example, forest specialists often depend on vegetation structure and type (Gabbe et al., 2002; Earnst and Holmes, 2012) as a substrate for food and shelter (Lee and Rotenberry, 2005), making them susceptible to extinction in fragmented forest environments (Henle et al., 2004).

Aquatic bird communities, with specialized habitat and foraging requirements (Andrade et al., 2018), exhibit greater structural complexity in interactions and resource partitioning (Albrecht and Gotelli, 2001; Palmer et al., 2003). The association of birds with their habitats helps unravel the influence of biotic interactions on bird species distributions, attributed to food availability and patterns of food exploitation (Jankowski et al., 2013; Rosenberg, 1990; Albrecht and Gotelli, 2001; Palmer et al., 2003).

Lake Manyara National Park (LMNP) stands among the smallest national parks in Tanzania, situated within the East African Rift Valley System (EARS), and serves not only as a tourist attraction but also as a transit point to the renowned Serengeti ecosystem (Kihwele, 2015). The escalating human population coupled with increased agricultural activities, deforestation, and expanding settlements near LMNP, poses a significant threat to bird ecology (Kihwele et al., 2014). As the lowest point in the basin, Lake Manyara acts as a sink for various pollutants, leading to eutrophication and posing a serious risk to the aquatic ecosystem, contributing to environmental damage and ecological shifts (Yanda and Madulu, 2005). This has potential direct adverse impacts on both aquatic and terrestrial birds in the area. Despite being a crucial conservation area for avifauna, recent studies have primarily focused on water quality and the Lesser Flamingo (Kihwele et al., 2014; Mmassy et al., 2018), neglecting other aquatic and terrestrial birds in the surrounding habitats. Consequently, there is limited knowledge about the community composition, distribution, and abundance of bird species in LMNP. To address this gap, the present study aimed to document the influence of habitat types on the diversity, distribution, and community composition of avian species in the area. The specific objectives of the study were: (i) to assess avian species composition in selected habitat types; (ii) to determine avian species diversity and distribution; and (iii) to compare the mean species abundances between different habitat types.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Lake Manyara National Park, situated in the northern part of Tanzania (03o 30' S and 35o 45' E), encompassing part of Lake Manyara and the Great Rift Valley in the Arusha and Manyara Regions. In addition to its role as a tourist attraction, LMNP serves as a transit point to well-known tourist destinations (Kihwele, 2015). The lake boasts a remarkable diversity of over 380 bird species, including the iconic pink Lesser Flamingo (*Phoeniconaias minor*), and is also home to some endangered fish species (Keijzer, 2020). The park features a wide range of habitats, including groundwater forests, serving as a habitat for tree-climbing lions, baboons, and monkeys, as well as acacia woodlands and open savannah grasslands (Mariki et al., 2011).

The climate in the area is semi-arid, characterized by two distinct rainy seasons: short rains from October to December and long rains during March to May, with a mean annual rainfall of approximately 700 mm (Rohde and Hilhorst, 2001). The soils exhibit variability, ranging from alkaline to non-saline-alkaline in reaction, with textures including clay, clay-loam, loam, loamy/sand-loam, and sandy-loam/sandy-clay-loam (Nonga et al., 2011). Figure 1 shows the Lake Manyara National Park.

Data collection

The bird survey employed the point count method conducted along the existing roads within the park and along the lake shores. The habitats surveyed were categorized as forest, aquatic, and woodland. For each habitat type, three transects of one-kilometer length were established, with each transect featuring four points at intervals of 200 meters to minimize the risk of double counting (Okosodo et al., 2016). To maximize the sample size and maintain uniformity, a total of 12 points were established for each habitat type.

During the survey, all birds observed or heard within a radius of 50 mon both sides of the transects were identified and recorded for a duration of 10 min before moving to the next point. Recorded data included the number of individuals, habitat type, behavior, and GPS coordinates. A waiting period of 5 min was observed upon reaching each point to minimize the potential disturbance effect before the identification and recording process commenced (Yihenew and Bezawork, 2018). Bird observations were conducted using binoculars, and a field guide, "Birds of East Africa" by John (2006), was utilized for species identification. The observations were carried out during the morning hours from 0630 to 1030 and in the evening from 1430 to 1830 when birds were most active.

Data analysis

The collected data were organized using a Microsoft Excel spreadsheet, and a Shapiro-Wilk test was employed for normality testing. Since the results indicated that the data was not normally distributed, a nonparametric test was chosen. Differences in bird abundance between different habitat types and across seasons were assessed using a Mann-Whitney U test, with habitats considered as an independent variable and abundance as a dependent variable. Species diversity was calculated using the Shannon-Weiner Diversity Index in the Palaeontological Statistics (PAST 4.03) program (Hammer et al., 2001). Statistical significance was defined at $p < 0.05$.

Additionally, the Sørensen similarity index (S) was utilized to measure species similarity between the selected habitat types. Dispersal pattern categories (Residents, Palearctic migrants, and Intra-African migrants) and conservation status with global population trends (Critical Endangered CE, Near Threatened NT, Vulnerable VU, and Least Concern LC) of the identified species were assigned following the IUCN (2022) status of threatened species.

RESULTS

Avian species composition

A total of 1,737 bird individuals representing 171 species,

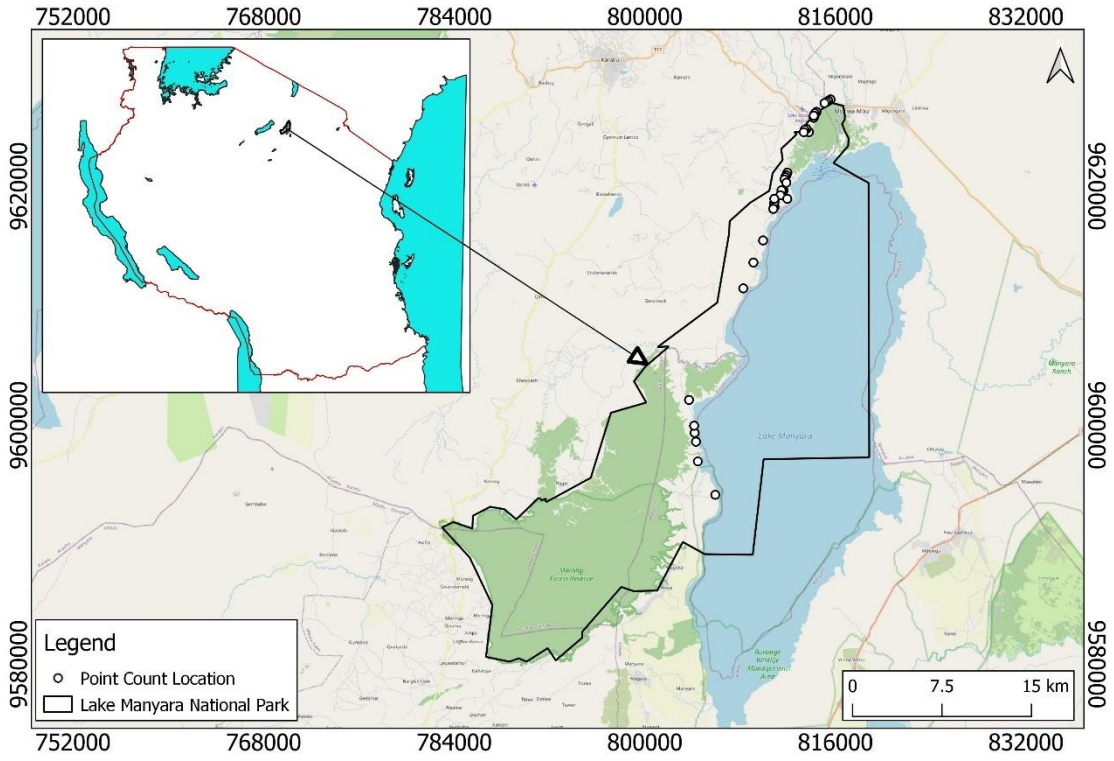

Figure 1. Map showing Lake Manyara National Park, the study area.

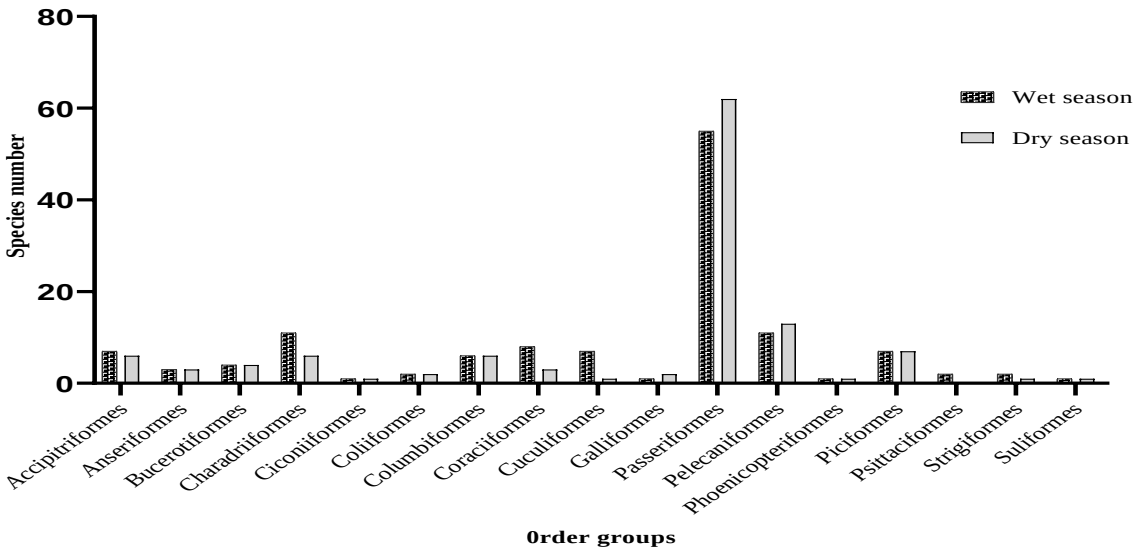

Figure 2. Bird orders and their distribution among two seasons.

52 families, and 17 orders were recorded during both the wet and dry seasons across three habitat types. Among the 17 orders, Passeriformes exhibited the highest abundance with 81 species, followed by Pelecaniformes (14), Charadriiformes (12), and Accipitriformes (11). The orders Ciconiiformes, Phoenicopteriphormes, and Suliformes had the least diversity, each with one species (Figure 2).

The seasonal dispersal pattern of the recorded species revealed that out of the 171 species, 129 (76%) were residents, while 42 (24%) were migratory, including 21 (12%) Palearctic migrants and another 21 (12%) Intra-

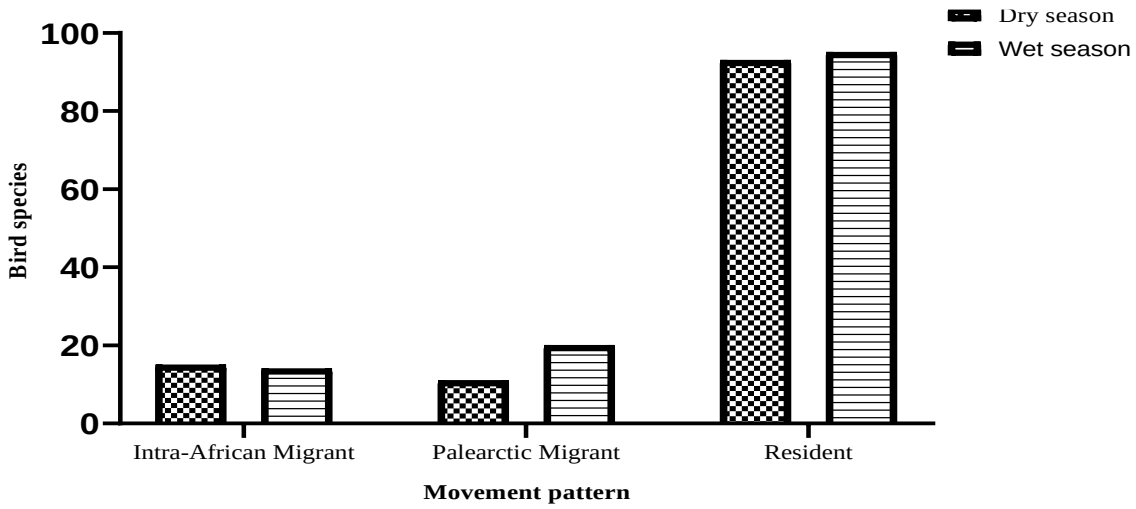

Figure 3. Bird movement pattern in relation to seasonality.

Table 1. Bird species according to IUCN conservation status.

IUCN conservation status	Number of species	Proportion (%)
Critical endangered (CE)	1	0.584
Vulnerable (VU)	1	0.585
Near threatened (NT)	2	1.170
Least concern (LC)	167	97.661

Table 2. Overall structural properties of bird species for three habitats.

Diversity measure	Aquatic	Forest	Woodland
Taxa_S	38	69	105
Individuals	661	331	745
Dominance_D	0.059	0.052	0.033
Simpson_1-D	0.941	0.948	0.967
Shannon_H	3.136	3.544	3.931
Evenness_e^H/S	0.606	0.501	0.485

African migrants (Figure 3).

In terms of conservation status based on the IUCN (2022) assessment, Fischer's Lovebird (*Agapornis fischeri*) and Lesser Flamingo (*P. minor)* were categorized as near threatened (NT), while the African White-backed Vulture (*Gyps africanus*) and Tawny Eagle (*Aquila rapax*) were classified as critically endangered (CE) and vulnerable (VU), respectively. The remaining 167 species were labeled as of least concern (LC) (Table 1).

Avian species diversity, abundance and distribution

The study recorded the highest bird diversity in woodland habitat (H' = 3.93), followed by forest habitat (H' = 3.54) and aquatic habitat (H' = 3.14). These differences in diversity among habitats were found to be statistically significant (Table 5). The aquatic habitat exhibited the highest even distribution of birds (0.605), while the lowest was observed in the woodland habitat (0.485) (Table 2). The majority of species were identified in the woodland (105), followed by the forest (69) and aquatic (38) habitats. Significant differences in species mean abundance were noted between woodland and forest ($z = 4.32$, $p < 0.001$), aquatic and woodland ($z = 5.89$, $p < 0.001$), and aquatic and forest habitats ($z = 2.43$, $p = 0.015$). The Shannon-Weiner diversity index was higher in the wet season (H' = 4.207) compared to the dry

Table 3. Overall seasonal species composition of birds.

Diversity measure	Wet season	Dry season
Taxa_S	128	119
Individuals	833	904
Dominance_D	0.02341	0.02716
Simpson_1-D	0.9766	0.9728
Shannon_H	4.207	4.111
Evenness_e^H/S	0.5247	0.5128

Table 4. Sørensen similarity index of bird species between habitats.

Habitats	Similarity index (S)
Aquatic and forest	0.019
Aquatic and woodland	0.014
Forest and woodland	0.439

Table 5. Diversity t-test of bird species between habitats.

Habitats	t-Value	p-Value	df.
Forest vs. Woodland	-4.85	<0.001	618.4
Aquatic vs. Woodland	-14.24	<0.001	1370
Forest vs. Aquatic	5.33	<0.001	513.11

season (H'= 4.111), but the difference in species diversity between the two seasons was statistically insignificant (t = 1.79, df = 1728.4, p = 0.074). The evenness index was greater during the wet season (D = 0.5247) than in the dry season (D = 0.5128) (Table 3). The mean species abundance between the wet and dry seasons for aquatic habitat (z = 1.052, p = 0.2928), forest habitat (z = 1.2997, p = 0.1937), and woodland habitat (z = 0.844, p = 0.3987) showed no significant variation. The Sørensen similarity index indicated high overall similarity between woodland and forest habitats (S = 0.439) and low similarity between aquatic and forest (0.019) and woodland and aquatic (0.014) habitats (Table 4). In the forest habitat, woodland, and aquatic, the most abundant species were Silvery-cheeked hornbill (52), Green-backed Camaroptera (73), and Glossy Ibis (93), respectively.

DISCUSSION

Bird community composition

Determining the community composition, abundance, and distribution of avifauna species inhabiting a specific area is crucial for understanding the overall health of that environment and devising effective bird conservation strategies that consider ecological, temporal, and spatial parameters for future management. The results of this study affirm that LMNP (presumably a specific location or park) is a significant area for bird species conservation. This importance may be attributed to the presence of diverse habitat types that offer a conducive environment for the proliferation of bird species. According to research by Pineda-Diez De Bonilla et al. (2012) and Mgelwa et al. (2023), the habitat heterogeneity within both aquatic and terrestrial locales makes the area crucial as an ecological determinant for bird species richness.

Species richness, a key component of biodiversity, is influenced by various factors, including the number of available habitats and the degree of habitat specificity exhibited by particular species (MacArthur et al., 1966; Kelt, 1994). In this study, Passeriformes emerged as the dominant order, boasting the highest number of species. This prevalence can be ascribed to the generalist feeding habits exhibited by many Passeriformes species. Beresford et al. (2005) further suggested that the high diversity of passerine birds is attributed to their versatile use of various habitats and their ability to exploit a wide variety of food sources, including grains, floral buds, fruits, nectar, and invertebrates. Variations in survival strategies and dietary preferences among bird species contribute to the specificity of their habitat (Mgelwa et al2023).

The presence of a lake within LMNP provides a

conducive habitat for waterbirds, contributing to the biological diversification of the area. The majority of aquatic birds observed during this study comprised both resident and migratory species, including Palearctic and Intra-African migratory birds. Migratory species such as the Common Greenshank (*Tringa nebularia*), Common Sandpiper (*Actitis hypoleucos*), Common Squacco Heron (*Ardeola ralloides*), Hadada Ibis (*Bostrychia hagedash*), Hamerkop (*Scopus umbretta*), Kittliz's Plover (*Charadrius pecuarius*), Lesser Flamingo (*Phoeniconaias minor*), and Grey-headed Gull (*Larus cirrocephalus*) were observed foraging in the lake. The presence of abundant migratory birds throughout both wet and dry seasons may be attributed to favorable habitat conditions across these periods (Mgelwa et al., 2023). Furthermore, the limited accessibility of the area for people may contribute to favorable conditions for breeding, feeding, and nesting sites (Aynalem and Bekele, 2008). As per Yihenew and Bezawork (2018), a habitat's poor environmental quality and disturbances increase the likelihood of the decline or loss of avian species.

The low similarity in species composition observed between aquatic and other habitats (Table 4) resulted from the exclusion of terrestrial birds sighted in the aquatic habitat, representing a limitation in this study. Notably, four species exhibiting a global declining trend (African White-backed Vulture, Tawny Eagle, Fischer's Lovebird, and Lesser Flamingo) were identified in the study area. The presence of these vulnerable, critically endangered, and near-threatened species in the study area underscores its conservation significance in harboring globally important species in need of conservation attention.

Bird diversity, abundance and distribution

This study revealed a heterogeneous distribution of birds across different habitat types and seasons. The higher diversity and abundance observed during the wet season compared to the dry season align with the understanding that bird diversity is influenced by weather conditions and seasonal migration (Waterhouse et al., 2003; Parmesan et al., 2005). Changes in favorable conditions, such as rainfall and food availability, likely contribute to the seasonal variation in species abundance and composition (Bibi and Ali, 2013; Shitta et al., 2016). Seasonal migration, particularly by Palearctic and Intra-African migrants, may significantly impact population dynamics by altering species composition and numbers (Richardson, 1990).

The woodland habitat exhibited the overall highest diversity, possibly attributed to its habitat heterogeneity, which enhances resource availability in LMNP. This may be linked to the greater openness of the habitat, rich in trees and shrubs, providing cover and food for a variety of bird species (Mengesha and Bekele, 2008; Desalgn and Subramanian, 2015; Lamesginew and Abebayehu, 2020). Bideberi (2013) also noted that differences in resource availability, including breeding sites, nesting materials, cover, food, and water, may restrict certain species to specific habitat types while allowing others to have a wider distribution. This variability could explain the significant differences in mean species abundance and diversity between the habitats. Additionally, factors such as habitat size, floristic composition, and foraging modes are known to influence avian species distribution (Manley and Webster, 2006).

In this study, habitat specificity and generalization of species were documented, with Silvery-cheeked Hornbill (*Bycanistes brevis*) and Trumpeter Hornbill (*Bycanistes bucinator*) recorded as most abundant only in the forest habitat. The habitat selection by birds is driven by their specific requirements for successful reproduction and survival, with some generalist species capable of utilizing multiple habitats (Rodríguez-Estrella, 2007). Green-backed Camaroptera (*Camaroptera brachyura*), Common Bulbul (*Pycnonotus barbatus*), and Emerald-spotted Wood-Dove (*Turtur chalcospilos*) were identified as abundant in both woodland and forest habitats. The close occurrence of these habitats and the similarity in vegetation types may explain this pattern. According to Fricke et al. (2009), the similarity in species distribution between habitats in close proximity is common, particularly for generalist species. Similar observations were reported by Doggart and Loserian (2007) in their study on Nguru Mountain in Tanzania.

The highest distribution of bird species was observed in the aquatic habitat, likely influenced by various factors such as the large size of the lake and differences in species foraging preferences. Some birds forage in wetland soil, others in the water column, and some utilize the dry landscape along the lake shore.

Conclusion

This study significantly contributes to the understanding of bird composition, abundance, and distribution across different habitat types, providing the most recent status of birds in the LMNP. Our findings affirm that LMNP is a critical area for bird conservation, given its diverse array of bird species, including migratory and globally threatened species. The study highlights the substantial influence of habitat type on bird species composition, abundance, and distribution, evident in the varied bird species observed across different habitats within the LMNP.

The results underscore the importance of conducting detailed avian species studies in the area, with a particular emphasis on cryptic and nocturnal species, as there is limited information available on these groups of birds. Furthermore, the study reinforces the urgency of raising awareness about the significance of LMNP for

biodiversity conservation. Consequently, we recommend the implementation of appropriate conservation measures to safeguard the breeding and roosting sites of both resident and migratory birds in LMNP.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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