

Full Length Research Paper

Comparative analysis of bird diversity, richness and evenness in three protected areas in Northern Tanzania

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Protected areas (PAs) play a crucial role in safeguarding and promoting ecological balance of bird diversity. This study presents a comparative analysis of bird diversity, richness, and evenness in three protected areas, Lake Manyara National Park (LMNP), Lake Natron Game Controlled Area (LNGCA), and Mtowambu Game Controlled Area (MGCA), during both wet and dry seasons. A standardized bird point count method was used to collect data on species composition, abundances, and distribution in each protected area during the wet (January) and dry (June) seasons of 2021. The results revealed a different trend of bird diversity across the three PAs, contrary to our expectations. It was expected to have high diversity of bird species in LMNP, only to find that during the wet season, LNGCA displayed high diversity of bird species ($H' = 4.859$, $n = 233$), followed by MGCA ($H' = 4.253$, $n = 137$), and lastly LMNP ($H' = 3.695$, $n = 125$), whereas in the dry season, MGCA was observed to have high diversity of bird species ($H' = 4.353$), followed by LMNP and LNGCA ($H' = 4.145$) and ($H' = 3.541$), respectively. The family Phoenicopteridae showed the highest number of individual birds in the wet season, and the family Ploceidae in the dry season. The study findings recommend that avitourism is one of the other forms of tourism that should be promoted. However, areas with lower protection status such as MGCA and LNGCA should receive additional conservation attention and stricter regulation.

Key words: Avitourism, bird point count, ecological balance, protection status.

INTRODUCTION

Birds play a crucial role as indicators of ecosystem health and occupy distinct ecological niches within their habitats (Joannon et al., 2008). The impact of granivorous birds on seed survival is notable, as they contribute to a decrease in the longevity of seeds. In contrast, insectivorous birds play a moderating role in regulating the abundance of herbivorous arthropods. Furthermore,

frugivorous birds serve as vital agents in seed dispersal (Fadini et al., 2009). The influence of birds extends beyond normal seed interactions. They directly affect the survival and reproductive rates of both herbaceous and woody plants through seed predation. Additionally, birds indirectly contribute to plant well-being by reducing the abundance of herbivorous insects (Rija et al., 2014). In

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this ecological relationship, birds emerge as key players in shaping the dynamics of ecosystems; however, their diversity varies from one place to another (Miranda, 2010).

Most of the research carried out on factors influencing local bird diversity has focused either on the effects of vegetation structure or the effect of human-induced habitat changes, such as habitat fragmentation and conversion (Somveille et al., 2018), leaving behind the influence of protection status. In Africa, despite other factors, spatial variation of bird species diversity is attributed to large mammals (Wotton et al., 2020). For example, the little grebe was reported to have been associated with hippopotamuses and therefore feeding on dipterans after the hippos have disturbed their settlements in Uganda. Likewise, the Yellow-billed stork was also found to associate with hippopotamuses and possibly to catch the aquatic species living in association with the hippos (Dean and Macdonald, 2020). Migratory bird species will spontaneously associate with migratory mammals, thus altering their diversity and abundance in specific areas of their occurrence (Murgui and Hedblom, 2017).

Tanzania is endowed with high biodiversity (Benítez-López et al., 2010), most of which falls in designated wildlife areas with relatively different protection statuses. National Parks exhibit strict protection where human activities are not allowed except for tourism development (Mmassy et al., 2018). Game Reserves incur moderate protection, while Game Controlled areas receive minimal protection status with some human activities such as cultivation, grazing, and human residence being allowed. Despite the importance of the adopted land management system in a particular area, little knowledge is available documenting the relationship between different protection statuses and their impact on bird diversity, richness, and evenness.

This knowledge gap hinders effective conservation planning and management strategies, as well as the establishment of appropriate protection measures for maximizing bird diversity and promoting balanced species distribution.

A comparative analysis study of species bird diversity, richness, and evenness in the three protected areas (LMNP, MGCA, and LNGCA) will address this knowledge gap and provide understanding on the effectiveness of different protected areas in supporting avian conservation. Specifically, this study aims at preparing a bird checklist as well as assessing and comparing bird species diversity, richness, and evenness across the three selected protected areas. The outputs of this study will contribute to improving protected area management practices of the avian group. Generally, the study predicts that highly protected areas will relatively host a higher diversity of bird species, richness, as well as evenness across dry and wet seasons.

MATERIAL AND METHODS

Description of the study area

The study was conducted at Lake Manyara National Park (LMNP), Mtombu Game Controlled Area (MMGCA) and Lake Natron Game Controlled Area (LNGCA) between January and June, 2021; covering both wet and dry season. These protected areas are located in Northern Tanzania within Arusha and Manyara regions as part of Tarangire-Manyara ecosystem. LMNP is located between Lake Manyara and the Great Rift Valley. It was declared as a National Park in 1960 and announced as a biosphere reserve in 1981 UNESCO (Kiffner et al., 2022). Being a National Park, Lake Manyara receives a strict protection and covers an area of about 325km² which includes both land and water surface. LMNP comprises a large variety of habitats ranging from underground water forest, a habitat for tree climbing lions (*Panthera leo*), baboons (*Papio anubis*) and blue monkeys (*Cercopithecus mitis*) to Vachellia woodland as well as open savanna habitat which provides a conducive environment for survival of bird species. The climate of an area is semi-arid with two distinct rainy seasons, short rains in October to December and long rains during March to May with a mean annual rainfall of about 700 mm (Kiffner et al., 2022).

LNGCA, is situated between Ngorongoro Highlands and Serengeti plain, the only African active volcano Oldonyo Lengai the Mountain of God (Mori, 2016). It is a soda Lake that attracts an abundance of bird life including thousands of flamingo (Mmassy et al., 2018). The area is bush dominated by Vachellia thorn trees and inhabited by pastoralists. Between the LMNP and LNGCA is interconnected with MGCA. The two Game Controlled Areas are unrestricted with human settlements, cultivation and livestock keeping which both pose negative disturbances to an area. Lake Natron has a high level of evaporation with high moisture deflecting between June and November making it one of the hottest places in Northern Tanzania (Mmassy et al., 2019). In January and February temperature is often above 40°C where else hunting of wildlife species is only permitted under hunting license (Mori, 2016) (Figure 1).

Data collection

The survey was conducted in three protected areas (LMNP, LNGCA, MGCA) across wet (January 2021) and dry season (June 2021). In each PA, existing road covering 40 km was established as the study route. Within the entire road, a transect of 1 km for counting bird species was selected, with a non-count transect of 2 km, resulting in a total of 14 bird count segments. Within each 1 km transect, a distance of 250 m was designated as a point count station. In every station the team spent 10 min of counting birds both heard and seen at a radius of 50m with the aid of field guide book Stevenson and Fanshawe (2004) for bird identification. Bird survey involved point count method which was carried out during early morning (0630 to 0930 h) and late afternoon (1530 to 1830 h) when birds were active. All data were recorded on a standardized data sheet including the following parameters Date, Time, GPS Coordinates, area, habitat type, feeding behavior. A total of 42 transect with 168 point counts were recorded during wet and dry season. A total of 42 transect with 168 point counts were recorded during wet and dry season.

Data analysis

The Shannon-Wiener Index of diversity H' was used to calculate the diversity of bird species across the three PAs in wet and dry season.

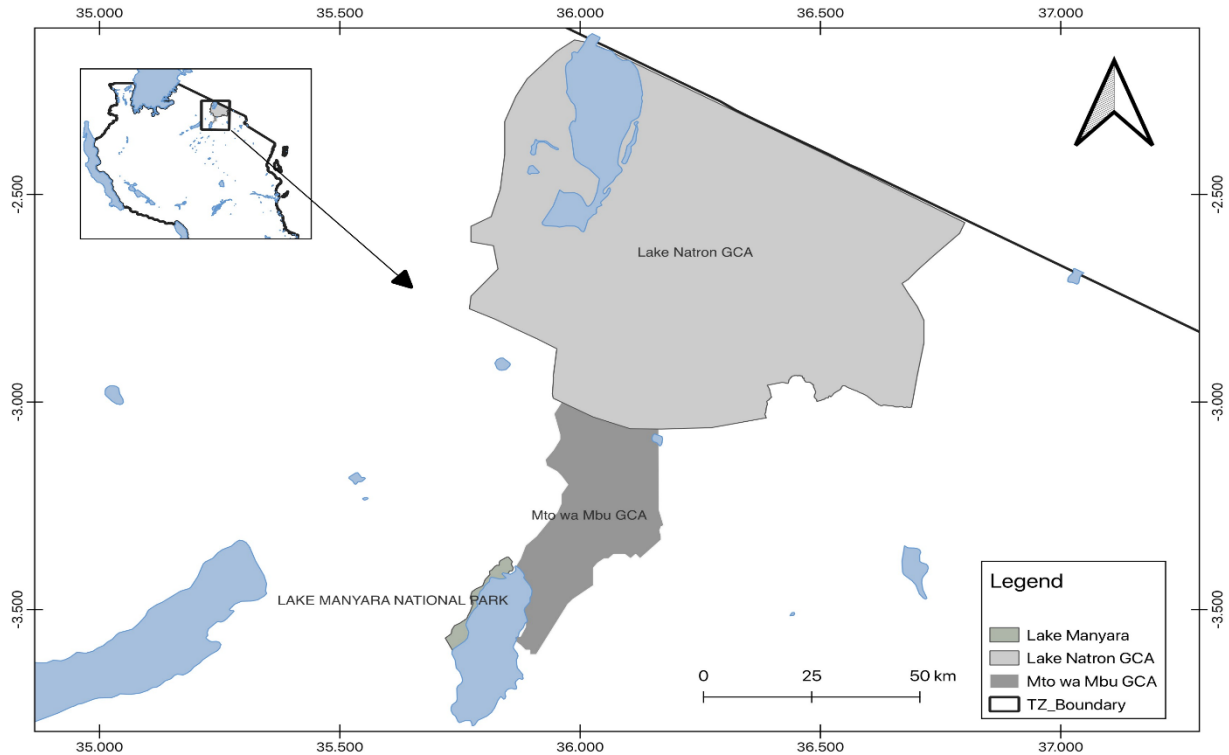


Figure 1. Map of study area showing the surveyed protected areas.

Table 1. Summary of Order and families with highest and lowest bird species in the study area.

Order	Family	<i>f0_wet</i>	<i>f0_dry</i>	Common name	Scientific name	IUCN status
Phoenicopteriformes	Phoenicopteridae	2989	334	Lesser Flamingo	<i>Phoeniconaias minor</i>	Near threatened
Phoenicopteriformes	Ploceidae	183	734	Lesser Masked Weaver	<i>Ploceus intermedius</i>	Least concern
Phoenicopteriformes	Vivuidae	1	23	Village Indigobird	<i>Vidua chalybeata</i>	Least concern
Coraciiformes	Coaciidae	9	12	Eurasian Roller	<i>Coracias garrulus</i>	Least concern

Diversity, richness and evenness of bird diversity in three PAs were computed using PAST version 4.03, where Marg alef's index was used to compute species richness (Hammer, 2001). A diversity t test was used to test significant differences of bird diversity, between wet and dry season.

RESULTS

Species composition

A total of 339 bird species were identified in all three protected areas, belonging to 68 families and 24 orders, with 234 and 238 bird species recorded in the wet and dry seasons respectively (Table 1). The family Phoenicopteridae was dominant, constituting 42% of all total species, followed by the family Scolopacidae (8%),

and the least was the family Vivuidae (0.001%) in the wet season. During the dry season, the family Ploceidae comprised the highest percentage (17%) of all total species, followed by Phoenicopteridae (8%), and the least represented was the family Coaciidae (0.01%). Bird species showed a variety of guilds including granivores, insectivores, and frugivorous. The order Passeriformes constituted 78% of all the species observed, with the highest number of observations in both wet and dry seasons.

Species diversity and richness

During the wet season, LNGCA had the highest species diversity ($H' = 4.859$, $n = 233$), followed by MGCA ($H' =$

Table 2. Species richness, diversity, and evenness between the three protected areas during wet and dry seasons (2021).

PAs	Diversity	Richness	Evenness
Wet season			
LMNP	3.695	124	0.3246
LNGCA	4.859	233	0.5533
MMGCA	4.253	137	0.5130
Dry season			
LMNP	4.145	127	0.4968
LNGCA	3.541	114	0.541
MMGCA	4.353	114	0.5396

Table 3. Diversity t-test between seasons in the study area.

Variable	T	df	p
Wet season vs dry season	-29.435	11570	P < 0.001

4.253, n = 137) and LMNP ($H' = 3.695$, n = 125) (Table 2). During the dry season, MGCA had the highest bird species diversity ($H' = 4.353$, n=114) followed by LMNP and LNGCA ($H' = 4.145$, n=127) ($H' = 3.541$, n=114), respectively (Table 2). The overall species richness was higher in the dry season (25.06) relative to wet season (23.35). Furthermore, species evenness was lower ($E=0.138$) during the wet season and high ($E=0.348$) during dry season. Species diversity was generally high in the dry season ($H'=4.303$), compared to that of wet season ($H'=3.357$). The study revealed significance difference in species diversity between wet and dry season (Table 3).

DISCUSSION

Species composition

The three study areas (LMNP, LNGCA, MGCA) exhibited different levels of diversity, richness as well as evenness of bird species in wet and dry season. Seasons significantly affected bird composition with high diversity during dry season correspondingly to the findings of Rija et al. (2014), who also concluded that differences seasons brings about variation in bird species diversity of a particular area. Some bird species (e.g. Dusky capped flycatcher and African hoopoe) were only recorded in the dry season indicating high species diversity relative to that of the wet season. Moreover, species evenness was lower during the wet season as the result of high record of water loving birds characterized by an abundance of resources in aquatic habitats. The results are directly

proportional to those of Busch et al 2020 who also suggested that presence of water bodies in an area would serve as the source of low species evenness in an area as most of the notable bird will be water loving species leaving behind the understory species.

Species diversity and richness

Species diversity was highest in LNCGA and MGCA compared to that of LMNP during the wet season presumably due to their differences in level of disturbances and availability of natural food resources for birds (Ulian et al., 2020). Lake Natron and Mtombu Game Controlled Areas had higher levels of disturbances characterized by farming and grazing activities. Farming activities provide natural food resources hence attracts more bird species in an area where else grazing activities would always make an association with bird species hence diversifying the avian group in an area (Ulian et al., 2020). The results of this study are consistent with the general observations that high level of disturbance can act as a driver behind high level of species diversity and richness in a particular area compared to area with lower level of disturbance (Wu et al., 2019).

During the dry season, Mtowambu Game Controlled area had the highest bird diversity, richness and evenness followed by Lake Manyara National Park and lastly was Lake Natron Game Controlled Area indicating the influence of conservation status in protection of the avian group (Busch et al 2020). Given these results, it is debated that highly protected areas put more effort in protection of vegetation structure keeping aside the

assemblage of bird species. Easily access of food materials from leftovers dumped by human beings in their area of residence attracts more bird species contributing to high species diversity and as well richness (Murgui and Hedblom, 2017). Cultivation would also attract more bird species contributing to high diversification as through cultivation bird species are in a position of obtaining food easily (Bellamy et al., 2009). The richness and evenness of bird species in Lake Natron Game Controlled Area was as well high as most of them were attracted with human activities which take place within the area. These results conform to those of Mc Mahon (2008) who recorded high diversity and richness of bird species in cultivated areas compared to non-cultivated sites. In addition, most farms were cultivated and livestock grazed extensively during the wet season which affected bird species composition positively (McKenzie and Robertson, 2015). This shows that there is a great influence of anthropogenic activities in diversification of bird species, evenness and richness in a particular area. Same results are observed by Joannon et al. (2020) who also state out that bird species would prefer disturbed areas compared to undisturbed areas.

The results further support that difference in feeding habits and habitats could increase species diversity, richness and evenness in an area (Mc Mahon, 2008). Game Controlled Areas attracted different types of bird species including the omnivores, insectivores and granivores as well as water loving birds, understory birds and ground bird species due to presence of heterogeneous vegetation structure hence increasing species diversity and richness (Anderle et al., 2023)

CONCLUSION AND RECOMMENDATIONS

Conclusively, protected areas play a crucial role in the conservation of bird diversity. The study demonstrates that all three protected areas contribute uniquely to the conservation of bird diversity. An interesting finding suggests that high bird diversity can exist in protected areas with minimal protection status. Mtowambu Game Controlled Area exhibited high species diversity, richness, and evenness during the dry season, whereas Lake Natron Game Controlled Area showed the highest species diversity, richness, and evenness during the wet season. This implies that alternative conservation approaches such as community-based conservation or participatory conservation may be effective in supporting bird populations, as game-controlled areas are often highly impacted by anthropogenic activities.

To ensure the long-term conservation of bird species, further research should focus on identifying the specific ecological mechanisms contributing to the observed patterns, such as the presence of specific habitat types, unique nesting sites, habitat characteristics, or anthropogenic activities. Furthermore, Avitourism is

emerging as a recognized business opportunity that creates jobs and promotes biodiversity conservation. In this case, it is recommended that areas with lower protection status receive additional conservation attention and stricter regulations for the sustainable conservation of avian populations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

Order	Family	fo-wet	fo-dry	Common name	Scientific name	IUCN status
Accipitriformes	Accipitridae	5	6	African fish-eagle	<i>Haliaeetus vocifer</i>	LC
		0	2	African goshawk	<i>Accipiter tachiro</i>	LC
		0	3	Black-chested snake-eagle	<i>Circaetus pectoralis</i>	LC
		1	0	African hawk-eagle	<i>Aquila spilogaster</i>	LC
		3	1	Tawny eagle	<i>Aquila rapax</i>	VN
		2	0	Gabar goshawk	<i>Micronisus gabar</i>	LC
		0	4	African harrier-hawk	<i>Polyboroides typus</i>	LC
		2	0	Eastern chanting-goshawk	<i>Melierax poliopterus</i>	LC
		2	0	Palm-nut vulture	<i>Gypohierax angolensis</i>	LC
		0	7	Pale chanting-goshawk	<i>Melierax canorus</i>	LC
		1	0	Forest buzzard	<i>Buteo trizonatus</i>	LC
		1	1	Lizard buzzard	<i>Kaupifalco monogrammicus</i>	LC
		3	1	Augar buzzard	<i>Buteo augur</i>	LC
		3	5	African-white-backed vulture	<i>Gyps africanus</i>	CE
	Alaudidae	132	332	Fischer's sparrow-lark	<i>Eremopterix leucopareia</i>	LC
		1	1	Short-tailed lark	<i>Spizocorys fremantlii</i>	LC
		1	0	Somali short-toed lark	<i>Alaudala somalica</i>	LC
		10	3	Rufous-naped lark	<i>Mirafra africana</i>	LC
Coraciiformes	Alcedinidae	0	1	African pygmy-kingfisher	<i>Ispidina picta</i>	LC
		6	0	Woodland kingfisher	<i>Halcyon senegalensis</i>	LC
		3	0	Melachite kingfisher	<i>Corythornis cristatus</i>	LC
		2	0	Striped kingfisher	<i>Halcyon chelicuti</i>	LC
		2	6	Pied kingfisher	<i>Ceryle rudis</i>	LC
		3	9	Grey headed kingfisher	<i>Halcyon leucocephala</i>	LC
Anseriformes	Anatidae	0	18	Capped teal	<i>Anas capensis</i>	LC
		46	0	Fulvous whistling duck	<i>Dendrocygna bicolor</i>	LC
		88	0	White-faced whistling duck	<i>Dendrocygna viduata</i>	LC
		0	2	Spur-winged goose	<i>Plectropterus gambensis</i>	LC
		70	37	Egyptian goose	<i>Alopochen aegyptiaca</i>	LC
		8	0	Red billed teal	<i>Anas erythrorhyncha</i>	LC
Apodiformes	Apodidae	1	0	African palm-swift	<i>Cypsiurus parvus</i>	LC
		0	46	Little swift	<i>Apus affinis</i>	LC
		5	0	Scarce swift	<i>Schoutedenapus myoptilus</i>	LC
		0	1	Palm nut swift	<i>Cypsiurus balasiensis</i>	LC
		2	0	Horus swift	<i>Apus horus</i>	LC
Pelecaniformes	Ardeidae	5	18	Black-headed heron	<i>Ardea melanocephala</i>	LC
		29	21	Grey heron	<i>Ardea cinerea</i>	LC
		1	5	Squacco heron	<i>Ardeola ralloides</i>	LC
		1	33	Intermediate egret	<i>Ardea intermedia</i>	LC
		14	40	Little egret	<i>Egretta garzetta</i>	LC
		1	4	Great egret	<i>Ardea alba</i>	LC
		346	27	Cattle egret	<i>Bubulcus ibis</i>	LC

Appendix Cont'd. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

		20	38	African grey hornbill	<i>Lophoceros nasutus</i>	LC
		60	70	Silvery-cheeked hornbill	<i>Bycanistes brevis</i>	LC
Bucerotiformes	Bucerotidae	0	6	Von der decken's hornbill	<i>Tockus deckeni</i>	LC
		6	7	Trumpeter hornbill	<i>Bycanistes bucinator</i>	LC
		6	16	Crowned hornbill	<i>Lophoceros alboterminatus</i>	LC
		0	1	Red-billed hornbill	<i>Tockus erythrorhynchus</i>	LC
		40	37	Black-throated barbet	<i>Tricholaema melanocephala</i>	LC
Piciformes	Capitonidae	3	1	Red-fronted tinkerbird	<i>Pogoniulus pusillus</i>	LC
		2	12	Red-and-yellow barbet	<i>Trachyphonus erythrocephalus</i>	LC
		0	5	Red-fronted barbet	<i>Tricholaema diademata</i>	LC
		38	95	Black smith lapwing	<i>Vanellus armatus</i>	LC
		86	32	Crowned lapwing	<i>Vanellus coronatus</i>	LC
		0	2	Fischers lapwing	<i>Erythrogonyx vanellus</i>	LC
Ciconiiformes	Charadriidae	62	42	African three-banded plover	<i>Charadrius tricollaris</i>	LC
		15	21	Kitliz's plover	<i>Charadrius pecuarius</i>	LC
		2	2	Spur-winged lapwing	<i>Vanellus spinosus</i>	LC
		17	0	Common ringed plover	<i>Charadrius hiaticula</i>	LC
		121	82	Chestnut banded plover	<i>Charadrius pallidus</i>	LC
Passeriformes	Campephagidae	0	1	Black cuckoo shrike	<i>Campephaga flava</i>	LC
		7	0	Red-backed shrike	<i>Lanius collurio</i>	LC
Caprimulgiformes	Caprimulgidae	0	1	Square tailed night jar	<i>Caprimulgus fossii</i>	LC
		1	0	Abdims stock	<i>Ciconia abdimii</i>	LC
		4	38	Yellow-billed stork	<i>Mycteria ibis</i>	LC
	Ciconiidae	0	1	Open billed stork	<i>Anastomus oscitans</i>	LC
		71	0	White stork	<i>Ciconia ciconia</i>	LC
Ciconiiformes		1	2	Marabou stork	<i>leptoptilos crumeniferus</i>	VN
		2	1	Desert cisticola	<i>Cisticola aridulus</i>	LC
	Cisticolidae	4	0	Zitting cisticola	<i>Cisticola juncidis</i>	LC
		5	0	Winding cisticola	<i>Cisticola marginatus</i>	LC
		65	15	Rattling cisticola	<i>Cisticola chiniana</i>	LC
Passeriformes	Collidae	35	127	Blue-naped mousebird	<i>Urocolius macrourus</i>	LC
		15	26	Speckled mousebird	<i>Colius striatus</i>	LC

Appendix Cont'd. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

		50	32	African mourning dove	<i>Zenaida macroura</i>	LC
		7	0	Tambourine dove	<i>Turtur tympanistria</i>	LC
		26	35	Loughing dove	<i>Spilopelia senegalensis</i>	LC
		3	0	Comoro olive-pigeon	<i>Columba pollenii</i>	NT
		43	82	Ring-necked dove	<i>Streptopelia capicola</i>	LC
Columbiformes	Columbidae	0	2	Rock pegin	<i>Columba livia</i>	LC
		0	5	Speckled pegin	<i>Columba guinea</i>	LC
		13	65	Namaqua dove	<i>Oena capensis</i>	LC
		6	0	African pigeon	<i>Nesoenas mayeri</i>	VN
		39	28	Emerald-spotted wood-dove	<i>Turtur chalcospilos</i>	LC
		17	14	Red-eyed dove	<i>Streptopelia semitorquata</i>	LC
Coraciiformes	Coaciidae	2	0	Eurasian roller	<i>Coracias garrulus</i>	LC
Columbiformes,	Corvidae	18	10	Pied crow	<i>Corvus albus</i>	LC
		0	15	White necked raven	<i>Corvus albicollis</i>	LC
		1	0	African cuckoo	<i>Cuculus gularis</i>	LC
		7	1	Klass's cuckoo	<i>Chrysococcyx klaas</i>	LC
		11	2	White-browed coucal	<i>Centropus superciliosus</i>	LC
		2	0	Great spotted cuckoo	<i>Clamator glandarius</i>	LC
Cuculiformes	Cuculidae	14	1	Red-chested cuckoo	<i>Cuculus solitarius</i>	LC
		6	0	Diederik cuckoo	<i>Chrysococcyx caprius</i>	LC
		3	0	Black-and-white cuckoo	<i>Clamator jacobinus</i>	LC
		4	0	Square-tailed drongo	<i>Dicrurus ludwigii</i>	LC
		8	21	Fork-tailed drongo	<i>Dicrurus adsimilis</i>	LC
		1	1	Cinnamon-breasted rock bunting	<i>Emberiza tahapisi</i>	LC
Passeriformes	Emberizidae	7	0	Straw-tailed whydah	<i>Vidua fischeri</i>	LC
		6	0	Red-throated twin-spot	<i>Hypargos niveoguttatus</i>	LC
		8	29	African firefinch	<i>Lagonosticta rubricata</i>	LC
		3	7	Blue-capped cordon-bleu	<i>Uraeginthus cyanocephalus</i>	LC
		2	23	Common waxbill	<i>Estrilda astrild</i>	LC
		1	0	Crimson-rumped waxbill	<i>Estrilda rhodopyga</i>	LC
Passeriformes	Estrildidae	1	9	Green-winged pytilia	<i>Pytilia melba</i>	LC
		0	1	Grey-headed silverbill	<i>Spermestes griseicapilla</i>	LC
		2	3	Purple grenadier	<i>Granatina ianthinogaster</i>	LC
		2	13	Red-cheeked cordon-bleu	<i>Uraeginthus bengalus</i>	LC
Passeriformes	Eurylaimidae	0	2	African broadbill	<i>Smithornis capensis</i>	LC
		0	2	Common kestrel	<i>Falco tinnunculus</i>	LC
		0	3	Lesser kestrel	<i>Falco naumanni</i>	LC
Falconiformes	Falconidae	1	0	Grey kestrel	<i>Falco ardosiaceus</i>	LC
		0	4	African pygmy-falcon	<i>Polihierax semitorquatus</i>	LC
		0	2	Greater kestrel	<i>Falco rupicoloides</i>	LC

Appendix Cont'd. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

Passeriformes	Fringillidae	3	1	African citril	<i>Crithagra hyposticta</i>	LC
		0	2	Yellow-fronted canary	<i>Crithagra mozambica</i>	LC
		0	17	Yellow-rumped seedeater	<i>Crithagra xanthopygia</i>	LC
		10	2	White-bellied canary	<i>Crithagra dorsostriata</i>	LC
Gruiformes	Gruidae	0	2	Grey crowned cranes	<i>Balearica regulorum</i>	EN
Passeriformes	Hirundinidae	0	1	Black saw-wing	<i>Cygnus atratus</i>	T
		0	6	Lesser striped swallow	<i>Cecropis abyssinica</i>	LC
		1	1	Rock martin	<i>Ptyonoprogne fuligula</i>	LC
		96	0	Barn swallow	<i>Hirundo rustica</i>	LC
		3	0	Red-rumped swallow	<i>Cecropis daurica</i>	LC
Passeriformes	Indicatoridae	1	2	Greater honeyguide	<i>Indicator indicator</i>	LC
		0	3	Lesser honeyguide	<i>Indicator minor</i>	LC
		4	1	Scaly-throated honeyguide	<i>Indicator variegatus</i>	LC
Passeriformes	Laniidae	2	1	Common fiscal shrike	<i>Lanius collaris</i>	LC
		2	0	Isabelline shrike	<i>Lanius isabellinus</i>	LC
		3	0	Taita fiscal	<i>Lanius dorsalis</i>	LC
		2	1	Long tail fiscal shrike	<i>Lanius cabanisi</i>	LC
		12	13	Northern white-crowned shrike	<i>Eurocephalus ruppelli</i>	LC
		7	0	Red-backed shrike	<i>Lanius collurio</i>	LC
Passeriformes	Laridae	173	102	Grey-headed gull	<i>Larus cirrocephalus</i>	LC
		0	1	Gull bellied tern	<i>Gelochelidon nilotica</i>	LC
		60	55	Whiskered tern	<i>Chlidonias hybrida</i>	LC
Charadriiformes	Leiotrichidae			Arrow-marked babbler	<i>Turdoides jardineii</i>	LC
				Rufous chatterer	<i>Argya rubiginosa</i>	LC
		3	0	D'arnaud's Barbet	<i>Trachyphonus darnaudii</i>	LC
		8	0	White-headed barbet	<i>Lybius leucocephalus</i>	LC
		0	1	Red-fronted tinkerbird	<i>Pogoniulus pusillus</i>	LC
Passeriformes	Malaconotidae	1	1	Usambiro barbet	<i>Trachyphonus usambiro</i>	LC
		1	1	White-eared barbet	<i>Stactolaema leucotis</i>	LC
		9	4	Black-backed puffback	<i>Dryoscopus cubla</i>	LC
		20	5	Brown-crowned tchagra	<i>Tchagra australis</i>	LC
		7	11	Brubru	<i>Nilaus afer</i>	LC
		1	0	Tropical boubou	<i>Laniarius aethiopicus</i>	LC
		0	5	Grey-headed bush-shrike	<i>Malaconotus blanchoti</i>	LC
		0	3	Pringle's puffback	<i>Dryoscopus pringlii</i>	LC
3	4	Rosy-patched bush-shrike	<i>Rhodophoneus cruentus</i>	LC		
46	37	Slate-coloured boubou	<i>Laniarius funebris</i>	LC		
16	6	Sulphur-breasted bush-shrike	<i>Telophorus sulfureopectus</i>	LC		

Appendix Cont'd. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

Coraciiformes	Meropidae	7	0	European bee-eater	<i>Merops apiaster</i>	LC
		32	64	White-throated bee-eater	<i>Merops albicollis</i>	LC
		5	6	Little bee-eater	<i>Merops pusillus</i>	LC
		1	2	White-fronted bee-eater	<i>Merops bullockoides</i>	LC
Passeriformes	Motacillidae	5	17	African pied wagtail	<i>Motacilla aguimp</i>	LC
		5	0	Western yellow wagtail	<i>Motacilla flava</i>	LC
		1	4	Long billed pipit	<i>Anthus similis</i>	LC
		0	7	Striped pipit	<i>Anthus lineiventris</i>	LC
		13	10	Grassland pipit	<i>Anthus pratensis</i>	LC
		35	43	White-browed scrub-robin	<i>Cercotrichas leucophrys</i>	LC
		6	15	African grey flycatcher	<i>Bradornis microrhynchus</i>	LC
		1	0	Northern black flycatcher	<i>Melaenornis edoloides</i>	LC
		3	0	Ruppell's robin -chat	<i>Cossypha semirufa</i>	LC
		13	1	Spotted flycatcher	<i>Muscicapa striata</i>	LC
		44	69	Spotted morning-thrush	<i>Cichladusa guttata</i>	LC
		6	2	White-browed robin chat	<i>Cossypha heuglini</i>	LC
		4	0	Schalow's wheatear	<i>Oenanthe schalowi</i>	EN
		6	0	Common rock thrush	<i>Monticola saxatilis</i>	LC
1	14	African paradise-flycatcher	<i>Terpsiphone viridis</i>	LC		
4	4	Eastern bearded scrub robin	<i>Tychaedon quadrivirgata</i>	LC		
Musophagiformes	Musophagidae	0	3	White bellied go-away-bird	<i>Criniferoides leucogaster</i>	LC
Passeriformes	Nectariniidae	1	0	Amethyst sunbird	<i>Chalcomitra amethystina</i>	LC
		21	19	Beautiful sunbird	<i>Cinnyris pulchellus</i>	LC
		6	6	Collared sunbird	<i>Hedydipna collaris</i>	LC
		19	16	Eastern violet-backed sunbird	<i>Anthreptes orientalis</i>	LC
		0	2	Hunters sunbird	<i>Chalcomitra hunteri</i>	LC
		0	10	Scarlet-chested sunbird	<i>Chalcomitra senegalensis</i>	LC
0	8	Variable sunbird	<i>Cinnyris venustus</i>	LC		
Passeriformse	Nicatoridae	0	2	Eastern nicator	<i>Nicator gularis</i>	LC
Galliformes	Numididae	34	11	Helmeted guineafowl	<i>Numida meleagris</i>	LC
Passeriformes	Oriolidae	3	12	African black-headed oriole	<i>Oriolus larvatus</i>	LC
Otidiformes	Otididae	0	4	White bellied bustard	<i>Eupodotis senegalensis</i>	LC
Passeriformse	Passeridae	8	17	Parrot-billed sparrow	<i>Passer diffusus</i>	LC
		3	0	Yellow-spotted petronia	<i>Gymnoris pyrgita</i>	LC
		1	0	Yellow-spotted bush-sparrow	<i>Gymnoris pyrgita</i>	LC
		0	2	Yellow bellied pretonia	<i>Prinia flaviventris</i>	LC
		0	1	Parrot-billed sparrow	<i>Passer gongonensis</i>	LC
		5	0	Rufous-collared sparrow	<i>Zonotrichia capensis</i>	LC
		3	50	House sparrow	<i>Passer domesticus</i>	LC
		2	0	African orange-billed sparrow	<i>Arremon aurantirostris</i>	LC
3	0	Crimson winged waxbill	<i>Estrilda rhodopyga</i>	LC		

Appendix Cont'd. Checklist of bird species observed across the three protected areas (MMGCA, LMNP and LNGCA) in wet and dry season.

Pelecaniformes	Pelecanidae	71	31	Great white pelican	<i>Pelecanus onocrotalus</i>	LC
		0	10	Common squacco heron	<i>Ardeola ralloides</i>	LC
		3	1	Pink-backed pelican	<i>Pelecanus rufescens</i>	LC
Phalacrocoracidae	Phalacrocoracidae	17	13	Long-tailed cormorant	<i>Microcarbo africanus</i>	LC
Galiiformes	Phasianidae	8	12	Crested francolin	<i>Ortygornis sephaena</i>	LC
		0	1	Red-necked francolin	<i>Pternistis afer</i>	LC
		4	1	Yellow-necked spurfowl	<i>Prinia flaviventris</i>	LC
Phoenicopteriformes	Phoenicopteridae	756	329	Lesser flamingo	<i>Phoeniconaias minor</i>	NT
		2223	5	Greater flamingo	<i>Phoenicopterus roseus</i>	LC
Bucerotiformes	Phoeniculidae	3	0	Green wood-hoopoe	<i>Phoeniculus purpureus</i>	LC
		0	1	Abyssinian schimitarbill	<i>Rhinopomastus minor</i>	LC
Piciformes	Picidae	0	3	Bearded woodpecker	<i>Dendropicos namaquus</i>	LC
		9	8	Cardinal woodpecker	<i>Dendropicos fuscescens</i>	LC
		0	1	Nubian woodpecker	<i>Campethera nubica</i>	LC
Passeriformes	platysteiridae	1	2	Chin-spot batis	<i>Batis molitor</i>	LC
Passeriformes	Ploceidae	0	5	Baglafecht weaver	<i>Ploceus baglafecht</i>	LC
		1	0	Black bishop	<i>Euplectes gierowii</i>	LC
		0	9	Black-necked weaver	<i>Ploceus nigricollis</i>	LC
		80	121	White-browed sparrow-weaver	<i>Plocepasser mahali</i>	LC
		55	148	Chestnut-bellied weaver	<i>Ploceus rubiginosus</i>	LC
		0	1	Golden-backed weaver	<i>Ploceus jacksoni</i>	LC
		23	61	Lesser masked weaver	<i>Ploceus intermedius</i>	LC
		0	10	Red-billed buffalo-weaver	<i>Bubalornis niger</i>	LC
		20	259	Red-billed quelea	<i>Quelea quelea</i>	LC
		1	0	Southern red bishop	<i>Euplectes orix</i>	LC
		3	112	Vitelline masked weaver	<i>Ploceus vitellinus</i>	LC
		0	8	Yellow bishop	<i>Euplectes capensis</i>	LC
		0	10	Grey capped social weaver	<i>Pseudonigrita araudi</i>	LC
Psttaciiformes	Psittaculidae	12	25	Fischer's lovebird	<i>Agapornis fischeri</i>	NT
Pteroclidiformes.	Pteroclididae	0	30	Chestnut bellied sandgrouse	<i>Pterocles exustus</i>	LC
		0	43	Yellow-throated sandgrouse	<i>Pterocles gutturalis</i>	LC
Passeriformes	Pycnonotidae	0	1	Cabanis's greenbul	<i>Phyllastrephus cabanisi</i>	LC
		41	199	Common bulbul	<i>Pycnonotus barbatus</i>	LC
		1	1	Yellow-bellied greenbul	<i>Chlorocichla flaviventris</i>	LC
		7	4	Grey-olive greenbul	<i>Phyllastrephus cerviniventris</i>	LC
Passeriformes	Rallidae	19	6	Black clake	<i>Zapornia flavirostra</i>	LC

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Charadriiformes	Recurvirostridae	90	39	Black-winged stilt	<i>Himantopus himantopus</i>	LC
		15	15	Pied avocet	<i>Recurvirostra avosetta</i>	LC
Charadriiformes	Scolopacidae	17	1	Common greenshank	<i>Tringa nebularia</i>	LC
		18	0	Common sandpiper	<i>Actitis hypoleucos</i>	LC
		497	0	Little stint	<i>Calidris minuta</i>	LC
		69	0	Ruff	<i>Calidris pugnax</i>	LC
		29	0	Marsh sandpiper	<i>Tringa stagnatilis</i>	LC
		1	0	Purple sandpiper	<i>Calidris maritima</i>	LC
		0	1	Common redshank	<i>Tringa totanus</i>	LC
		11	3	Wood sandpiper	<i>Tringa glareola</i>	LC
Pelecaniformes	Scopidae	17	17	Hamerkop	<i>Scopus umbretta</i>	LC
Strigiformes	Strigidae	2	1	Pearl-spotted owl	<i>Glucidium perlatum</i>	LC
		2	0	Varreaux's eagle-owl	<i>Bubo lacteus</i>	LC
Passeriformes	Sturnidae	3	2	Hildebrandt's starling	<i>Lamprotornis hildebrandti</i>	LC
		19	21	Wattled starling	<i>Creatophora cinerea</i>	LC
		0	2	Ashy starling	<i>Lamprotornis unicolor</i>	LC
		33	75	Red-winged starling	<i>Onychognathus morio</i>	LC
		1	0	Greater blue-eared starling	<i>Lamprotornis chalybaeus</i>	LC
		0	5	Red-billed oxpecker	<i>Buphagus erythrorynchus</i>	LC
		20	22	Superb starling	<i>Lamprotornis superbus</i>	LC
		1	2	Violet-backed starling	<i>Cinnyricinclus leucogaster</i>	LC
Passeriformes	Sylviidae	7	11	Banded parosoma	<i>Curruca boehmi</i>	LC
		2	2	Yellow-bellied eremomela	<i>Eremomela icteropygialis</i>	LC
		7	1	Yellow breasted apalis	<i>Apalis flavida</i>	LC
		1	0	Willow warbler	<i>Phylloscopus trochilus</i>	LC
		2	1	Common whitethroat	<i>Curruca communis</i>	LC
		11	4	Grey wren warbler	<i>Calamonastes simplex</i>	LC
		2	15	Red-faced warbler	<i>Cardellina rubrifrons</i>	LC
		0	15	Red-fronted prinia	<i>Prinia rufifrons</i>	LC
		1	2	Tawny-flanked prinia	<i>Prinia subflava</i>	LC
		29	55	Grey-backed camaroptera	<i>Camaroptera brachyura</i>	LC
Passeriformes	Timillidae	1	5	Buff-bellied warbler	<i>Phyllolais pulchella</i>	LC
		1	1	Garden warbler	<i>Sylvia borin</i>	LC
Passeriformes	Timillidae	6	0	Arrow-marked babbler		
		0	7	Rufous chatterer	<i>Argya rubiginosa</i>	LC
Passeriformes	Threskiornithidae	43	47	African spoonbill	<i>Platalea alba</i>	LC
		2	109	Glossy ibis	<i>Plegadis falcinellus</i>	LC
		8	31	Hadada ibis	<i>Bostrychia hagedash</i>	LC
		77	24	African sacred ibis	<i>Threskiornis aethiopicus</i>	LC
Passeriformes	Trogonidae	1	3	Narnia trogon	<i>Apaloderma narina</i>	LC

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		13	5	Capped wheatear	<i>Oenanthe pileata</i>	LC
Passeriformes	Turdidae	51	0	Isabelline wheatear	<i>Oenanthe isabellina</i>	LC
		1	0	Thrush nightingale	<i>Luscinia luscinia</i>	LC
		16	0	Northern wheatear	<i>Oenanthe oenanthe</i>	LC
Passeriformes	Tyrannidae	0	1	Dusky capped flycatcher	<i>Muscicapa adusta</i>	LC
Bucerotiformes	Upupidae	0	4	African hoopoe	<i>Upupa africana</i>	LC
Passeriformes	Viduidae	1	1	Village indigobird	<i>Vidua chalybeata</i>	LC
Passeriformes	Zosteropidae	51	0	Abyssinian white-eye	<i>Zosterops abyssinicus</i>	LC