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# The role of kopjes in bird species' conservation within an agricultural matrix west of the Greater Serengeti Ecosystem, Tanzania

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## Summary

This study was conducted in unprotected agricultural land located just west of the Greater Serengeti Ecosystem to assess 1) avian community composition in four different habitat types, and 2) the importance of kopjes found in agricultural areas in conservation of birds. All species recorded during this study have been recorded in the nearby Serengeti Ecosystem suggesting that the study area is a subset of this ecosystem. The density of bird species and individuals were higher in the kopjes than in the surrounding human-impacted habitats. Thus the kopjes in farmland increase regional avifaunal diversity, and this is likely due to the provision of diverse habitats. The kopjes as well as the surrounding habitats are important for bird species conservation even though they are found in agricultural areas.

## Introduction

Just west of the Greater Serengeti Ecosystem (GSE), an area defined by movements of migratory wildebeest (see Hopcraft *et al.* 2015), lies agricultural land (hereafter agriculture) under intensive cultivation and animal husbandry. In this area also occur patches of degraded woodlands in hilly areas, riparian vegetation, as well as rocky outcrops (kopjes) that may be of importance for the birds and other fauna. It is assumed that similar natural savanna habitat found inside the present GRE previously extended into this area until agriculture and small holdings took over in the 1950s (Sinclair *et al.* 2002). The underlying assumption is that this area was originally similar in flora and fauna, geology, soil and nutrients and other ecological features to the southwestern and western parts of the existing Serengeti National Park (Sinclair *et al.* 2002).

Kopjes are impressive granite outcrops that protrude like “terrestrial islands” within a sea of the surrounding habitat matrix. They form exceptional habitats because their flora is often rich in species composition that differs from the vegetation in the surrounding areas (Poelchau & Mistry 2006). As evidence of their exceptionality, different species of amphibians, reptiles, birds and small mammals inhabit the kopjes (Sinclair & Arcese 1995, Timbuka & Kabigumila 2006, Trager & Mistry 2003, Byrom *et al.* 2015), as well as rare and endemic species (Porembski 1996, Porembski *et al.* 1996). Some animals take refuge in kopjes to forage during droughts, while others, especially predators may use kopjes as vantage points when hunting (Timbuka & Kabigumila 2006). Thus kopjes contribute considerably to the ecological diversity in

the areas where they occur in terms of habitat heterogeneity and through the provision of shelter to a variety of fauna (Hoeck 1975, Anderson *et al.* 2008).

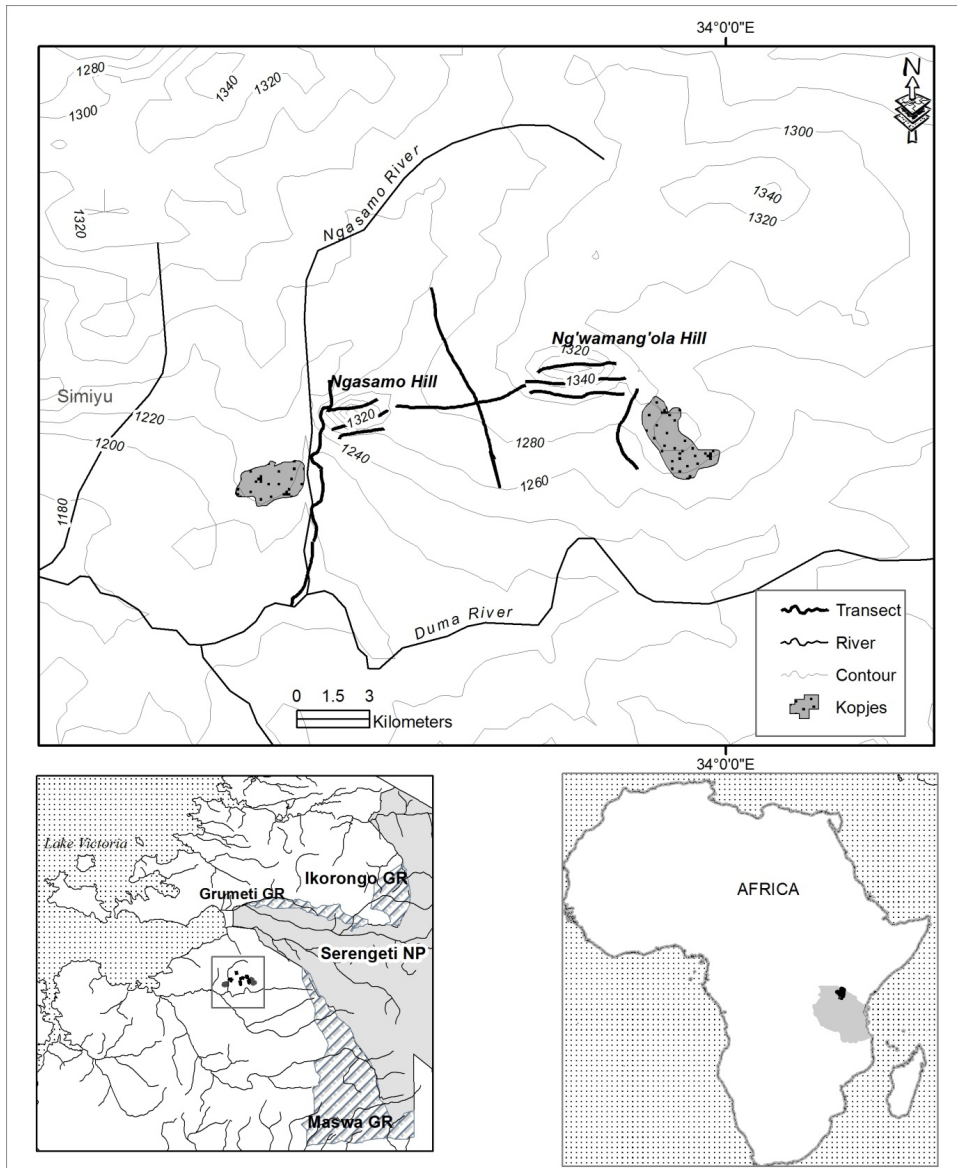
While the avian fauna of the GRE is fairly well known (e.g. Sinclair 1978, Folse 1982, Schmidl 1982, Gottschalk 2001, 2002, 2007, Sinclair *et al.* 2002, Trager & Mistry 2003, Jankowski *et al.* 2015, Turkington *et al.* 2015), the areas surrounding this ecosystem, particularly agricultural areas, are poorly known. To the best of our knowledge, the only study that has been carried out in the farmlands is that of Sinclair *et al.* (2002) which compared land under agriculture and protected areas, and found that many more species of birds are confined to the latter than the former.

Among the studied areas in the GSE are the kopjes (within Serengeti National Park), which have been found to differ significantly in bird species composition from those of the surrounding matrices and were of importance to the conservation of birds (Trager & Mistry 2003). For kopjes found in farmlands little or no attention has been focused on them. Using birds as a representative taxon, we assessed the role of the kopjes as habitats for birds in unprotected areas consisting of a matrix of agriculture, riparian vegetation, settlements and degraded shrub lands. The objectives were (i) to compare community composition across the four habitats, (ii) to assess whether or not birds found in the study area were similar to those of the nearby GSE, and (iii) to compare densities of birds (in terms of species and individuals) in the kopjes with the surrounding habitat matrix.

## Materials and methods

### *Study area*

The study area (2°27'40"-2°33'40"S, 33°49'13"-34°00'00"E; ~208 km<sup>2</sup>, 1100-1140 m) was located at Igaganulwa and Ngasamo to the west of Maswa Game Reserve and Serengeti National Park, about 25 km southeast of Lake Victoria (Fig. 1). Rainfall is bimodal with periods of short rains during November-December and long rains during March-June. There is a long dry season that lasts from July to October and a short dry season in January and February.



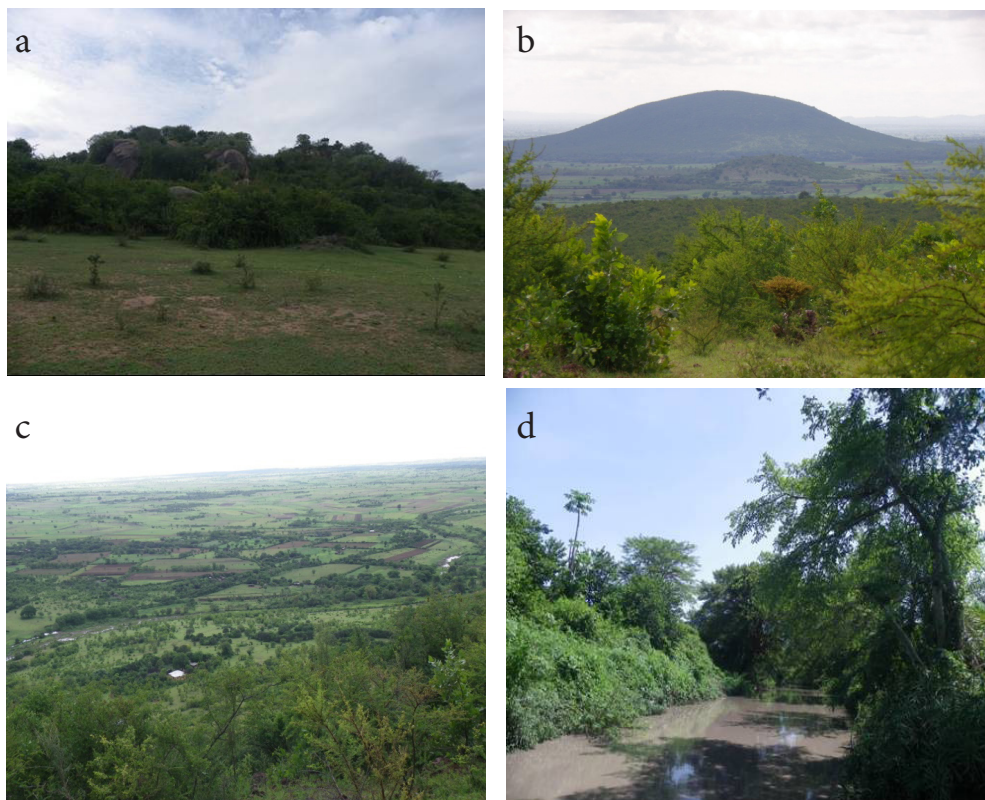
**Figure 1.** Map of the study area.

The study area consisted of two large groups of kopjes that had shrubs and broad-leaved trees such as *Ficus sycomorus*. The trees and shrubs formed dense thickets by growing among the rocks (Fig. 2; see Byrom *et al.* 2015). For comparison, three other main habitat types present in the study area were surveyed. These were:

- 1) Degraded woodland (hereafter shrub land) on Ngasamo and Ng'wamang'ola Hills (Fig. 1) and chiefly composed of shrubs with very few trees. The most frequent shrub species were *Acacia seyal*, *Rhus natalensis*, *Combretum adenogonium*, *Lantana camara*, *Harrisonia abyssinica*, *Acalypha fruticosa*, *Ormocarpum kirkii*, *Grewia microcarpa* and *A. drepanolobium*.

2) Farmland which consisted of small-scale farms, grazing land and some patches of wooded areas that all had scattered trees with farms around them (Fig. 2). This habitat surrounds the kopjes and hills. In the farmlands the predominant tree species included *Acacia* spp. and *F. natalensis*. The latter was fruiting during the dry season. Some farms were surrounded by hedges consisting of mainly *Acacia* sp. (Fig. 2).

3) Riparian vegetation found along the Ngasamo River that had well developed thickets and disturbed woodland comprised predominantly of *F. sur* and *A. polyacantha* (Fig 2).



**Figure 2.** Four habitats composing the study area. (a) kopjes, (b) shrub land, (c) farmland and, (d) riparian vegetation. Photographs were taken during the wet season.

### Methodology

We used line transects to sample birds because this method covers large areas quickly (Bibby *et al.* 2000). A total of 35 transects whose lengths varied from 1–4 km were surveyed in four main habitats during the wet season (April 2012) and during the dry season (August 2012). The lengths of transects were as follows:

- Kopjes: 16 transects, each 1 km
- Riparian vegetation: 6 transects each 2 km
- Farmland: 4 transects total, three 3-km and one 4-km transect
- Shrub land: 9 transects total, six 1-km transects, two 3-km transects and one 4-km transect

For the kopje transects, we ventured onto the kopjes where the rock structure and vegetation allowed, otherwise we walked around the perimeter. Data were collected by walking slowly along the transects in the mornings (between 06:30–11:00h) and afternoons (between 16:00–18:00h) during each season. All birds seen or heard up to 50m on either side of the transect lines were identified and recorded. Birds seen opportunistically within the study area were also recorded.

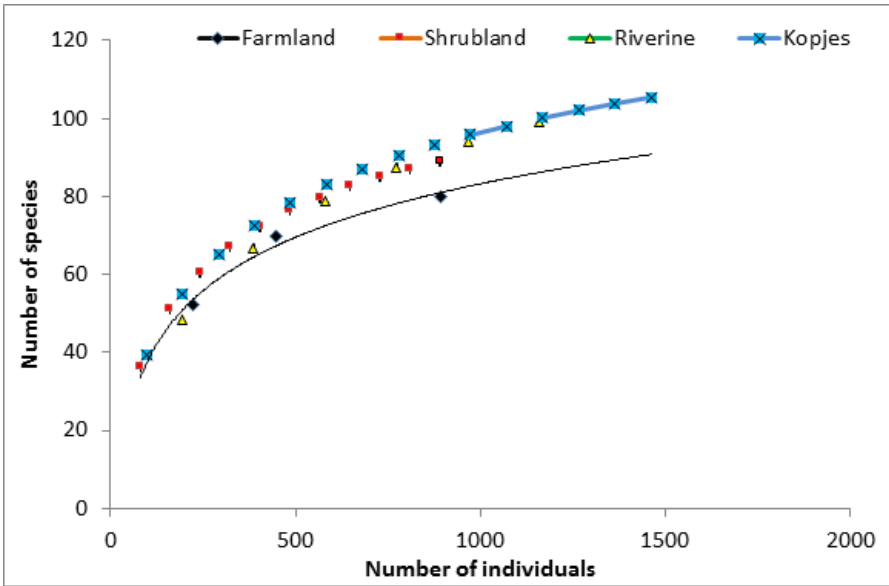
#### *Data analysis*

To assess whether our sampling effort was adequate, we used rarefaction curves to compare species numbers between habitats because sampling efforts between habitats differed. We calculated density indices to assess whether there were significant differences in densities of species and individuals between and across different habitats. Data were tested for normality using Shapiro-Wilk test. Kruskal-Wallis test was used to assess whether there were significant differences in number of species per kilometre of transect, and densities of birds and species across the four habitat types. Mann-Whitney U-test was used to assess whether the number of species per kilometre of transect, and density of birds and species were significantly higher in the in kopjes than in farmland, riparian vegetation and shrub land habitats. These statistical tests were computed using the software package PAST (Hammer *et al.* 2001). Community composition of birds among different habitat types was assessed using the Sørensen Disimilarity Index, comparing birds based on presence-absence data. The index is bound between 0 and 1, where 0 means the two sites have the same species composition and 1 means the two sites do not share any species. This analysis was done using the software package Community Analysis Package (CAP) version 4.1.3 (Seaby & Henderson 2007). Species order, taxonomy and common names follow Sinclair & Ryan (2010).

## **Results**

#### *Species richness*

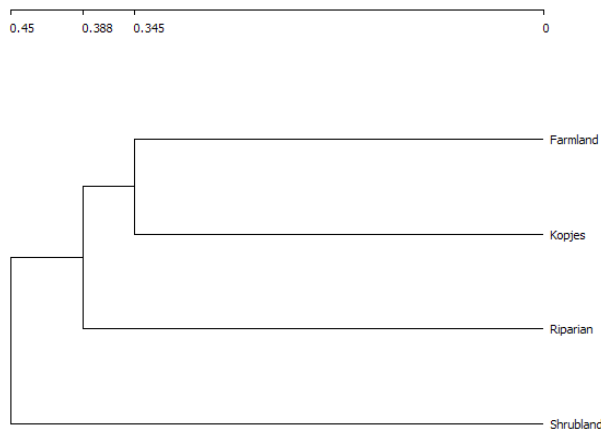
A total of 164 avian species were recorded (Appendix 1). Of these, 145 and 19 species were recorded along transects and during ad hoc observations, respectively. In total, 91 species were found in kopjes while more species, (n=99) were observed in the riparian vegetation (Appendix 1). Eighty-nine and 76 species were recorded in farmlands and shrub land habitats, respectively (Appendix 1). Species accumulation curves for each habitat showed upward trends without reaching an asymptote, although they started to taper off somewhat (Fig. 3). The species accumulation curve for farmland fell below the other three habitats (Fig. 3).



**Figure 3.** Rarefaction curves for the numbers of species in four habitats. The black line indicates rarefaction curve for the farmland.

*Community structure*

The bird community of the kopjes was more similar to that found in farmland, and was least similar to that of shrub land (Fig. 4).



**Figure 4.** Community structure of birds found in the kopjes compared to those of other habitats.

*Density of species and individual birds in the kopjes and surrounding matrix*

The mean number of species per km of transect was 17.3 ( $\pm 1.4$ ). There were significant differences in numbers of species per kilometre between the four habitat types (Kruskal-Wallis test,  $\chi^2 = 20.65$ ,  $p < 0.005$ ; Fig. 5). Mean numbers of species per kilometre were significantly higher in kopjes than in farmland ( $U = 4$ ,  $p < 0.005$ ), riparian vegetation ( $U = 18$ ,  $p < 0.05$ ) and shrub land habitats ( $U = 2.5$ ,  $p < 0.0005$ ).



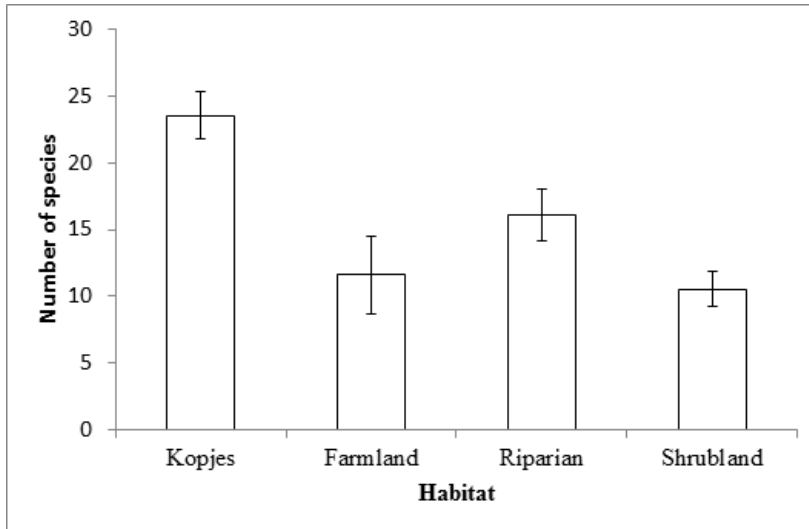


Figure 5. Number of species per kilometre of transect ( $\pm$  standard error).

Mean densities of species per square kilometre varied across the four habitats (Appendix 1). The most abundant were Wattled Starling *Creatophora cinerea* and Speckled Mousebird *Colius striatus*, particularly in farmland and riparian habitats, respectively (Appendix 1). These species were also abundant in the kopjes (Appendix 1).

The mean number of birds per square kilometre was 767.7 ( $\pm 108.0$ ). There were significant differences in the densities of birds across the four habitats (Kruskal-Wallis test,  $\chi^2=12.05$ ,  $p<0.01$ ; Fig. 6). Kopjes had more birds per square kilometre than shrub land ( $U=7$ ,  $p<0.005$ ), but not in the farmland ( $U=23$ ,  $p>0.1$ ) or in riparian vegetation ( $U=47$ ,  $p>0.5$ ).

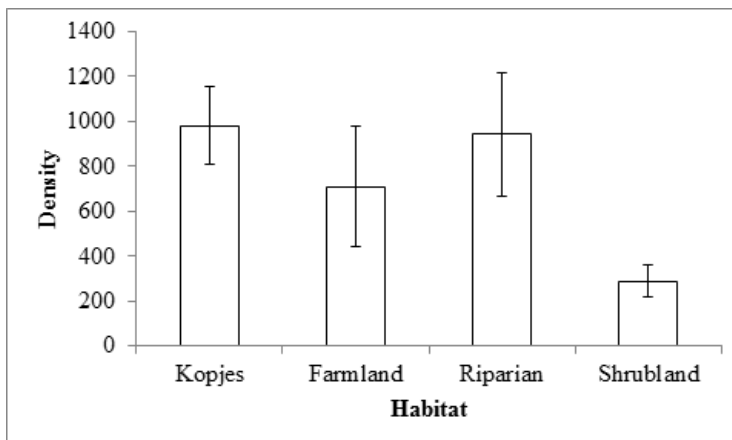


Figure 6. Density of birds per square kilometre ( $\pm$  standard error).

## Discussion

### *Species richness and community structure*

One hundred and sixty-four species of birds were recorded which is a quarter of

the 617 species that have been found in the entire GRE (Jankowski *et al.* 2015). The number of species recorded in this study is more than the 131 species that were recorded in kopjes and the surrounding matrix within the Serengeti National Park by Trager & Mistry (2003) of which about 55% (n=72) were detected in the present study. In this study, the availability of different habitats (i.e. shrub land, riparian vegetation, kopjes and farmland) may have created a heterogeneous matrix that attracted different species of avifauna. This agrees with the findings that structural heterogeneity of habitats is correlated with avian species richness (Trager & Mistry 2003, Mulwa *et al.* 2012).

All the species observed during this study have been recorded in the nearby GRE. These results imply that the study area is a subset of the entire GRE, except that it is under heavy human pressure. Of the birds detected, ten species were Palaearctic migrants that either used the study area as a wintering ground or as a habitat to move through during migration.

Results of the species accumulation curves suggest that the study was by no means an exhaustive survey of birds in the area. While more species were recorded in the riparian vegetation, about 55% of species found in the study area were recorded in the kopjes.

The bird community of the kopjes is most similar to that of farmlands. This could be due to the fact that the kopjes are surrounded by farmland and the birds could be moving freely between either habitat. The bird community in the kopjes was more similar to that found in riparian vegetation compared to that found in shrub land. This implies that the birds found in the shrubs (on the hills) were somehow distinct from those of the other habitats. In the other habitats there were more trees than there were on the hills, which were dominated by shrubs. For example, the absence of herons, ibises and storks in the shrub land habitat suggests that it was probably because this habitat was located on the hills where there were few resources (such as water) that could have been attractive to these birds.

#### *Density of species and individuals*

The higher density of both species and individuals in the kopjes compared to the other habitats could be a result of the presence of diverse and abundant vegetation both among the rocks and around the kopje edges. The kopjes form a distinct habitat that harbours diverse communities (Poelchau & Mistry 2006), probably due to minimal anthropogenic disturbance. It is likely that the high local habitat heterogeneity on the kopjes (see Poelchau & Mistry 2006, Poembski & Bathlott 2000) led to a higher density of bird species and individuals compared to the other habitats. The trees and shrubs found in the kopjes likely provide resources such as food, nesting sites and protection compared to the other habitats. For example, the presence of fruiting *F. sycomorus* in the kopjes attracted Speckled Pigeon *Columba guinea* and White-fronted Barbet *Lybius leucocephalus*, which were observed feeding on fruits of this tree. In addition, the rocks provided appropriate habitat for the Rock Martin *Ptyonoprogne fuligula*, which was only observed in the kopjes. Furthermore, large trees such as *F. sycomorus* likely provided potential nesting sites that were rarely found in the surrounding farmland. Large species such as Marabou Stork *Leptoptilos crumeniferus* and Hamerkop *Scopus umbretta* were nesting on the trees found only in the kopjes. Similarly, the kopjes provided perches, and refuge for the large-sized bird species such as Hamerkop, Hageda Ibis *Bostrichia hagedash*, Marabou Stork, Bateleur *Terathopius ecaudatus*, Augur



Buzzard *Buteo augur*, Lesser Spotted Eagle *Aquila pomarina*, Tawny Eagle *Aquila rapax* and Spotted Eagle Owl *Bubo africanus*. The higher densities of species and individual birds in the kopjes implies that the kopjes represent local hotspots of avian diversity similar to the results of Trager & Mistry (2003).

## Conclusion

Our findings suggest that kopjes have a high conservation value that needs to be recognized. Kopjes increase regional avifaunal diversity by providing unique microhabitats and abundant resources within an agricultural landscape. Thus, kopjes provide landscape level heterogeneity as has been proposed by Trager & Mistry (2003). Similar to kopjes found in the GSE, those found in unprotected areas should be recognised as important for the conservation of biodiversity and as potentially fragile habitats that merit protection. While it has been found that farmland has lower avian species richness compared to protected areas in the Serengeti (Sinclair *et al.* 2002, Jankowski *et al.* 2015), the findings of this study demonstrate that the kopjes increase regional avifaunal diversity. We recommend further studies in other farmland surrounding the GSE in order to have a better understanding of how agriculture has shaped bird communities neighbouring this ecosystem.

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**Appendix 1.** List of birds observed in the kopjes and in the surrounding habitats. Abbreviations are as follows: d = mean density (individuals per km<sup>2</sup>), s.e. = standard error, \* = Palearctic migrants and x = *ad hoc* observations (species not observed during transect surveys).

Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Scopus umbretta</i>	Hamerkop	3.75	1.55	0.83	0.83	0.63	0.63		
<i>Ardea cinerea</i>	Grey Heron			x					
<i>Ardea melanocephala</i>	Black-headed Heron			0.83	0.83	1.67	0.96		
<i>Bubulcus ibis</i>	Cattle Egret					x			
<i>Ardeola ralloides</i>	Squaco Heron			0.83	0.83				
<i>Butorides striata</i>	Green-backed Heron			1.67	1.67				
<i>Nycticorax nycticorax</i>	Black-crowned Night Heron			0.83	0.83				
<i>Bostrychia hagedash</i>	Hadedda Ibis	1.25	1.25	3.33	2.11	0.83	0.83		
<i>Leptoptilos crumeniferus</i>	Marabou Stork	5.63	5.63						
<i>Anastomus lamelligerus</i>	African Openbill			2.50	2.50				
<i>Ciconia abdimii</i>	Abdim's Stork					64.55	6.55		
<i>Mycteria ibis</i>	Yellow-billed Stork			0.83	0.83				
<i>Milvus migrans</i>	Black Kite	1.88	1.88	0.83	0.83				
<i>Circaetus pectoralis</i>	Black-chested Snake-Eagle			0.83	0.83	0.63	0.63		
<i>Macheiramphus alcinus</i>	Bat Hawk			1.67	1.67				
<i>Teraphopius ecaudatus</i>	Bateleur	0.63	0.63	0.83	0.83				
* <i>Circus macrourus</i>	Pallid Harrier					x			
<i>Polyboroides typus</i>	African Harrier Hawk					x		x	
<i>Kaupifalco monogrammicus</i>	Lizard Buzzard					0.83	0.83		
<i>Melierax metabates</i>	Dark Chanting Goshawk	0.63	0.63			1.88	1.88		
<i>Accipiter minullus</i>	Little Sparrowhawk	1.25	0.85						
<i>Buteo augur</i>	Augur Buzzard	6.88	1.98	1.67	1.05				
* <i>Aquila pomarina</i>	Lesser Spotted Eagle	0.63	0.63					0.91	0.91
* <i>Aquila rapax</i>	Tawny Eagle			2.50	2.50				
<i>Numida meleagris</i>	Helmeted Guineafowl	1.88	1.88					0.61	0.61
<i>Peliperdix coqui</i>	Coqui Francolin					0.63	0.63		

Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Pternistis hildebrandti</i>	Hildebrandt's Francolin	1.88	1.01					0.61	0.61
<i>Amaurornis flavirostra</i>	Black Crake			1.67	1.05				
<i>Ardeotis kori</i>	Kori Bustard					1.25	1.25		
<i>Burhinus capensis</i>	Spotted Thick-knee							x	
<i>Charadrius tricollaris</i>	Three-banded Plover			1.67	1.67				
<i>Vanellus lugubris</i>	Senegal Lapwing							0.61	0.61
* <i>Actitis hypoleucos</i>	Common Sandpiper			5.00	4.08				
<i>Columba guinea</i>	Speckled Pigeon	1.25	1.25						
<i>Streptopelia semitorquata</i>	Red-eyed Dove	6.88	2.70	11.67	9.80	1.25	1.25		
<i>Streptopelia decipiens</i>	African Mourning Dove	4.38	2.03	4.17	2.39	6.67	6.67	1.21	0.93
<i>Streptopelia capicola</i>	Ring-necked Dove	50.00	17.09	30.83	25.31	2.29	1.57		
<i>Streptopelia senegalensis</i>	Laughing Dove	70.63	28.34	48.33	21.24	14.38	8.51	18.79	8.12
<i>Treeron calvus</i>	African Green Pigeon	10.63	9.38	0.83	0.83				
<i>Turtur chalcospilos</i>	Emerald-spotted Wood-Dove	6.88	2.18	6.67	2.47	0.63	0.63	3.03	2.71
<i>Turtur tympanistria</i>	Tambourine Dove			0.83	0.83				
<i>Oena capensis</i>	Namaqua Dove			0.83	0.83	1.67	1.67	3.03	1.93
<i>Agapornis fischeri</i>	Fisher's Lovebird	46.88	30.71	43.33	35.93	3.33	1.92		
<i>Chrysococcyx caprius</i>	Diderick Cuckoo	3.75	1.55	1.67	1.05	5.63	4.83	5.00	2.47
<i>Chrysococcyx klaas</i>	Klaas's Cuckoo	0.63	0.63						
<i>Clamator jacobinus</i>	Jacobin Cuckoo			0.83	0.83				
<i>Clamator levallantii</i>	Levallant's Cuckoo			1.67	1.67				
<i>Cuculus solitarius</i>	Red-chested Cuckoo			x				x	
<i>Centropus grillii</i>	Black Coucal	0.63	0.63	0.83	0.83				
<i>Centropus superciliosus</i>	White-browed Coucal	3.13	1.20	3.33	1.67	0.83	0.83	0.45	0.45
<i>Bubo lacteus</i>	Verreaux's Eagle-Owl						x		
<i>Bubo africanus</i>	Spotted Eagle-Owl	1.25	1.25			0.83	0.83		
<i>Caprimulgus fosii</i>	Square-tailed Nightjar	0.63	0.63					2.12	1.21
<i>Caprimulgus tristigma</i>	Freckled Nighthjar	x							
<i>Colius striatus</i>	Speckled Mousebird	83.75	24.05	315.00	131.33	23.75	7.95	48.18	19.24

Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Urocolius macrourus</i>	Blue-naped Mousebird	23.13	21.87	1.67	1.67	27.50	27.50	6.67	3.92
<i>Rhinopomastus minor</i>	Abyssinian Scimitarbill					x			
<i>Alcedo cristata</i>	Malachite Kingfisher			2.50	1.71				
<i>Ispidina picta</i>	African Pygmy-Kingfisher	3.75	2.02	6.67	2.47	2.92	1.72	0.91	0.91
<i>Halcyon leucocephala</i>	Grey-headed Kingfisher	3.75	1.80			2.29	1.57		
<i>Halcyon senegalensis</i>	Woodland Kingfisher	0.63	0.63	1.67	1.67				
<i>Eurystomus glaucurus</i>	Broad-billed Roller			x					
<i>Coracias naevius</i>	Rufous-crowned Roller							1.82	1.82
<i>Coracias caudatus</i>	Lilac-breasted Roller					x			
<i>Merops pusillus</i>	Little Bee-eater	7.50	2.81	1.67	1.67	5.00	5.00	2.42	1.86
<i>Merops superciliosus</i>	Madagascar Bee-eater					0.63	0.63	10.91	10.91
* <i>Merops apiaster</i>	European Bee-eater			6.67	4.77	5.00	5.00		
<i>Tockus nasutus</i>	African Grey Hornbill	0.63	0.63						
<i>Pogonius pusillus</i>	Red-fronted Tinkerbird			1.67	1.67	0.83	0.83	0.91	0.91
<i>Lybius leucocephalus</i>	White-headed Barbet	0.63	0.63						
<i>Trachyphonus darnaudii</i>	D'Arnaud's Barbet			1.67	1.67	4.17	2.50	7.88	3.12
<i>Indicator minor</i>	Lesser Honeyguide	0.63	0.63	1.67	1.05	0.83	0.83	2.73	1.26
<i>Campethera nubica</i>	Nubian Woodpecker					0.83	0.83		
<i>Dendropicus fuscescens</i>	Cardinal Woodpecker			x					
<i>Mirafr africana</i>	Rufous-naped Lark							3.94	1.67
<i>Mirafr rufocinnamomea</i>	Flappet Lark	0.63	0.63					8.71	5.39
<i>Eremopteryx leucopareia</i>	Fisher's Sparrow Lark			8.33	6.54	18.33	17.24	11.36	8.04
<i>Ptyonoprogne fuligula</i>	Rock Martin	40.63	17.09						
* <i>Hirundo rustica</i>	Barn Swallow	3.75	3.75	1.67	1.67			100.91	82.14
<i>Hirundo smithii</i>	Wire-tailed Swallow	13.13	12.47						
<i>Cercropis abyssinica</i>	Lesser Striped Swallow	10.00	4.74	2.50	2.50	2.50	2.50		
<i>Motacilla aguimp</i>	African Pied Wagtail	0.63	0.63	14.17	6.11	2.29	1.57		
<i>Anthus cinnamomeus</i>	African Pipit							0.91	0.91
<i>Coracina pectoralis</i>	White-breasted Cuckoo-shrike			0.83	0.83				

Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Dicrurus adsimilis</i>	Fork-tailed Drongo	2.50	1.94			2.72	1.72		
<i>Corvus albus</i>	Pied Crow			0.83	0.83				
<i>Oriolus auratus</i>	African Golden Oriole	0.63	0.63						
<i>Oriolus larvatus</i>	Black-headed Oriole	0.63	0.63	x					
<i>Turdoides rubiginosa</i>	Rufous Chatterer	1.88	1.88	10.83	7.12	4.17	4.17	4.55	3.66
<i>Pycnonotus tricolor</i>	Dark-capped Bulbul	33.75	5.39	35.0	16.68	6.04	2.13	17.80	6.10
* <i>Monticola saxatilis</i>	Rufous-tailed Rock-Thrush	8.13	3.44	1.67	1.67			0.91	0.91
<i>Cossypha natalensis</i>	Red-capped Robin-Chat			0.83	0.83				
<i>Cossypha heuglini</i>	White-browed Robin-Chat	21.25	6.12	12.50	5.88	3.96	2.13	0.23	0.23
<i>Cichladusa guttata</i>	Spotted Palm-Thrush	8.75	2.87	8.33	2.79	8.34	3.09	3.33	1.96
<i>Erythropygia leucophrys</i>	White-browed Scrub Robin	3.13	1.51	1.67	1.05	2.08	1.25	16.36	5.92
<i>Cercomela familiaris</i>	Familiar Chat			x				2.73	1.95
<i>Oenanthe pileata</i>	Capped Wheatear							3.03	2.22
<i>Thamnolaea cinnamomeiventris</i>	Mocking Cliff-Chat	12.50	3.71	x					
* <i>Phylloscopus trochilus</i>	Willow Warbler							1.82	1.82
* <i>Sylvia borin</i>	Garden Warbler			1.67	1.05			3.64	2.44
<i>Cisticola chiniana</i>	Rattling Cisticola	10.63	3.92	8.33	3.33	8.33	6.31	31.44	9.22
<i>Cisticola marginatus</i>	Winding Cisticola	1.88	1.88	3.33	2.11	0.83	0.83		
<i>Apalis flavida</i>	Yellow-breasted Apalis	1.88	1.36	1.67	1.67				
<i>Prinia subflava</i>	Tawny-flanked Prinia	17.50	4.52	1.67	1.67	2.50	1.60	0.30	0.30
<i>Eminia lepida</i>	Grey-capped Warbler	0.63	0.63	19.17	8.00				
<i>Sylvietta whytii</i>	Red-faced Crombec	1.88	1.36	3.33	1.67	0.63	0.63	3.94	2.41
<i>Camaroptera brevicaudata</i>	Grey-backed Camaroptera	23.13	4.54	10.00	5.48	4.79	2.21	8.03	5.59
<i>Bradornis microrhynchus</i>	African Grey Flycatcher	2.50	1.12			7.71	2.83	7.88	5.01
<i>Empidonis semipartitus</i>	Silverbird	1.25	1.25	1.67	1.67	2.08	1.25	1.59	1.08
<i>Muscicapa aquatica</i>	Swamp Flycatcher			45.00	14.78				
<i>Terpsiphone viridis</i>	African Paradise-Flycatcher	6.25	2.72	14.17	6.25	6.67	2.36	1.82	1.82
<i>Batis molitor</i>	Chinspot Batis	3.75	2.72			4.79	3.01	6.36	2.36
* <i>Lanius collurio</i>	Red-backed Shrike	0.63	0.63						



Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Lanius collaris</i>	Common Fiscal			1.67	1.05	2.50	1.60	2.73	2.73
<i>Dryoscopus cubla</i>	Black-backed Puffback	1.88	1.01	5.00	3.16	0.63	0.63	0.23	0.23
<i>Laniarius funebris</i>	Slate-coloured Boubou	26.88	6.50	5.83	3.27	10.63	4.19	19.24	9.58
<i>Laniarius erythrogaster</i>	Black-headed Gonolek			13.33	5.58	1.25	1.25		
<i>Tchagra australis</i>	Brown-crowned Tchagra	3.75	1.55	3.33	1.67	1.67	0.96	6.89	3.56
<i>Tchagra senegalus</i>	Black-crowned Tchagra	0.63	0.63	0.83	0.83	0.63	0.83		
<i>Lamprotornis purpuropterus</i>	Rüppell's Starling			4.17	2.71				
<i>Lamprotornis superbus</i>	Superb Starling					5.42	2.84	10.61	6.11
<i>Cinnyricinclus leucogaster</i>	Violet-backed Starling	15.61	5.08	30.83	30.83	0.63	0.63	1.82	1.82
<i>Onychognathus morio</i>	Red-winged Starling	5.63	5.00	1.67	1.67				
<i>Creatophora cinerea</i>	Wattled Starling	102.50	93.57	15.00	15.00	295.00	290.56	13.33	10.01
<i>Drepanorhynchus reichenowi</i>	Golden-winged Sunbird			0.83	0.83				
<i>Chalcomitra senegalensis</i>	Scarlet-chested Sunbird	5.63	2.88	2.50	1.71	2.50	2.50	2.73	1.95
<i>Antheptes orientalis</i>	Eastern Violet-backed Sunbird	5.00	2.24			4.38	1.71		
<i>Hedydipna collaris</i>	Collared Sunbird	6.88	2.99	0.83	0.83	1.25	1.25	0.61	0.41
<i>Cinnyris venustus</i>	Variable Sunbird	6.88	2.99	1.67	1.67			5.45	5.45
<i>Cinnyris pulchellus</i>	Beautiful Sunbird	3.75	2.72	2.50	1.71	2.08	1.25		
<i>Passer rufocinctus</i>	Kenya Rufous Sparrow					x			
<i>Passer suahelicus</i>	Swahili Sparrow	1.88	1.36			8.13	3.09		
<i>Passer emini</i>	Chestnut Sparrow							0.91	0.91
<i>Sporopipes frontalis</i>	Speckle-fronted Weaver					7.50	4.79	5.45	3.66
<i>Pseudonigrita arnaudi</i>	Grey-capped Social Weaver					6.67	6.67	1.21	1.21
<i>Ploceus ocularis</i>	Spectacled Weaver	1.25	1.25	2.50	1.71				
<i>Ploceus cucullatus</i>	Village Weaver			5.83	3.27	46.88	43.61	0.91	0.91
<i>Ploceus vitellinus</i>	Vitelline Masked Weaver	9.38	4.75					4.55	4.55
<i>Ploceus intermedius</i>	Lesser Masked Weaver	1.25	1.25			5.00	5.00		
<i>Ploceus nigricollis</i>	Black-necked Weaver							x	
<i>Amblyospiza albifrons</i>	Grosbeak Weaver			0.83	0.83				
<i>Ploceus jacksoni</i>	Golden-backed Weaver					x			

Species name	English name	Kopjes		Riparian		Agriculture		Shrubland	
		d	s.e.	d	s.e.	d	s.e.	d	s.e.
<i>Anaplectes melanotis</i>	Red-headed Weaver					x		x	
<i>Quelea erythroptus</i>	Red-headed Quelea							2.42	2.42
<i>Quelea quelea</i>	Red-billed Quelea			14.17	14.17				
<i>Euplectes orix</i>	Southern Red Bishop	x		x		x			
<i>Euplectes hordeaceus</i>	Black-winged Bishop	36.25	21.52	1.67	1.67	0.83	0.83		
<i>Euplectes albonotatus</i>	White-winged Widowbird					0.83	0.83		
<i>Pytilia melba</i>	Green-winged Pytilia	6.25	2.21			1.25	1.25	7.27	5.48
<i>Lagonosticta senegala</i>	Red-billed Firefinch	18.75	7.85	24.17	10.83	10.63	6.16		
<i>Ortygospiza fuscocrissa</i>	African Quail-Finch							0.61	0.61
<i>Spermestes cucullata</i>	Bronze Mannikin	28.75	12.28	31.67	16.16	8.33	5.00	23.33	14.65
<i>Odontospiza griseicapilla</i>	Grey-headed Silverbill	3.13	3.13					0.91	0.91
<i>Uraeginthus bengalus</i>	Red-cheeked Cordonbleu							2.73	2.73
<i>Uraeginthus cyanocephalus</i>	Blue-capped Cordonbleu	14.38	7.85	41.67	13.21	31.04	14.36	10.00	7.01
<i>Granatina ianthinogaster</i>	Purple Grenadier	14.38	4.38			11.46	5.68	13.03	5.40
<i>Estrilda astrild</i>	Common Waxbill			0.83	0.83				
<i>Vidua chalybeata</i>	Village Indigobird					x			
<i>Vidua fischeri</i>	Straw-tailed Whydah					1.88	1.88		
<i>Vidua hypocherina</i>	Steel-blue Whydah							0.91	0.91
<i>Vidua paradisaea</i>	Long-tailed Paradise-Whydah	x		x		x		x	
<i>Crithagra mazambica</i>	Yellow-fronted Canary	20.00	6.77	10.00	2.89	3.54	2.05	13.94	7.20
<i>Crithagra reichenowi</i>	Reichenow's Seed-eater	2.50	2.50	1.67	1.67	5.00	5.00	10.91	7.32
<i>Emberiza tahapisi</i>	Cinnamon-breasted Bunting	1.25	0.85			0.63	0.63	3.64	3.64