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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, Jankowiski *et al.* 2015, Turkington *et al*. 2015), the areas surrounding this ecosystem, particularly agricultureal 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^2, 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.

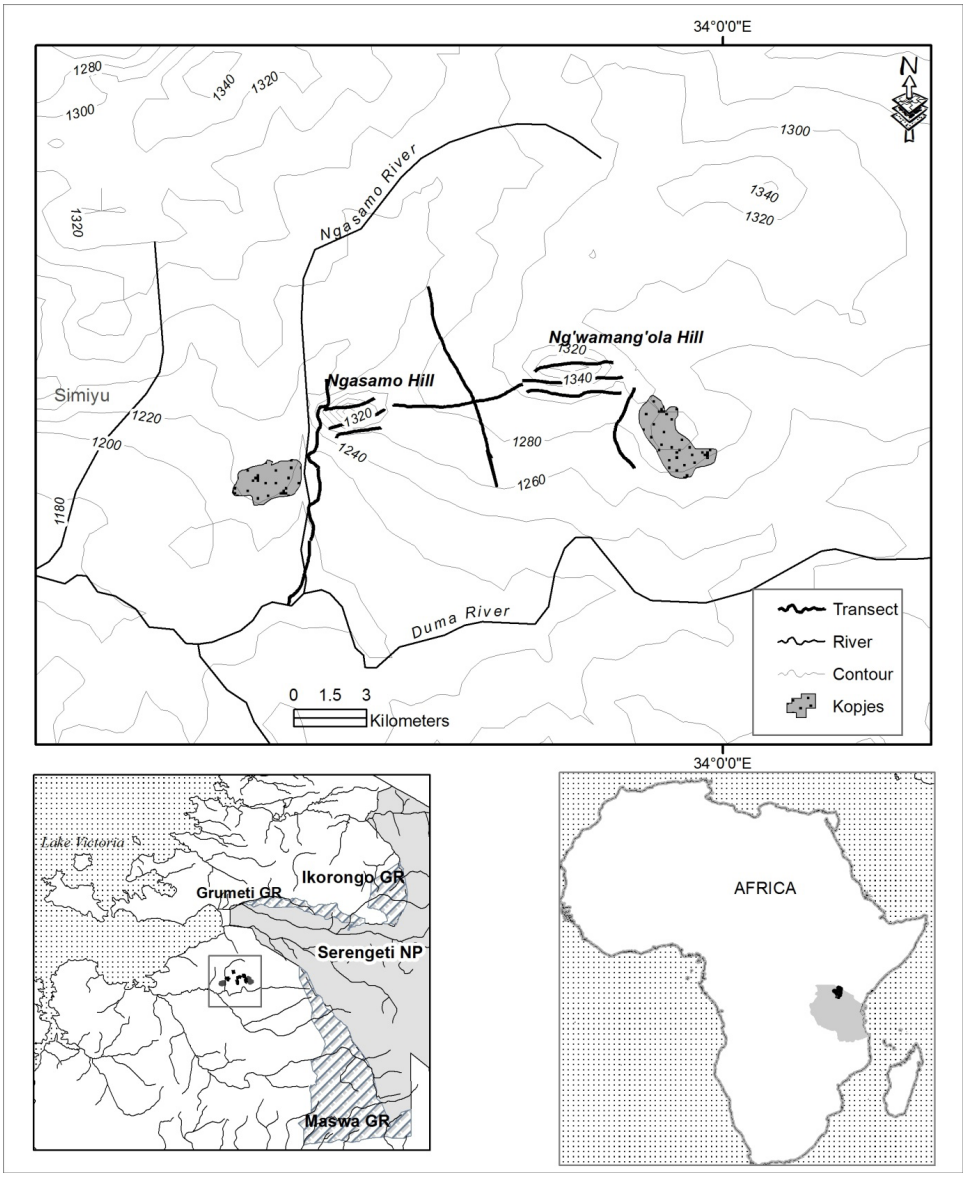

Figure 1. Map of the study area.

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).

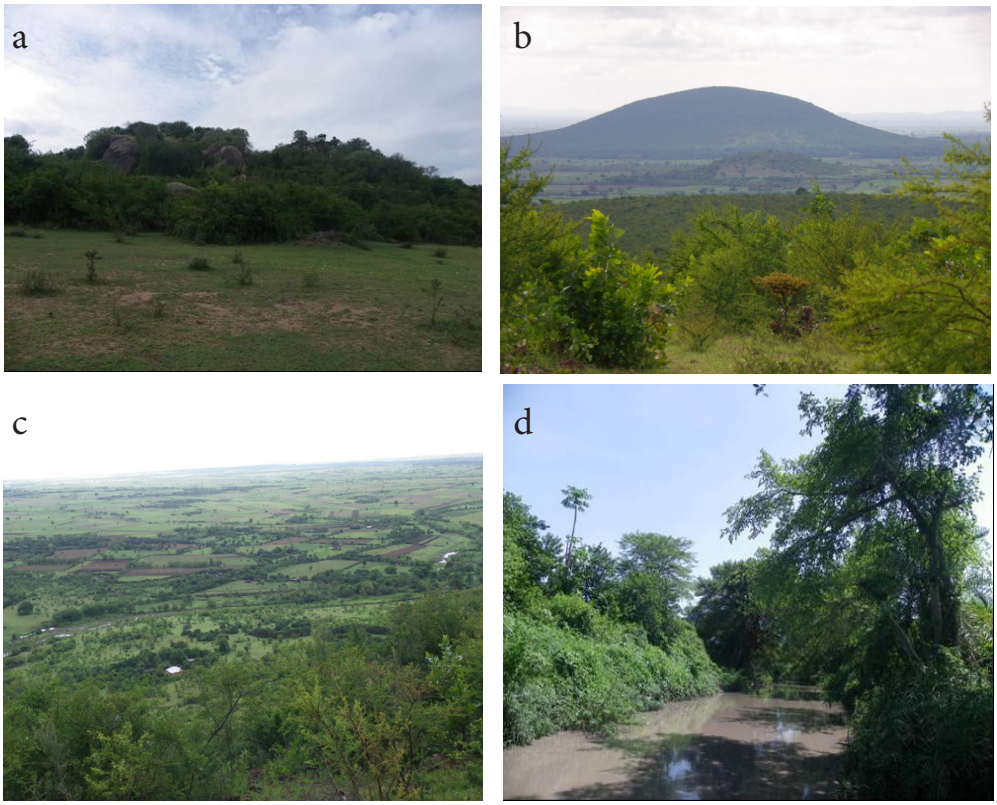

Figure 2. Four habitats composing the study area. (a) kopjes, (b) shrub land, (c) farmland and, (d) riparian vegetation. Photographs were taken during the wet season.

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 06:30–11:00 h) and afternoons (between 16:00–18:00 h) during each season. All birds seen or heard up to 50 m 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 Sørrensen 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).

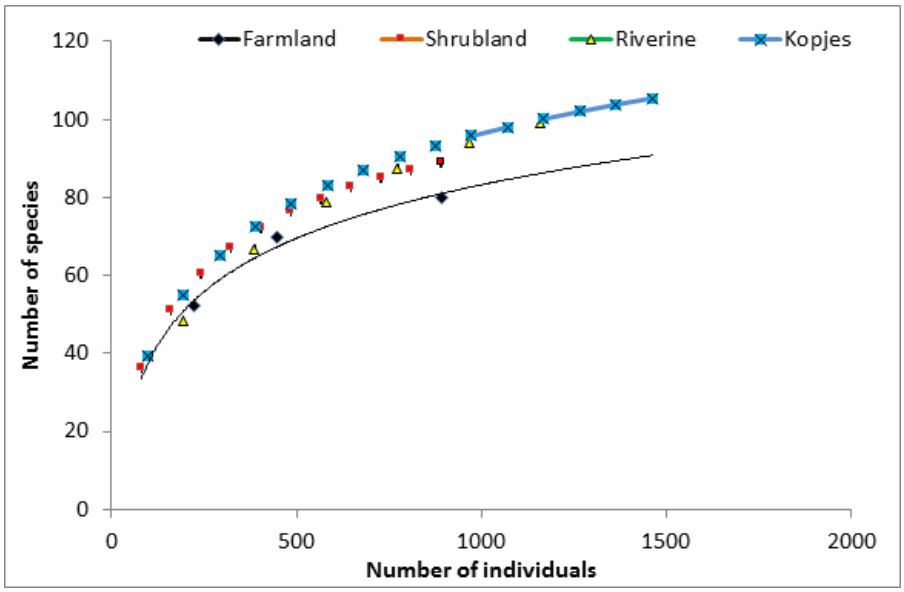

Figure 3. Rarefaction curves for the numbers of species in four habitats. The black line indicates rarefaction curve for the farmland.

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).

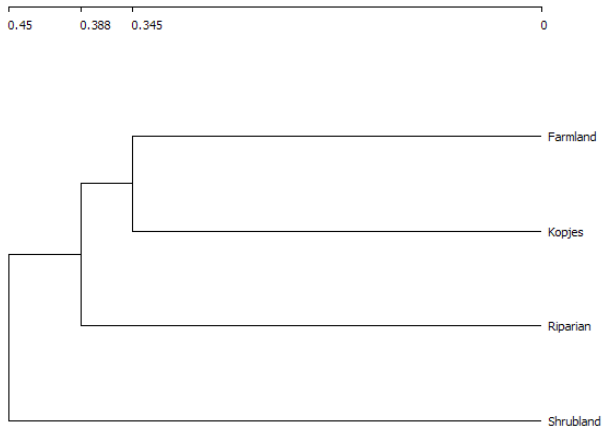

Figure 4. Community structure of birds found in the kopjes compared to those of other habitats.

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

The mean number of species per km of transect was 17.3 (±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 ($U = 2.5$, $p < 0.0005$).

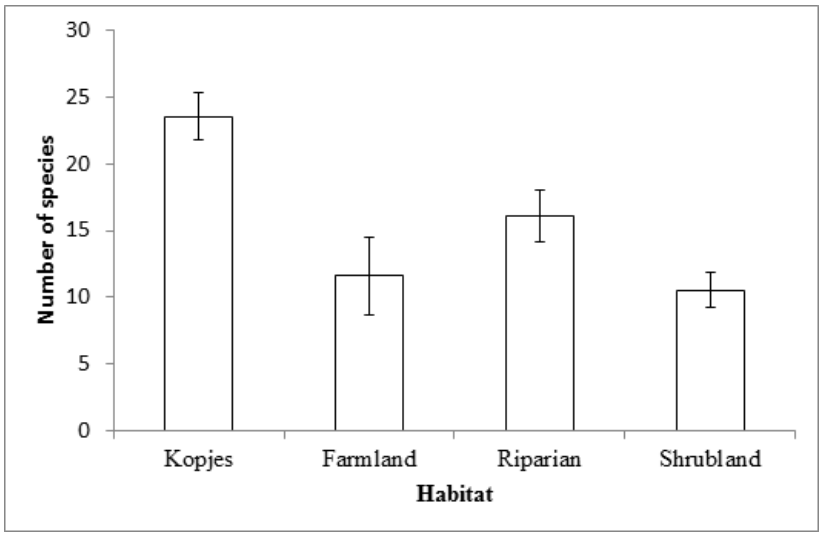

Figure 5. Number of species per kilometre of transect (± standard error).

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 (±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 ($U = 47$, $p > 0.5$).

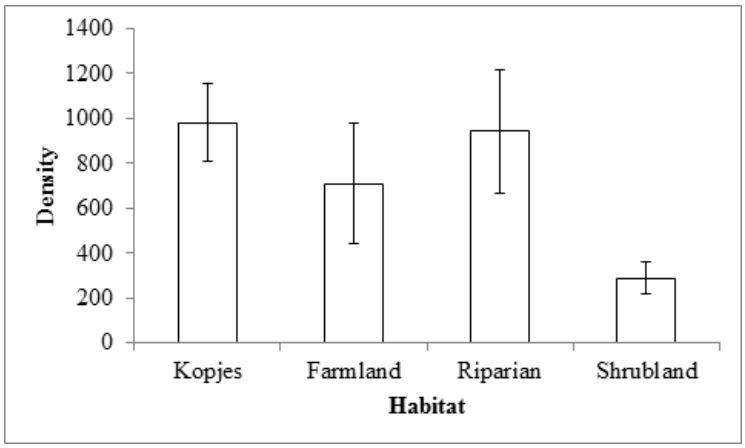

Figure 6. Density of birds per square kilometre (± standard error).

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 (Jankowiski *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, Hadeda 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, Jankowiski *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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References

Anderson, T.M., Dempewolf, J., Metzger, K.L., Reed, D.N. and Serneels, S. 2008. Generation and maintainance of heterogeneity in the Serengeti Ecosystem. Pp 135–182 in Sinclair, A.R.E., Packer, C., Mduma, S.A.R. and Fryxell, J.M. *Serengeti III: Human impacts on ecosystem dynamics.* Chicago: The University of Chicago Press.

Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. 2000. *Birds Census Techniques*. London: Academic Press.

Byrom, A.E., Ruscoe, W.A., Nkwabi, A.K., Metzger, K.L., Forester, G.J., Craft, M.E., Durant, S.M., Makacha, S. Bukombe, J., Mchetto, J. and Mduma, S.A.R. 2015. Small mammal diversity and population dynamics in the Greater Serengeti Ecosystem. Pp. 323–357 *In* Sinclair, A.R.E., Metzger, K.L., Fryxel, J.M. & Mduma, S.A.R. (eds) *Serengeti IV: Sustaining Biodiversity in a Coupled Human-Natural System*. Chicago: The University of Chicago Press.

Folse, L.J. 1982. An analysis of avifauna-resource relationships on the Serengeti plains. *Ecological Monographs* 52: 111–127.

Gottschalk, T.K. 2001. Black-backed Cisticola *Cisticola eximius* a new species for Tanzania. *Bulletin of the African Bird Club* 8: 135–137.

Gottschalk, T.K. 2002. Birds of a Grumeti River forest in Serengeti National Park, Tanzania. *Bulletin of the African Bird Club* 9: 153–158.

Gottschalk, T.K. 2007. New and notable records of birds from Serengeti National Park. *Scopus* 26: 10–21.

Hammer, Ø., Harper, D.A.T. & Ryan, P.D. 2001. PAST: paleontological statistics software package for education and data analysis. *Paleontol. Electron.* 4: 9.

Hoeck, H.N. 1975. Differential feeding behaviour of sympatric hyrax *Procavia johnstoni* and *Heterohyrax brucei*. *Oecologia* 22: 15–47.

Hopcraft, J.G.C., Holdo, R.M., Mwangomo, E., Mduma, S.A.R., Thirgood, S.J., Borner, M. Fryxell, J.M., Olff, H. & Sinclair, A.R.E. 2015. Why are wildebeest the most abundant herbivore

in the Serengeti Ecosystem? Pp 125–174 in Sinclair, A.R.E., Metziger, K.L., Mduma, S.A.R. & Fryxell, J.M. (eds) *Serengeti IV: Sustaining Biodiversity in a Coupled Human-Natural system*. Chicago: The University of Chicago Press.

Jankowiski, J.E, Sinclair, A.R.E. & Metzger, K.L. 2015. Bird diversity of the greater Serengeti ecosystem: spatial patterns of taxonomic and functional richness and turnover. Pp. 359–394 *in* Sinclair, A.R.E., Metzger, K.L., Mduma, S.A.R. & Fryxel, J.M. (eds) *Serengeti IV: Sustaining Biodiversity in a Coupled Human-Natural System*. Chicago: The University of Chicago Press.

Mulwa, R.K., Böhning-gease, K. & Schleuning, M. 2012. High bird species diversity in a structurally heterogeneous farmland in Western Kenya. *Biotropica* 44(6): 801–809.

Poelchau, M.F. & Mistry, S. 2006. Ford diversity and community similarity of kopjes in the Serengeti National Park, Tanzania. *African Journal of Ecology* 44: 38–46.

Porembski, S. 1996. Notes on the vegetation of inselbergs in Malawi. *Flora* 191: 1–8.

Porembski, S. & Barthlott, W. 2000. *Inselbergs – Biotic Diversity of Isolated Rock Outcrops in Tropical and Temperate Regions*. Berlin: Springer-Verlag.

Porembski, S., Szarzynski, J., Mund, J. & Barthlott, W. 1996. Biodiversity and vegetation of small-sized inselbergs in a West African rainforest (Tai, Ivory Coast). *Journal of Biogeography* 23: 47–55.

Schmidl, D. 1982. *The Birds of the Serengeti National Park Tanzania: an annotated check-list*. BOU Check-list No. 5. London: British Ornithologists' Union.

Seaby, R.M. & Henderson, P.A. 2007. *Community Analysis Package 4*. Lymington, UK: Pisces Conservation Ltd.

Sinclair, A.R.E. 1978. Factors affecting the food supply and breeding seasons of resident birds and movements of Palaearctic migrants in a tropical African savannah. *Ibis* 120: 480–497.

Sinclair, A.R.E. & Arcese, P. 1995. *Serengeti II. Dynamics, Management and Conservation of an Ecosytem*. Chicago: University of Chicago Press.

Sinclair, A.R.E., Mduma, S.A.R. & Arcese, P. 2002. Protected areas as biodiversity benchmarks for human impacts: agriculture and the Serengeti avifauna. *Proceedings of the Royal Society B* 269: 2401–2405.

Sinclair, I. & Ryan, P. 2010. *Birds of Africa South of the Sahara*: Second Edition. Cape Town: Struik Nature.

Timbuka, C.D. & Kabigumila, J. 2006. Diversity and abundance of small mammals in the Serengeti kopjes. *Tanzania Journal of Science* 32: 1–12.

Trager, M. & Mistry, S. 2003. Avian community composition of kopjes in a heterogeneous landscape. *Oecologia* 135: 458–468.

Turkington, R., Sharam, G. & Sinclair, A.R.E. 2015. Biodiversity and the dynamics of riverine forests in Serengeti. Pp 235–264 In Sinclair, A.R.E., Metzger, K.L., Mduma, S.A.R. & Fryxel, J.M. (eds) *Serengeti IV: Sustaining Biodiversity in a Coupled Human-Natural System*. Chicago: The University of Chicago Press.

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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^2), s.e. = standard error, * = Palaearctic 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.
Scopus umbretta	Hamerkop	3.75	1.55	0.83	0.83	0.63	0.63		
Ardea cinerea	Grey Heron			x					
Ardea melanocephala	Black-headed Heron			0.83	0.83	1.67	0.96		
Bubulcus ibis	Cattle Egret					x			
Ardeola ralloides	Squaco Heron			0.83	0.83				
Butorides striata	Green-backed Heron			1.67	1.67				
Nycticorax nycticorax	Black-crowned Night Heron			0.83	0.83				
Bostrychia hagedash	Hadeda Ibis	1.25	1.25	3.33	2.11	0.83	0.83		
Leptoptilos crumeniferus	Marabou Stork	5.63	5.63						
Anastomus lamelligerus	African Openbill			2.50	2.50				
Ciconia abdimii	Abdim's Stork					64.55	6.55		
Mycteria ibis	Yellow-billed Stork			0.83	0.83				
Milvus migrans	Black Kite	1.88	1.88	0.83	0.83				
Circaetus pectoralis	Black-chested Snake-Eagle			0.83	0.83	0.63	0.63		
Macheiramphus alcinus	Bat Hawk			1.67	1.67				
Teraphopius ecaudatus	Bateleur	0.63	0.63	0.83	0.83				
**Circus macrourus*	Pallid Harrier					x			
Polyboroides typus	African Harrier Hawk					x		x	
Kaupifalco monogrammicus	Lizard Buzzard					0.83	0.83		
Melierax metabates	Dark Chanting Goshawk	0.63	0.63			1.88	1.88		
Accipiter minullus	Little Sparrowhawk	1.25	0.85						
Buteo augur	Augur Buzzard	6.88	1.98	1.67	1.05				
**Aquila pomarina*	Lesser Spotted Eagle	0.63	0.63					0.91	0.91
**Aquila rapax*	Tawny Eagle			2.50	2.50				
Numida meleagris	Helmeted Guineafowl	1.88	1.88					0.61	0.61
Peliperdix coqui	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.
Pternistis hildebrandti	Hildebrandt's Francolin	1.88	1.01					0.61	0.61
Amaurornis flavirostra	Black Crake			1.67	1.05				
Ardeotis kori	Kori Bustard					1.25	1.25		
Burhinus capensis	Spotted Thick-knee							x	
Charadrius tricollaris	Three-banded Plover			1.67	1.67				
Vanellus lugubris	Senegal Lapwing							0.61	0.61
**Actitis hypoleucos*	Common Sandpiper			5.00	4.08				
Columba guinea	Speckled Pigeon	1.25	1.25						
Streptopelia semitorquata	Red-eyed Dove	6.88	2.70	11.67	9.80	1.25	1.25		
Streptopelia decipiens	African Mourning Dove	4.38	2.03	4.17	2.39	6.67	6.67	1.21	0.93
Streptopelia capicola	Ring-necked Dove	50.00	17.09	30.83	25.31	2.29	1.57		
Streptopelia senegalensis	Laughing Dove	70.63	28.34	48.33	21.24	14.38	8.51	18.79	8.12
Treron calvus	African Green Pigeon	10.63	9.38	0.83	0.83				
Turtur chalcospilos	Emerald-spotted Wood-Dove	6.88	2.18	6.67	2.47	0.63	0.63	3.03	2.71
Turtur tympanistria	Tambourine Dove			0.83	0.83				
Oena capensis	Namaqua Dove			0.83	0.83	1.67	1.67	3.03	1.93
Agapornis fischeri	Fisher's Lovebird	46.88	30.71	43.33	35.93	3.33	1.92		
Chrysococcyx caprius	Diderick Cuckoo	3.75	1.55	1.67	1.05	5.63	4.83	5.00	2.47
Chrysococcyx klaas	Klaas's Cuckoo	0.63	0.63						
Clamator jacobinus	Jacobin Cuckoo			0.83	0.83				
Clamator levaillantii	Levaillant's Cuckoo			1.67	1.67				
Cuculus solitarius	Red-chested Cuckoo			x				x	
Centropus grillii	Black Coucal	0.63	0.63	0.83	0.83				
Centropus superciliosus	White-browed Coucal	3.13	1.20	3.33	1.67	0.83	0.83	0.45	0.45
Bubo lacteus	Verreaux's Eagle-Owl						x		
Bubo africanus	Spotted Eagle-Owl	1.25	1.25			0.83	0.83		
Caprimulgus fosii	Square-tailed Nightjar	0.63	0.63					2.12	1.21
Caprimulgus tristigma	Freckled Nighjar	x							
Colius striatus	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.
Urocolius macrourus	Blue-naped Mousebird	23.13	21.87	1.67	1.67	27.50	27.50	6.67	3.92
Rhinopomastus minor	Abyssinian Scimitarbill					x			
Alcedo cristata	Malachite Kingfisher			2.50	1.71				
Ispidina picta	African Pygmy-Kingfisher	3.75	2.02	6.67	2.47	2.92	1.72	0.91	0.91
Halcyon leucocephala	Grey-headed Kingfisher	3.75	1.80			2.29	1.57		
Halcyon senegalensis	Woodland Kingfisher	0.63	0.63	1.67	1.67				
Eurystomus glaucurus	Broad-billed Roller			x					
Coracias naevius	Rufous-crowned Roller							1.82	1.82
Coracias caudatus	Lilac-breasted Roller					x			
Merops pusillus	Little Bee-eater	7.50	2.81	1.67	1.67	5.00	5.00	2.42	1.86
Merops superciliosus	Madagascar Bee-eater					0.63	0.63	10.91	10.91
**Merops apiaster*	European Bee-eater			6.67	4.77	5.00	5.00		
Tockus nasutus	African Grey Hornbill	0.63	0.63						
Pogoniulus pusillus	Red-fronted Tinkerbird			1.67	1.67	0.83	0.83	0.91	0.91
Lybius leucocephalus	White-headed Barbet	0.63	0.63						
Trachyphonus darnaudii	D'Arnaud's Barbet			1.67	1.67	4.17	2.50	7.88	3.12
Indicator minor	Lesser Honeyguide	0.63	0.63	1.67	1.05	0.83	0.83	2.73	1.26
Campethera nubica	Nubian Woodpecker					0.83	0.83		
Dendropicos fuscescens	Cardinal Woodpecker			x					
Mirafra africana	Rufous-naped Lark							3.94	1.67
Mirafra rufocinnamomea	Flappet Lark	0.63	0.63					8.71	5.39
Eremopteryx leucopareia	Fisher's Sparrow Lark			8.33	6.54	18.33	17.24	11.36	8.04
Ptyonoprogne fuligula	Rock Martin	40.63	17.09						
**Hirundo rustica*	Barn Swallow	3.75	3.75	1.67	1.67			100.91	82.14
Hirundo smithii	Wire-tailed Swallow	13.13	12.47						
Cercropis abyssinica	Lesser Striped Swallow	10.00	4.74	2.50	2.50	2.50	2.50		
Motacilla aguimp	African Pied Wagtail	0.63	0.63	14.17	6.11	2.29	1.57		
Anthus cinnamomeus	African Pipit							0.91	0.91
Coracina pectoralis	White-breasted Cuckoo-shrike			0.83	0.83				

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

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

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