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Chapter

Avifauna in Relation to Habitat Disturbance in Wildlife Management Areas of the Ruvuma Miombo Ecosystem, Southern Tanzania

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Abstract

Understanding of relative distribution of avifauna provides insights for the conservation and management of wildlife in the community managed areas. This study examined relative diversity, abundance, and distribution of avifauna in selected habitat types across five Wildlife Management Areas of the Ruvuma landscape in miombo vegetation, southern Tanzania. Five habitat types were surveyed during the study: farmland, swamps, riverine forest, dense and open woodland. Transect lines, mist-netting, and point count methods were used to document 156 species of birds in the study sites. Descriptive statistics and Kruskal-Wallis tests were used to compare species richness and diversity across habitat types. We found differences in avifaunal species distribution in the study area whereby farmland had the highest abundance of avifauna species and lowest in the riverine forest. These results suggest that variations of avifauna species abundance, diversity, and distribution could be attributed by human activities across habitat types; due to the reason that habitats with less human encroachment had good species diversity and richness. Therefore, to improve avitourism and avoid local extinction of species, we urge for prompt action to mitigate species loss by creating awareness in the adjacent community through conservation education on the importance of protecting such biodiversity resources.

Keywords: Avifauna, diversity, conservation, habitat destruction, wildlife management areas, miombo

1. Introduction

The miombo ecosystems are known worldwide for their higher biodiversity [1, 2]. Woodlands in the miombo ecosystems are dominated by trees of the genera *Brachystegia*, *Julbernardia*, and *Isoberlinia* Leguminosae, subfamily Caesalpinioideae [1, 3]. The woodlands cover between 2.7 and 3.6 million km² in 11 African countries [2, 4–6]. In Tanzania, this vegetation type covers more than 90% of forested land

[4, 7–10], and some of the miombo woodlands are found within several of the iconic protected areas including Selous Game Reserves and the Mikumi, Ruaha, Nyerere National Park as well as the Ruvuma Landscape in southern Tanzania. The ecological services it provides include: the provision of forage for wild and domestic animals, nesting sites for birds, water catchments, carbon sequestration, and biodiversity conservation in general and is archived due to the presence of habitat heterogeneity in particular flora diversity that exists in the miombo areas [3, 4].

Floral species compositions are a very important component to determine the distribution and diversity of avifauna communities [11]. Bird species diversity in savannah landscapes increases with an increase in vegetation/habitat heterogeneity in the miombo woodlands [5, 6]. In heterogeneous habitats, some avian species tend to show preference on certain habitat types, which also influence avifaunal diversity, abundance, and distribution across landscapes [7, 8, 12]. For example, miombo pied barbet (*Tricholaema frontata*), miombo rock thrush (*Monticola angolensis*), stierling's wren warbler (*Calamonastes stierlingi*), racket-tailed roller (*Coracias spatulatus*) and white-tailed blue-flycatcher (*Elminia albicauda*) prefer miombo woodland, only stierling's wren warbler and racket-tailed roller were observed during data collection other species listed here were not recorded during this study possibly due to habitat degradation.

The Ruvuma landscape in Tunduru District, in southern Tanzania encompasses five Wildlife Management Areas (WMAs) namely: Mbarang'andu, Kimbanda, and Kisungule in Namtumbo District, Nalika and Chingoli WMAs in Tunduru District (**Figure 1**). It borders the Selous Game Reserve and Nyerere National Park in the north and the Niassa National Reserve (Mozambique) to the south. The Ruvuma River forms an international boundary between Tanzania and Mozambique within Namtumbo and Tunduru districts [13]. The two protected areas rely on the presence of the five Wildlife Management Areas as they provide dispersal and movement area (corridor) to Niassa National Reserve in Mozambique and to Nyerere National Park. Habitat destruction by humans is a serious threat that alters the integrity of ecosystems [8], also affects vegetation cover. It is possible that human activities occurring in the miombo woodland resulted in land cover change [7, 9, 10, 14, 15]. Currently, the Wildlife Management Areas (WMAs) of the Ruvuma region in southern Tanzania undergo fragmentations caused by human activities which include uncontrolled wildfires, collection of fuel wood, charcoal, timber, illegal hunting, cattle grazing, and agriculture. In this area, communities have formulated the Wildlife Management Area (WMA), which is the form of community-based conservation which ensures villagers or communities rich in wildlife sustainably conserve, utilize and benefit from wildlife. Wildlife Management Areas are formed within village land from which villagers set aside a piece of land purposely for sustainable conservation and utilization of wildlife resources. The Tanzania government actualized WMAs for the local community to participate in wildlife management and conserve wildlife habitats in the communal land.

Apart from the study investigated on abundance, nesting and habitat of the white-browed sparrow-weaver (*Plocepasser mahali*) conducted by Ngongolo and Mtoka [16] no other study attempted to describe the diversity, abundance, and distribution of avifaunal species across the habitat gradient, and assess the implication of ongoing human activities to the conservation of avifauna species across the Ruvuma Landscape. This gives an opportunity to assess avifauna diversity and distribution in relation to habitat disturbance and how avifauna responded to this habitat destruction. Studying avifauna in Ruvuma landscape will open a room for avitourism activities and conserve from habitat degradation. Therefore, this chapter aimed at presenting the diversity of avifauna species in the Wildlife Management Areas in the Ruvuma Landscape in relation to human activities. It is predicted that

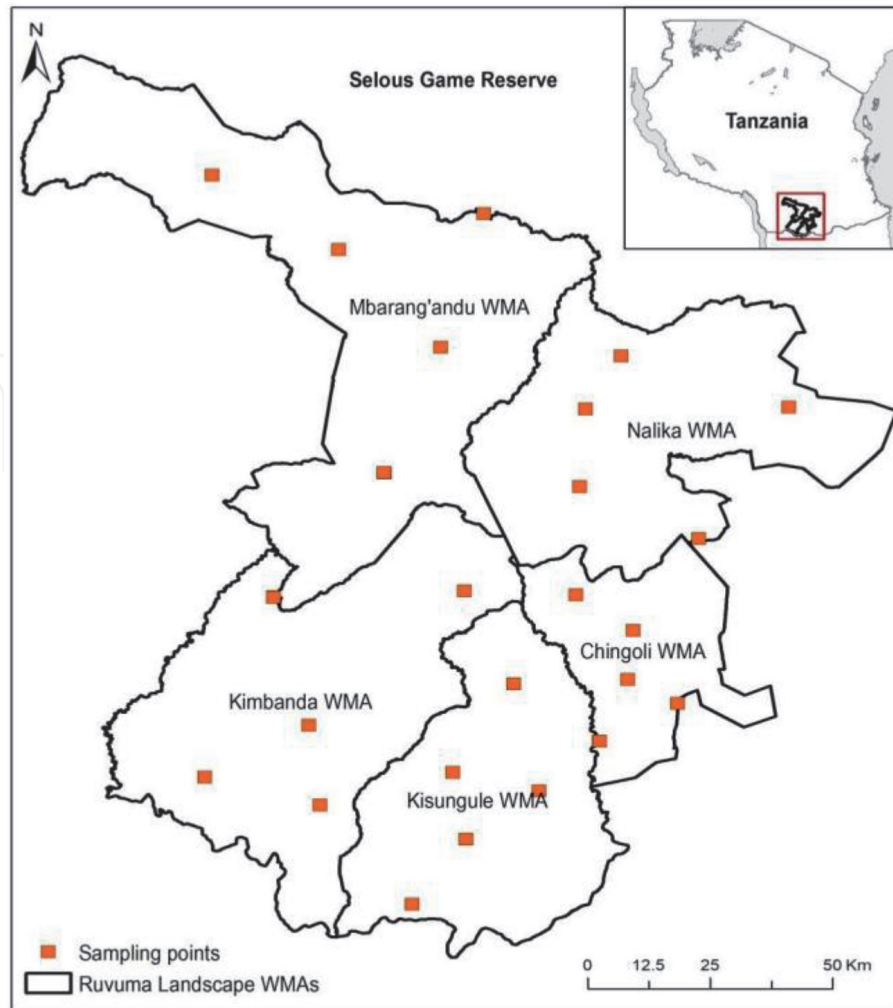


Figure 1.
Map of Ruvuma WMAs showing the location of the sampling sites.

avian species diversity and abundance would be higher in protected habitats inside WMA than in areas dominated by human activities namely farmlands.

In this study we treated the presence of farmlands in WMAs where they are not supposed to be as disturbance, because all WMAs in Tanzania have land use planning. The land use planning in all WMAs provides guidelines by zoning communal land where different activities can be conducted, such cattle grazing, settlements, farming and wildlife conservation area (tourist areas). All plots selected in this study were from wildlife conservation zones where also farms existed. Potential actions for intervention have been highlighted.

2. Methods and materials

2.1 Climate and vegetation types

The rainfall pattern is unimodal spanning from late November to May with a mean annual rainfall of 800–1200 mm in a north–south gradient. The mean annual temperature is 21°C, following the Köppen system [17]. The area consists of extensive miombo woodland, including *Brachystegia* sp., *Julbernardia* sp., *Isoberlinia* sp., *Azelia quanzensis*, *Pterocarpus angolensis*, and rare and threatened plant species such as *Dalbergia melanoxydon*, which forms dense miombo along the hills and rivers [18]. Also, there are seasonal and permanent wetlands (swamps), riverine forests along numerous perennial and seasonal streams. Due to the increasing

anthropogenic activities, the area currently has farmlands and patches of wooded with scattered trees and grazing land.

2.2 Sampling design

Five sites of 200 m x 200 m were established in each WMA, making a total of 25 sites. We selected different habitat types for each of the five sites, namely miombo woodland (open and dense), farmland, swamps, and riverine forest.

2.3 Avifauna survey

Each site was sampled using three complementary methods to maximize the sample size. First, in each habitat type, avifauna counts were carried out using the point transects technique [6, 19]. This method consists of standing at a particular point or walking slowly across the site back and forth several times, to detect cryptic and skulking species in the area. These counts were repeated for 3 days, based on results from our pilot study, and the numbers for each site were averaged. A 20-minute counting period was used at each site, and the starting time (between 6:30 and 10:30 h) was rotated among the sites to reduce bias. Avifauna was identified by both sight and call, and numbers were recorded [20].

Secondly, the transect method was used. Three transects 40 km in length each were established in every WMA using existing roads. The locations of all transects were based on accessibility and were sampled using a vehicle driven at a speed of 20 km/hr. or less that stopped for each individual or group of birds encountered [21]. Two observers sighted and recorded all avifauna on either side of the vehicle and notes on habitat type were also taken [21].

Thirdly, mist-netting was used to the targeted cryptic, understory, and lower canopy avian species. Nets were erected and checked every 15 min in the early morning (between 6:30–10:30 h) and late afternoon (between 16:00–18:00 h). The total number of each species caught, and the associated habitat type was recorded. Each bird was marked with a drop of red permanent spray paints at the base of its toes on the right tarsi for verification, if recaptured, to avoid double counting [22].

2.4 Statistical analysis

The biodiversity indices in different habitats or within these WMAs were obtained following Magurran [23]. This index uses three biodiversity indices including, diversity, richness, and abundance. A non-parametric Kruskal-Wallis test was used to assess whether there were significant differences in mean species abundance among five WMAs, and across each habitat type [24]. Differences in mean bird numbers between habitats in each WMA were tested using Mann-Whitney tests to assess whether the number of species was significantly lower in human-encroached habitat (farmland), i.e., farmland, compared to riverine forest, and dense and open miombo woodland habitats. Statistical tests were computed using the software package PAST [24]. For all these analyses, farmland habitat in this study represented human encroachment into protected areas and was used to compare with other habitat types found in the WMAs. We further calculated the Jaccard similarity index (J_i) between different habitat types to determine the level of similarities in species composition using the formulae [24]:

$$\text{Jaccard similarity coefficient (J)}; J = A/(A + B + C) \quad (1)$$

Where A = number of species found in both communities, B = number of species only found in community 1 and C = number of species found in community 2. The equation returns a number between 0 and 1, where a number close to 1 indicates a higher similarity in species composition [23]. We then multiplied J by 100 to obtain a percent, to easily interpret the results.

3. Results

3.1 Avian species diversity, distribution, and richness

A total of 156 avian species representing 18 orders and 61 families were recorded in the five WMAs. The overall avian species Shannon diversity (H') for all the habitat types ranged from 2.28–4.08, except for dense miombo woodland which had $H' = 1.69$ (Table 1). Riverine forest habitat had higher species richness ($n = 101$ species), representing almost 45% of the total recorded individuals (Table 1). Avian species diversity was highest in riverine forest and lowest in dense miombo woodlands (Table 1; Figure 2). The Shannon Index of diversity revealed that species evenness for the five habitats surveyed was relatively low ranging from 0.29–0.59 (Table 1).

Values bearing different letters within column are significantly different ($p < 0.05$) and values with similar letters within column are not significantly

Habitat type	Number of avian species	Overall abundance	Mean abundance	Shannon diversity (H')	Shannon evenness (E_H)
Dense miombo	14	105	7.50 ± 3.91	1.69	0.39
Farmland	40	580	14.50 ± 5.82	2.46	0.29
Open miombo	98	1338	13.65 ± 2.08	3.9	0.51
Riverine forest	101	759	7.52 ± 0.97	4.08	0.59
Swamp areas	20	188	9.40 ± 3.26	2.28	0.49

Table 1. Avian species diversity, abundance, and evenness in different habitats of WMAs in Ruvuma landscape (\pm standard error).

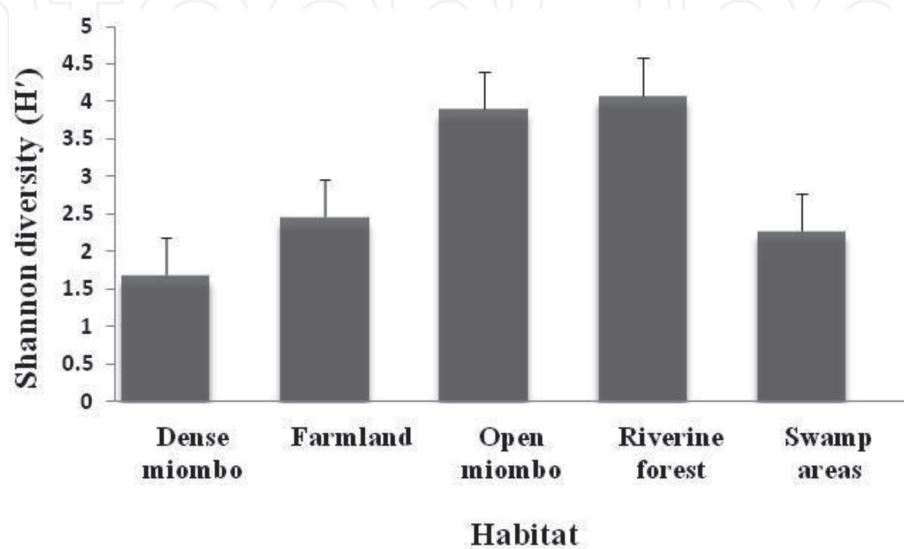


Figure 2. Avian species diversity in different habitats.

different ($p > 0.05$; **Table 2**). Dense miombo woodland, farm and swamp exhibited higher number of birds per point count than in open miombo woodland and riverine forest implying that the avian species were more scattered in open miombo woodlands and riverine forests.

The overall mean abundance of avifauna in the WMAs differed significantly (Kruskal-Wallis test, $\chi^2 = 50.13$, $df = 4$, $P = 0.03$). Kimbanda had the highest mean abundance of species followed by Kisungule (**Figure 3**). There was a significant difference in the mean abundance of avifauna across the five habitats (Kruskal-Wallis test, $\chi^2 = 13.18$, $df = 4$, $P = 0.010$). Mean abundance of species was significantly higher in farmland than in dense miombo (Mann-Whitney tests, $U = 19$, $P < 0.0001$), open miombo woodland ($U = 66.5$, $P < 0.0003$), riverine forest ($U = 157$, $P < 0.019$) and swamps ($U = 93.5$, $P < 0.004$) (**Figure 3**).

The distribution of the 2970 avifauna species recorded in the five habitat types is given in (**Table 1** above; **Figure 4**). Some species were found in more than one habitat type, a total of six species with bronze mannikin (*Lonchura cucullata*) the most abundant (**Figure 5**). Tawny-flanked prinia (*Prinia subflava*), blue-spotted wood dove (*Turtur afer*), common bulbul (*Pycnonotus barbatus*), violet-backed starling (*Cinnyricinclus leucogaster*), and Jameson's firefinch (*Lagonosticta rhodopareia*) were observed in four habitat types, except swamp habitat (see **Figure 5**; Appendix **Table A1**). Southern cordon-bleu (*Uraeginthus bengalus*) was observed in three habitat types and was the second most abundant species recorded

Habitats	Average bird count
Dense miombo woodland	6.18a
Farm	6.11a
Open miombo woodland	3.71b
Riverine forest	3.45b
swamp	6.48a

Table 2.
Average number of birds per point count in different habitats.

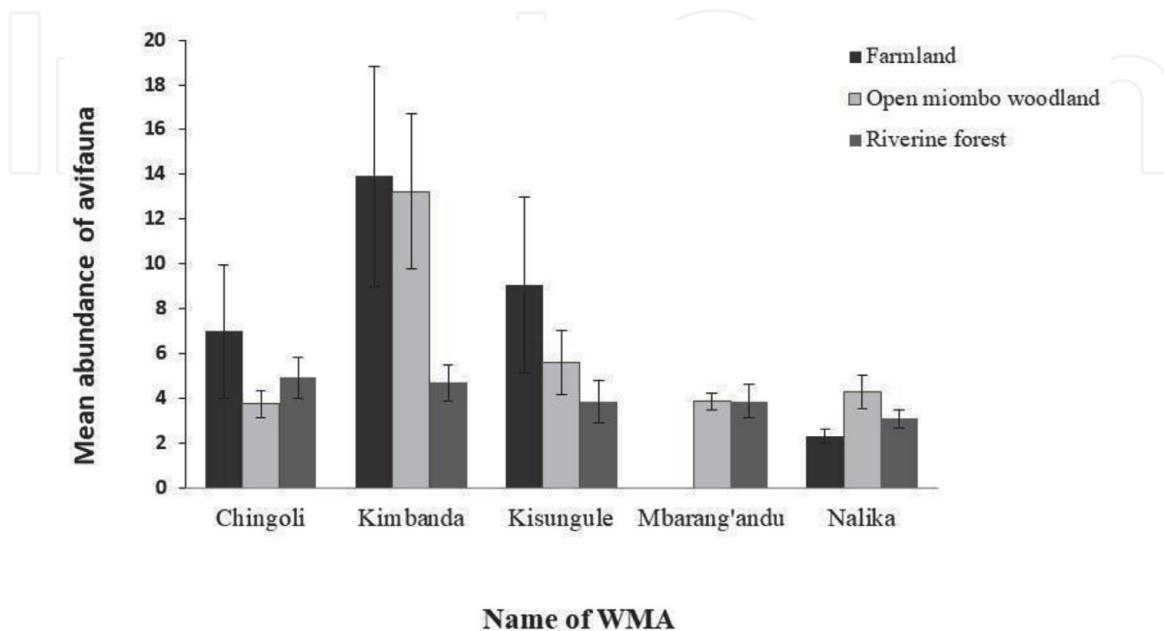


Figure 3.
Avian abundance in different habitats of wildlife management areas in southern Tanzania.

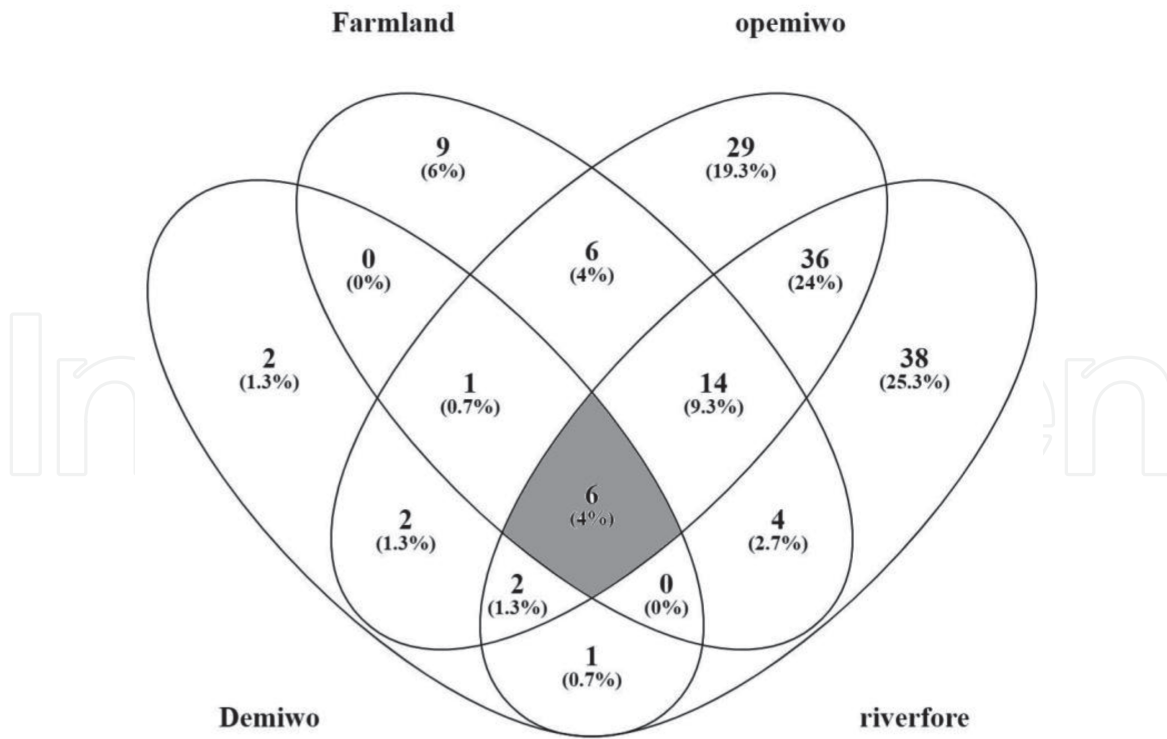


Figure 4. Avifauna species observed foraging in different habitats. Definition of abbreviation used (Demiwo = dense miombo woodland, riverfore = riverine forest, farmland = farmland habitat, opemiwo = open miombo woodland).

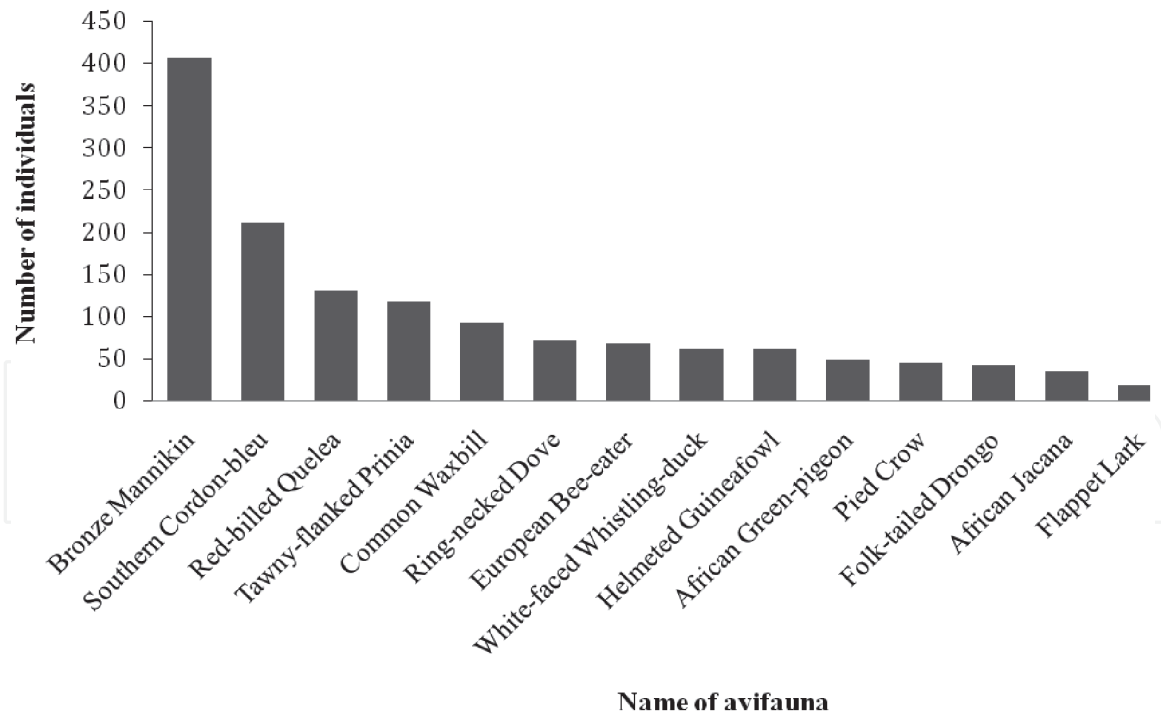


Figure 5. Distribution of avian species in different habitats within WMAs of the Ruvuma landscape in southern Tanzania.

during this study (Figure 5). Other species including pied crow (*Corvus albus*), brown-headed parrot (*Poicephalus cryptoxanthus*), and red-necked francolin (*Pternistis afer*) were observed in three habitat types (see Appendix Table A1) whereas black-faced waxbill (*Estrilda erythronotos*) and African pied wagtail (*Motacilla aguimp*), were observed only in farmland areas.

Cryptic species like African broadbill (*Smithornis capensis*) and red-capped robin-chat (*Cossypha natalensis*) and understory bird species including red-throated twinspot (*Hypargos niveoguttatus*) were observed only in the riverine forest using mist-nets and point count methods (Appendix Table A1). Palearctic migrants including European nightjar (*Caprimulgus europaeus*), European swift (*Apus apus*), and European bee-eater (*Merops apiaster*) were also recorded. Trumpeter hornbill (*Bycanistes bucinator*) is a bird of conservation status that was observed during the study in forest patches.

3.2 Species composition and similarities between different habitat types

We found strong contrast in species composition among habitat types (Table 3). The highest species similarities were between open woodland vs. Riverine forest (41%), Farmland vs. Open woodland (24%) and Farmland vs. Riverine forest (21%)

Habitat types	Dense woodland	Open woodland	Farmland	Riverine	Swamp area
	—	—	—	—	—
Open woodland	11	—	—	—	—
Farmland	15	24	—	—	—
Riverine forest	8	41	21	—	—
Swamp area	0	1	2	5	—

Table 3.

Jaccard species composition similarity index (J) between habitat types of the WMAs in Ruvuma landscape, in southern Tanzania. In this table the similarity presented in percentage (%).

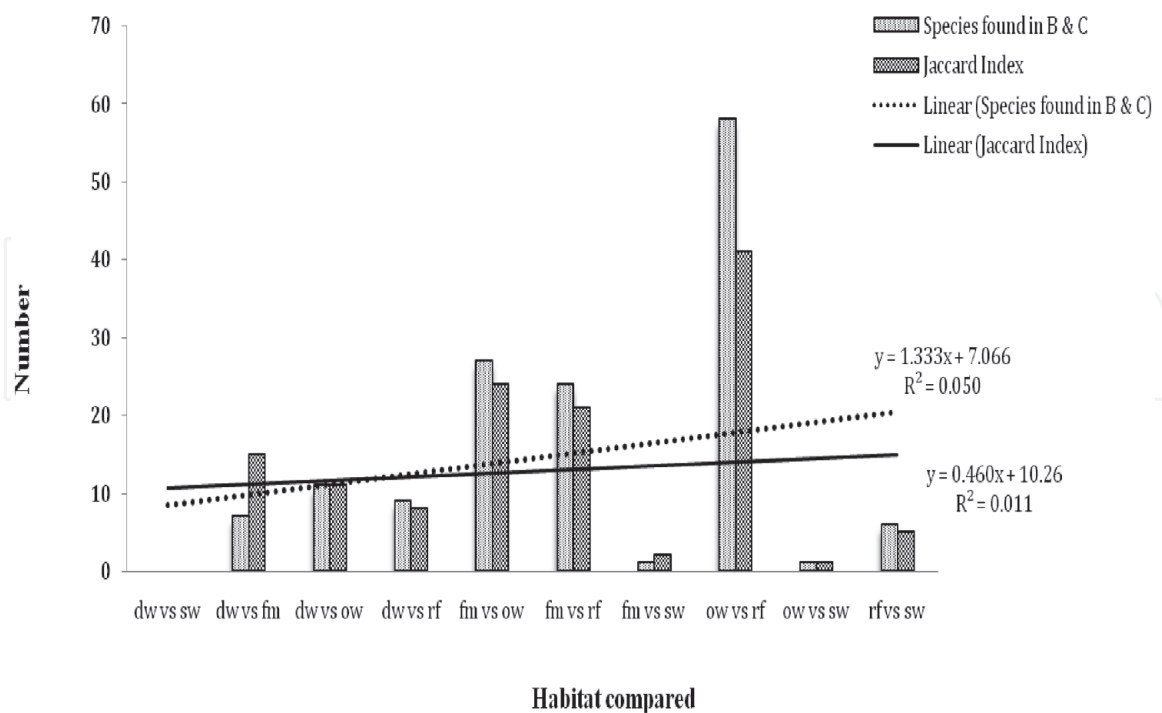


Figure 6.

Plotted trend line to show species composition similarities between habitat types of the WMAs in Ruvuma landscape, in southern Tanzania. Definition of abbreviation used (dw vs. sw = dense woodland vs. swamp area; dw vs. fm = dense woodland vs. farmland; dw vs. ow = dense woodland vs. open woodland; dw vs. rf = dense woodland vs. riverine forest; fm vs. ow = farmland vs. open woodland; fm vs. rf = farmland vs. riverine forest; fm vs. sw = farmland vs. swamp area; ow vs. rf = open woodland vs. riverine forest; ow vs. sw = open woodland vs. swamp area; rf vs. sw = riverine forest vs. swamp area).

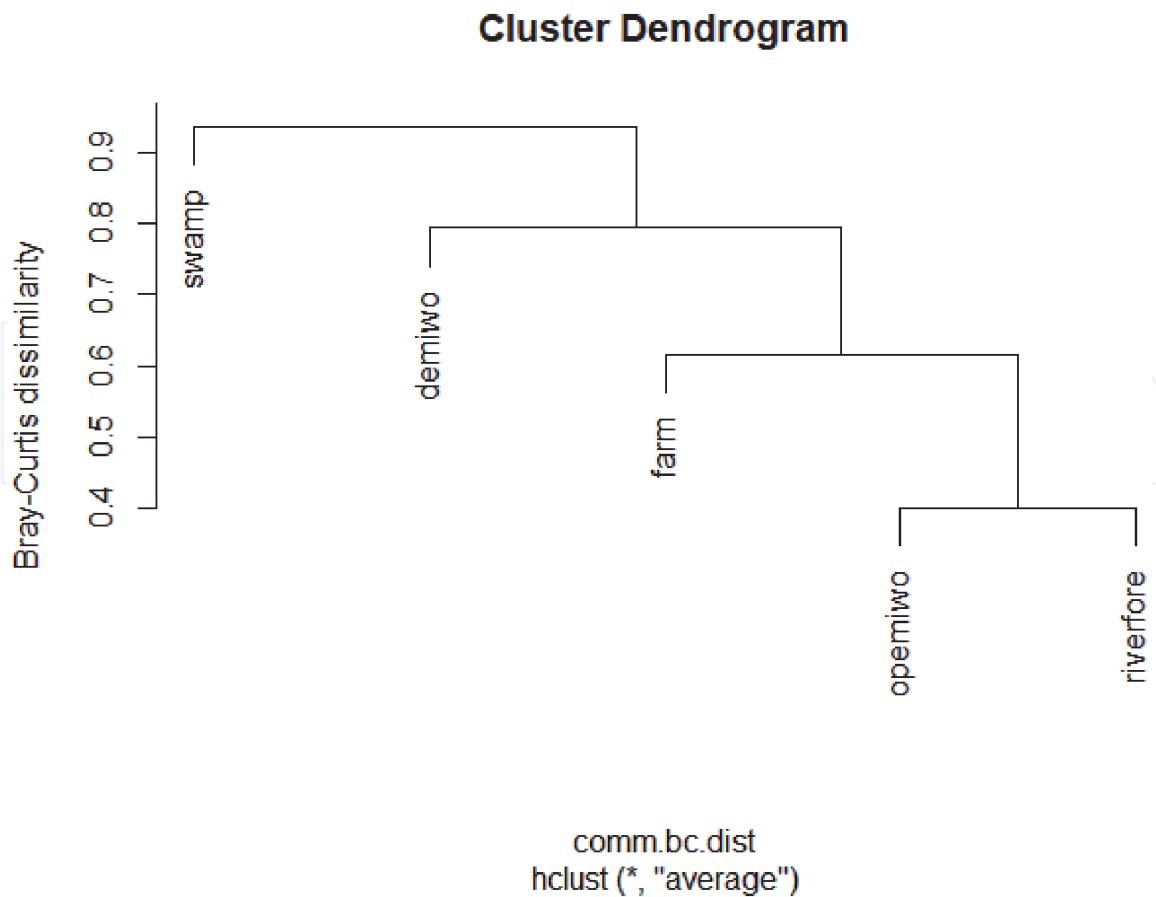


Figure 7. Cluster analysis of different habitat types based on bird species composition (presence/absence). Definition of abbreviation used (Demiwo = dense miombo woodland, riverfore = riverine forest, farmland = farmland habitat, opemiwo = open miombo woodland).

while dense woodland vs. Swamp areas had no similarity in composition (0%), Open woodland vs. Swamp area (1%) and Farmland vs. Swamp area (2%; **Table 3**). The Jaccard similarity indices among various pairs of habitat types compared (**Table 3**; **Figure 6**).

From the results, avian species adapted to open miombo woodlands and those adapted to riverine forest were very closely related and far from avian species adapted to swamps (**Figure 7**). Avian species adapted to swamps were separated from all other avian species adapted other habitats (**Figure 7**). Indeed, this entails a need for conservation of swamps to avoid local distinction of swamp adapted species.

4. Discussion and conclusion

4.1 Avian species diversity, distribution, and richness

Farmland habitats were observed in all WMAs except in Mbarang'andu where we did not encounter cultivated areas inside the core WMA. Possibly due to the presence of an anti-poaching office established inside WMA by Tanzania Wildlife Management Authority (TAWA, formerly Wildlife Division). In our study, we predicted that there would be higher avian diversity, richness, and abundance in WMAs than in human-modified areas named here as farmlands. We found strong support for this prediction for the species diversity and richness of avifauna but not for abundance. This suggested that the differing occurrence of avifauna species

across given habitats could be attributed to some reasons including food requirement as well as heat tolerance [25].

The richness and diversity imply a variety of taxa that exist in an area, many taxa should, therefore, survive in habitats that have a variety of favorable conditions and resources such as the presence of food, nesting areas, shade and water that might contribute to higher species richness and diversity. Therefore, low species diversity in the farmland might be contributed by the insufficient supply of food as well as insufficient cover for birds to hide against predators, lack of shade to hide from diurnal temperature [12, 26] low food supply compared to forests and woodlands. Suggesting that farmlands have reached maximum disturbance, as in lower farmlands heterogeneous vegetation offer foods and shelter for birds encouraging higher diversity and abundance [8]. Thus the granivores which are largely seed eaters such as the bronze mannikin, southern cordon-bleu, and red-billed quelea were dominant in farmlands than in other habitats because farmlands were rich in seed types vegetation, in line with the findings of others [12, 26]. Furthermore, for similar reasons, the abundance of the granivores species was also higher in open miombo where grassland patches are dominant than in forest areas. Birds that preferred mixed habitat of tree-covered vegetation and open areas chose forest and woodlands but are not water-bound and avoided farmlands such as red-throated twinspot, pygmy kingfisher and red-capped robin-chat, they co-existed in riverine forest and woodland, together with birds that prefer evergreen or lowland forest, dense deciduous thickets, or other dense woodlands such as black-throated wattle-eye and the African broadbill.

4.2 Species composition and similarities between different habitat types

The presence of higher species composition and similarities among habitat types suggests that miombo woodlands harbor unique avifauna species. Some avian species are observed to occur in more than one habitat type indicating that avian species are not habitat specialists. In this study, such patterns were observed; some species existed in more than 4 habitat types suggesting areas visited they provide similar resource abundance, types, and habitat heterogeneity.

Therefore, under no intervention strategies, the Ruvuma Landscape will result in a marked loss of avian richness and diversity. This suggests that measures that will reduce land clearance for agriculture need to be promptly implemented to reduce the ecological impacts on avifauna. Wildlife management areas should involve adjacent communities that are the key stakeholders of the habitats and species biodiversity conservation. Such measures can enhance the resilience of wildlife management areas and complement the goals of community-based conservation measures [27, 28]. Unfortunately, any proposed measures may be challenged by increasing human pressure due to agricultural intensification needs as well as a rapidly changing climate that may be beyond the WMA's management control. Examining the links of these threats to avian biodiversity and addressing such in an urgent manner is likely to abate current human disturbance in the WMAs of Ruvuma region.

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Conflict of interest

The authors have not declared any conflict of interests.

Appendix

No.	English name	Species name	Habitat type					Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas		
1	Bronze mannikin	<i>Spermestes cuculiata</i>	56	222	56	72	0	406	0.137
2	Southern (Blue-breasted) cordon-bleu	<i>Uraeginthus angolensis</i>	3	85	123	0	0	211	0.071
3	Red-billed quelea	<i>Quelea quelea</i>	0	15	115	0	0	130	0.044
4	Tawny-flanked prinia	<i>Prinia subflava</i>	18	27	38	34	0	117	0.039
5	Common waxbill	<i>Estrilda astrild</i>	0	9	63	20	0	92	0.031
6	Common bulbul	<i>Pycnonotus goiavier</i>	5	1	37	33	0	76	0.026
7	Ring-necked dove	<i>Streptopelia capicola</i>	0	21	51	0	0	72	0.024
8	European bee-eater	<i>Merops apiaster</i>	0	3	51	8	6	68	0.023
9	Violet-backed starling	<i>Cinnyricinclus leucogaster</i>	2	4	45	17	0	68	0.023
10	White-faced whistling-duck	<i>Dendrocygna viduata</i>	0	0	0	0	62	62	0.021
11	Helmeted guineafowl	<i>Numida meleagris</i>	0	0	59	2	0	61	0.021
12	Blue-spotted wood-dove	<i>Turtur afer</i>	5	7	26	11	0	49	0.016
13	African green-pigeon	<i>Treron calvus</i>	0	2	42	4	0	48	0.016
14	Pied crow	<i>Corvus albus</i>	0	30	10	5	0	45	0.015
15	Fork-tailed drongo	<i>Dicrurus adsimilis</i>	0	2	35	5	0	42	0.014
16	Arrow-marked babbler	<i>Turdoides jardineii</i>	0	0	12	26	0	38	0.013
17	Gray-backed (bleating) camaroptera	<i>Camaroptera brevicaudata</i>	0	0	6	32	0	38	0.013

No.	English name	Species name	Habitat type						Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas			
18	Little greenbul	<i>Eurillas virens</i>	0	0	2	36	0	38	0.013	
19	African jacana	<i>Actophilornis africanus</i>	0	0	0	2	33	35	0.012	
20	Black-crowned tchagra	<i>Tchagra senegalus</i>	0	4	26	5	0	35	0.012	
21	Lesser striped swallow	<i>Cecropis abyssinica</i>	0	13	0	21	0	34	0.011	
22	Wire-tailed swallow	<i>Hirundo smithii</i>	0	34	0	0	0	34	0.011	
23	Rufous-naped lark	<i>Mirafra africana</i>	0	0	32	0	0	32	0.011	
24	Brown-headed parrot	<i>Poicephalus cryptoxanthus</i>	2	0	25	2	0	29	0.010	
25	Lesser blue-eared starling	<i>Lamprotornis chloropterus</i>	0	0	25	3	0	28	0.009	
26	Black-backed puffback	<i>Dryoscopus cubla</i>	0	0	10	16	0	26	0.009	
27	Black-headed oriole	<i>Riolus larvatus</i>	0	1	18	6	0	25	0.008	
28	Collared sunbird	<i>Hedydipna collaris</i>	1	0	9	15	0	25	0.008	
29	Mosque swallow	<i>Cecropis senegalensis</i>	0	6	12	6	0	24	0.008	
30	Pied kingfisher	<i>Ceryle rudis</i>	0	0	0	6	18	24	0.008	
31	Mottled spinetail	<i>Telacanthura ussheri</i>	0	0	0	23	0	23	0.008	
32	Purple-crested turaco	<i>Gallirex porphyreolophus</i>	0	0	15	8	0	23	0.008	
33	Pennant-winged nightjar	<i>Caprimulgus vexillarius</i>	0	0	19	2	0	21	0.007	
34	Rattling cisticola	<i>Cisticola chiniana</i>	4	0	0	17	0	21	0.007	
35	Tropical boubou	<i>Laniarius aethiopicus</i>	0	0	7	14	0	21	0.007	
36	White-headed black chat	<i>Myrmecocichla arnotti</i>	0	0	17	4	0	21	0.007	
37	African paradise-flycatcher	<i>Terpsiphone viridis</i>	0	3	12	5	0	20	0.007	
38	Gray-headed bush-shrike	<i>Malaconotus blanchoti</i>	0	0	6	13	0	19	0.006	
39	African palm-swift	<i>Cypsiurus parvus</i>	0	19	0	0	0	19	0.006	
40	Brown-crowned tchagra	<i>Tchagra australis</i>	0	4	7	7	0	18	0.006	

No.	English name	Species name	Habitat type						Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas			
41	Flappet lark	<i>Mirafraga rufocinnamomea</i>	0	2	10	6	0	18	0.006	
42	Pale-billed hornbill	<i>Lophoceros pallidirostris</i>	0	0	2	16	0	18	0.006	
43	Red-throated twinspot	<i>Hypargos niveoguttatus</i>	0	0	0	18	0	18	0.006	
44	Gray-headed kingfisher	<i>Halcyon leucocephala</i>	0	0	15	2	0	17	0.006	
45	Jameson's finch	<i>Lagonosticta rhodopareia</i>	2	2	5	8	0	17	0.006	
46	Red-necked francolin	<i>Pternistis afer</i>	0	6	3	8	0	17	0.006	
47	Yellow bishop	<i>Euplectes capensis</i>	0	0	8	9	0	17	0.006	
48	African golden oriole	<i>Oriolus auratus</i>	0	2	14	0	0	16	0.005	
49	Black-faced waxbill	<i>Estrilda erythronotos</i>	0	15	0	0	0	15	0.005	
50	White-rumped swift	<i>Apus caffer</i>	0	3	0	12	0	15	0.005	
51	Yellow-breasted apalis	<i>Apalis flavida</i>	0	0	3	12	0	15	0.005	
52	Black-throated wattle-eye	<i>Platysteira peltata</i>	0	0	0	14	0	14	0.005	
53	African firefinch	<i>Lagonosticta rubricata</i>	0	6	4	3	0	13	0.004	
54	Green woodhoopoe	<i>Phoeniculus purpureus</i>	0	0	13	0	0	13	0.004	
55	Spotted flycatcher	<i>Muscicapa striata</i>	0	0	12	1	0	13	0.004	
56	Orange-breasted bush-shrike	<i>Chlorophoneus sulfureopectus</i>	0	0	8	5	0	13	0.004	
57	White-backed duck	<i>Thalassornis leuconotus</i>	0	0	0	0	12	12	0.004	
58	White-browed sparrow-weaver	<i>Plocepasser mahali</i>	0	0	12	0	0	12	0.004	
59	Yellow-fronted canary	<i>Crithagra mozambica</i>	0	0	12	0	0	12	0.004	
60	African darter	<i>Anhinga rufa</i>	0	0	0	0	11	11	0.004	
61	Kurrichane thrush	<i>Turdus libonyana</i>	0	0	9	2	0	11	0.004	
62	African gray hornbill	<i>Lophoceros nasutus</i>	0	2	3	5	0	10	0.003	
63	Böhm's spinetail	<i>Neafrapus boehmi</i>	0	0	0	10	0	10	0.003	

No.	English name	Species name	Habitat type						Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas			
64	Common squacco heron	<i>Ardeola ralloides</i>	0	0	0	0	10	10	0.003	
65	Coqui francolin	<i>Peliperdix coqui</i>	0	0	10	0	0	10	0.003	
66	Shelley's sunbird	<i>Cinnyris shelleyi</i>	0	0	3	7	0	10	0.003	
67	Reichenow's woodpecker	<i>Campethera scriptoricauda</i>	1	0	9	0	0	10	0.003	
68	African broadbill	<i>Smithornis capensis</i>	0	0	0	9	0	9	0.003	
69	Black crake	<i>Zapornia flavirostra</i>	0	0	0	2	7	9	0.003	
70	Green-capped eremomela	<i>Eremomela scotops</i>	0	0	6	3	0	9	0.003	
71	Striped kingfisher	<i>Halcyon chelicuti</i>	0	0	7	2	0	9	0.003	
72	Little bee-eater	<i>Merops pusillus</i>	0	0	6	2	0	8	0.003	
73	Little swift	<i>Apus affinis</i>	0	8	0	0	0	8	0.003	
74	Pied wagtail	<i>Motacilla aguimp</i>	0	8	0	0	0	8	0.003	
75	Senegal lapwing	<i>Vanellus lugubris</i>	0	0	8	0	0	8	0.003	
76	Amethyst sunbird	<i>Chalcomitra amethystina</i>	0	0	0	7	0	7	0.002	
77	Greater honeyguide	<i>Indicator indicator</i>	0	0	7	0	0	7	0.002	
78	Racket-tailed roller	<i>Coracias spatulatus</i>	0	1	6	0	0	7	0.002	
79	Red-faced cisticola	<i>Cisticola erythrops</i>	0	0	0	4	3	7	0.002	
80	Rufous-bellied tit	<i>Melaniparus rufiventris</i>	0	0	5	2	0	7	0.002	
81	Broad-billed roller	<i>Eurystomus glaucurus</i>	0	0	5	1	0	6	0.002	
82	Brown-hooded kingfisher	<i>Halcyon albiventris</i>	0	0	6	0	0	6	0.002	
83	Dark chanting-goshawk	<i>Melierax metabates</i>	0	1	4	1	0	6	0.002	
84	Eastern bearded scrub-robin	<i>Tychaedon quadrivirgata</i>	0	0	2	4	0	6	0.002	
85	Great white egret	<i>Ardea alba</i>	0	0	0	0	6	6	0.002	
86	Southern ground-hornbill	<i>Bucorvus leadbeateri</i>	0	0	6	0	0	6	0.002	
87	Livingstone's turaco	<i>Tauraco livingstonii</i>	0	0	6	0	0	6	0.002	

No.	English name	Species name	Habitat type						Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas			
88	Red-cheeked cordon-bleu	<i>Uraeginthus bengalus</i>	0	0	0	6	0	6	0.002	
89	Southern gray-headed sparrow	<i>Passer diffusus</i>	0	0	6	0	0	6	0.002	
90	Swallow-tailed bee-eater	<i>Merops hirundineus</i>	0	0	6	0	0	6	0.002	
91	Trumpeter hornbill	<i>Bycanistes bucinator</i>	0	0	0	6	0	6	0.002	
92	White-crested helmetshrike	<i>Prionops plumatus</i>	0	0	6	0	0	6	0.002	
93	Willow warbler	<i>Phylloscopus trochilus</i>	0	0	6	0	0	6	0.002	
94	Common hoopoe	<i>Upupa epops</i>	0	0	0	5	0	5	0.002	
95	Black cuckoo	<i>Cuculus clamosus</i>	0	0	0	5	0	5	0.002	
96	Black kite	<i>Milvus migrans</i>	0	2	3	0	0	5	0.002	
97	Common sandpiper	<i>Actitis hypoleucos</i>	0	0	0	3	2	5	0.002	
98	Golden-tailed woodpecker	<i>Campethera abingoni</i>	0	0	4	1	0	5	0.002	
99	Little sparrowhawk	<i>Accipiter minullus</i>	0	0	4	1	0	5	0.002	
100	Pale (East coast) batis	<i>Batis soror</i>	0	0	2	3	0	5	0.002	
101	Pygmy kingfisher	<i>Ispidina picta</i>	0	0	0	3	2	5	0.002	
102	Red-chested cuckoo	<i>Cuculus solitarius</i>	0	0	0	5	0	5	0.002	
103	Miombo wren warbler	<i>Calamonastes stierlingi</i>	0	0	5	0	0	5	0.002	
104	Wattled lapwing	<i>Vanellus senegallus</i>	0	0	0	3	2	5	0.002	
105	White-bellied sunbird	<i>Cinnyris talatala</i>	0	0	3	2	0	5	0.002	
106	White-breasted cuckoo-shrike	<i>Cebilepyris pectoralis</i>	0	0	5	0	0	5	0.002	
107	Yellow-bellied greenbul	<i>Chlorocichla flaviventris</i>	0	0	2	3	0	5	0.002	
108	Cardinal woodpecker	<i>Dendropicops fuscescens</i>	1	0	3	0	0	4	0.001	
109	African pipit	<i>Anthus richardi</i>	0	0	3	0	2	5	0.002	
110	Hamerkop	<i>Scopus umbretta</i>	0	0	0	4	0	4	0.001	
111	Lilac-breasted roller	<i>Coracias caudatus</i>	0	0	2	2	0	4	0.001	
112	Pearl-spotted owlet	<i>Glaucidium perlatum</i>	0	0	4	0	0	4	0.001	

No.	English name	Species name	Habitat type						Grand Total	Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas			
113	Red-capped robin-chat	<i>Cossypha natalensis</i>	0	0	0	4	0	4	0.001	
114	White-browed coucal	<i>Centropus superciliosus</i>	0	0	2	2	0	4	0.001	
115	White-browed robin-chat	<i>Cossypha heuglini</i>	0	0	0	4	0	4	0.001	
116	Black cuckoo-shrike	<i>Campephaga flava</i>	0	0	1	2	0	3	0.001	
117	Böhm's bee-eater	<i>Merops boehmi</i>	0	0	0	3	0	3	0.001	
118	Brubru	<i>Nilaus afer</i>	0	0	3	0	0	3	0.001	
119	Cabanis's bunting	<i>Emberiza cabanisi</i>	0	2	1	0	0	3	0.001	
120	Crested barbet	<i>Trachyphonus vaillantii</i>	0	0	1	2	0	3	0.001	
121	Crowned hornbill	<i>Lophoceros alboterminatus</i>	0	3	0	0	0	3	0.001	
122	European swift	<i>Apus apus</i>	0	0	0	3	0	3	0.001	
123	African fish eagle	<i>Haliaeetus vocifer</i>	0	0	0	1	2	3	0.001	
124	Hadada ibis	<i>Bostrychia hagedash</i>	0	0	0	0	3	3	0.001	
125	Harlequin quail	<i>Coturnix delegorguei</i>	0	0	0	3	0	3	0.001	
126	Namaqua dove	<i>Oena capensis</i>	3	0	0	0	0	3	0.001	
127	Speckle-throated woodpecker	<i>Campethera scriptoricauda</i>	0	0	3	0	0	3	0.001	
128	Parasitic weaver	<i>Anomalospiza imberbis</i>	0	0	3	0	0	3	0.001	
129	Red-fronted tinkerbird	<i>Pogoniulus pusillus</i>	0	0	0	3	0	3	0.001	
130	Red-headed weaver	<i>Anaplectes rubriceps</i>	0	0	3	0	0	3	0.001	
131	Speckled mousebird	<i>Colius striatus</i>	0	0	0	3	0	3	0.001	
132	Stripe-breasted seedeater	<i>Crithagra striatipectus</i>	0	0	3	0	0	3	0.001	
133	White-browed scrub-robin	<i>Cercotrichas leucophrys</i>	0	0	1	2	0	3	0.001	
134	Wood sandpiper	<i>Tringa glareola</i>	0	0	0	0	3	3	0.001	
135	Black-headed heron	<i>Ardea melanocephala</i>	0	1	0	1	0	2	0.001	

No.	English name	Species name	Habitat type						Ratio
			Dense miombo woodland	Farmland	Open miombo woodland	Riverine forest	Swamp areas	Grand Total	
136	Black-winged stilt	<i>Himantopus himantopus</i>	0	0	0	2	0	2	0.001
137	Brimstone canary	<i>Crithagra sulphurata</i>	0	0	2	0	0	2	0.001
138	Egyptian goose	<i>Alopochen aegyptiaca</i>	0	0	0	0	2	2	0.001
139	Fiscal shrike	<i>Lanius collaris</i>	0	2	0	0	0	2	0.001
140	Golden-breasted bunting	<i>Emberiza flaviventris</i>	2	0	0	0	0	2	0.001
141	Retz's helmet shrike	<i>Prionops retzii</i>	0	0	0	2	0	2	0.001
142	Scarlet-chested sunbird	<i>Chalcomitra senegalensis</i>	0	0	0	2	0	2	0.001
143	Tambourine dove	<i>Turtur tympanistria</i>	0	0	0	2	0	2	0.001
144	African barred owlet	<i>Glaucidium capense</i>	0	0	1	0	0	1	0.000
145	Piping cisticola	<i>Cisticola fulvicapilla</i>	0	0	3	0	0	3	0.001
146	Red-eyed dove	<i>Streptopelia semitorquata</i>	0	0	0	3	0	3	0.001
147	Beautiful sunbird	<i>Cinnyris pulchellus</i>	0	1	0	0	0	1	0.000
148	Black coucal	<i>Centropus grillii</i>	0	0	0	1	0	1	0.000
149	Brown snake-eagle	<i>Circaetus cinereus</i>	0	0	0	1	0	1	0.000
150	European nightjar	<i>Caprimulgus europaeus</i>	0	0	1	0	0	1	0.000
151	Gray heron	<i>Ardea cinerea</i>	0	0	0	0	1	1	0.000
152	Olive sunbird	<i>Cyanomitra olivacea</i>	0	0	0	1	0	1	0.000
153	Saddlebill	<i>Ephippiorhynchus senegalensis</i>	0	0	0	0	1	1	0.000
154	Spectacled weaver	<i>Ploceus ocularis</i>	0	0	1	0	0	1	0.000
155	Spotted creeper	<i>Salpornis salvadori</i>	0	0	0	1	0	1	0.000
156	Woodland kingfisher	<i>Halcyon senegalensis</i>	0	0	0	1	0	1	0.000
Grand Total			105	580	1338	759	188	2970	

Table A1.
 List of avifauna species observed in different habitats of WMAs in Ruvuma.

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