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Research Article

Diversity, Relative Abundance and Distribution of Avian Fauna in and Around Wondo Genet Forest, South-central Ethiopia

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Abstract

Background: Birds are important as bio-indicators and in ecosystem functioning such as pollination, seed dispersal and insect pest controls. However, birds are threatened by threats such as habitat loss, fragmentation and degradation all over their range. Furthermore, bird species composition and their distribution is poorly understood in forest fragments like the present study area.

Objective: The objective of the study was to assess the species composition, relative abundance and distribution of avifauna in and around Wondo Genet forest areas, South-central Ethiopia as a proxy to contribute in filling up the bird species check list of Ethiopia.

Materials and Methods: A stratified random sampling design across the four dominant habitat types; natural forest, wooded grassland, grassland and agro-forestry land was used. A point transect count aided by binocular was employed to investigate avian species diversity and distribution. Biodiversity indexes were used to calculate the bird species diversity and one way-ANOVA was used to test for significant variation in species richness and abundance per plot among habitats. **Results:** A total of 137 species in to 47 families and 14 orders were identified. Accipitridae (12 species) was the most abundant family followed by Columbidae and Muscicapidae, each 9 species. Species richness and abundance varied between the four habitats. There was significant difference in average species richness ($F_{3,127} = 4.85, p = 0.003$) and individuals ($F_{3,127} = 10.38, p = 0.000$) per plot between the grass land and natural forest habitat types. The highest Shannon-Weiner diversity index ($H' = 3.78$) was recorded from the wooded grassland habitat while the lowest was from the agro-forestry land ($H' = 2.84$). From the 14 order identified, Passeriformes were the dominant in all of the four habitat types, while Columbiformes, Coraciiformes and Cuculiformes were dominant in the natural forest habitat. **Conclusion:** It can be concluded that the area has good potential for bird watching tourism that can integrate economic gain with biodiversity conservation. Hence, urgent conservation measures and further detail research is recommended.

Key words: Abundance, distribution, diversity, species similarity, avian species

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ethiopia is a vast ecologically diverse country blessed with extensive and unique environmental conditions¹. The elevation variations that is as low as 110 m a.s.l., at the Danakil of Afar depression and as high as 4500 m at the summit of Ras Dajen has given rise to the wide variations in climatic conditions². This in turn has led to the formation of diverse ecosystem from moist rain forest to desert ecosystems contributing to the formation of diverse plants and animals assemblages³.

Ethiopia has 857 species of birds, of which 20 are endemic, 31 are globally threatened ones⁴ and 13 species restricted to the geographical region of Ethiopian and Eritrean highlands and thus, shared only by Ethiopia and Eritrea⁵. Birds are important bio indicators of climate change and water quality and also potential tourist attractions⁶. Particularly, birds have been shown to be effective bio indicators for monitoring habitat change in Abijata-Shala lakes National Park, Ethiopia. For instance, the abundance of the birds as bio indicator species showed strong and significant positive correlations with both tree abundance and cover in each vegetation type in Abijata-Shala lakes National Park, Ethiopia⁷.

Despite the rich diversity of birds in Ethiopia, habitat destruction, fragmentation and loss have been observed for decades and severely impacted the survival of bird species⁶. Forest loss and forest fragmentation have been widely recognized for their significant impacts on avian biodiversity⁸. For example, a study carried out in Bale mountains National Park, Ethiopia revealed that birds diversity and abundance significantly differed between habitat types, the abundance of bird species was positively correlated with shrub and grass height⁹. Furthermore, environmental changes due to forest loss and fragmentation are highly likely to affect bird dispersal ability and resource use as well as the role of birds in ecosystem functioning such as pollination, seed dispersal and insect pest controls^{8,10}.

However, the ornithology of Ethiopia is still in its infancy, because of its limited observers and clearly not for lack of birds. Only few researchers have conducted studies on the diversity and ecology of avian species in some parts of Ethiopia¹¹⁻¹⁴. Birds diversity and distribution and their role to ecosystem functioning have been over looked by avian studies especially in developing countries like Ethiopia. As a result, the bird's check list of Ethiopia is still far from complete.

The present study area, Wondo Genet forest is a patch of remnant Afro-Montane forest serving as wildlife refuge in

South central Ethiopia^{15,16}. It is one of the 73 Important Bird Areas (IBAs) site of Ethiopia¹⁷. The study area has been indicated to harbour different species of birds. It had been a home for 111 species of birds, of which 7 were endemic, some share habitat between Ethiopia and Eritria¹⁸. Out of the 111 species of birds that had been identified 3 were inter-African migrants and 6 were Northern wintering migrants¹⁸. However, the relative abundance and distribution of the avian species among different habitat types in the study area have never been investigated, the study¹⁸ only provided incomplete checklist of birds only assessing few habitat types¹⁸. As a result, the present study is aimed at providing up to date information about diversity and distribution of birds and their habitat association among all habitat types that exist in Wondo Genet patch of forest.

MATERIALS AND METHODS

Study area: The study area is situated in the Southern part of Ethiopia at about 260 km South of the capital city, Addis Ababa and located between 38° 36'30" and 38° 39'0" E longitude and 7° 5'30" and 7° 7'30" N latitude (Fig. 1). The study was carried out in a remnant forest patches and mosaics of wooded grasslands, agro-forestry land and built up areas covering a total of 958 ha that is owned by Wondo Genet College of Forestry and Natural Resources (WGCFNR), Hawassa University. The lower elevation areas were mostly covered by agro-forestry land, the college infrastructure and plantation forests and grasslands, while the uplands were covered by the natural forests and wooded grassland.

For this study, the area was stratified into four habitat types based on altitudinal ranges and vegetation types (Fig. 1). Natural forest represents valley areas and middle altitude areas between 1800 and 2200 m a.s.l., with dominant tree species of *Celtis africana*, *Albizia guminefera*, *Croton macrostachyus* and *Millettia ferruginea*¹⁶. The natural forest was relatively intact and undisturbed compared other habitat types, was covered with tall giant dominant tree species mentioned above and some other fruiting species like *Ficus vasta* and *Ficus sur* in the lower altitudes¹⁶. The wooded grassland habitat covers the upland areas with rugged topography (2200-2670 m a.s.l.) and dominated by grassland intermixed with scattered stands of trees predominantly *Protea gaguedi*, *Myrsine africana*, *Dodonaea viscosa*, *D. angustifolia* and scattered *Erica arborea* at the summit of mount Abaro¹⁶. Anthropogenic fire occasionally occurs in the upper altitude of the wooded grassland habitat often impacting the vegetation

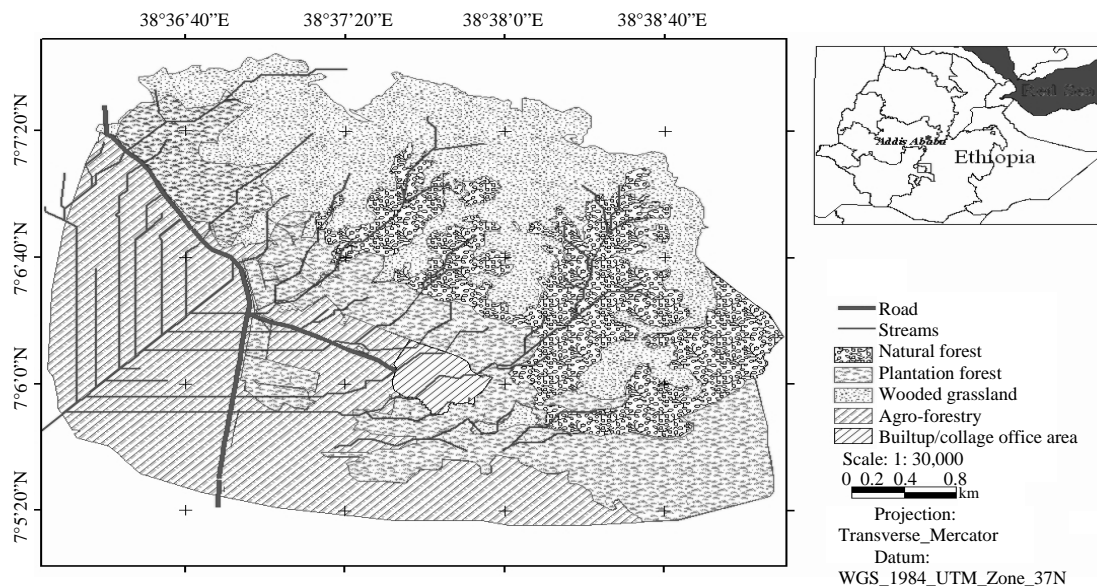


Fig. 1: Location map of the study area, Source: NASA Landsat Program, 2003, Landsat ETM+ scene L71168055_05520051203.ETMGLS2005, SLC-Off, USGS, Sioux Falls, 03/12/2005)

dynamics and survival of the wildlife species^{15,16}. The grassland habitat consisted of undifferentiated grassland with scattered tree species of *Podocarpus falcatus*, *Acacia* spp. and *Eucalyptus* spp., occurs from 1760-1780 m a.s.l. The grassland habitat was disturbed habitat with livestock grazing and human encroachments. The grassland habitat was managed by the college through prescribed burning and grass cutting in an attempt to grow fresh grass for the college's dairy livestock grazing, burning occurred during the study period. The agro-forestry land consisted of coffee plantation and cultivated land covered by such as sugarcane plantation and vegetables that occupies the lower altitudes areas (1747-1775 m a.s.l.) of the study area.

The study area falls under humid montane climate having a bimodal rainfall during the long rainy season from June-October and the shorter rainy season occurring from March-April. The total amount of annual rainfall varies between 700-1400 mm with an average¹⁷ of 1,200 mm. The mean monthly temperature¹⁶ is 19.5°C.

Data collection and analysis: A stratified random sampling design across the four dominant habitat types found in the study area; natural forest, wooded grassland, grassland and agro-forestry land was used following the methods of^{11-15,19,20}. Location points were randomly generated in a Geographic Information System (GIS) using Arc GIS software²¹ v10.1. From field observations and site descriptions found in the

literature^{15,16}, the approximate area of each habitat type in the study area was estimated to determine the proportion of sample plots needed to represent each of the four habitat types. A total of 16 point transects representing each habitat types were systematically established to estimate the diversity and abundance of birds of Wondo Genet forest patch. Six point transects were established in the natural forest, six in the wooded grassland, two in the grassland and two in the agro-forestry habitat. Navigation to each plot location was made using a Garmin eTrex Legend Global Positioning System (GPS). The radius of each point transect was 30 m wide. Each point transect was 100 m far away from road side to avoid edge effect and was at least 300 m far away from each other to avoid double counting of the same individual of a species following Aynalem and Bekele¹¹.

Data collection was carried out from December, 2011 to July, 2012. Bird identifications and counting of individuals were conducted by direct observations aided with binoculars (7x400). Observations were made by standing in the middle of the point transect and observing 360° round quietly and gently up to a distance of 30 m radius. Observation at each point transect lasted for 15 min and field guides of Perlo²² and Redman *et al.*²³ were used for identification of the birds. In each observation bird species were identified and number of individuals observed within the 30 m radius were recorded. Survey of the birds was carried out in the morning from 07:00-10:00 am. Each point transect was visited eight times in the course of the study period.

Table 1: Bird species richness and diversity indexes per habitat types

Diversity measures	Habitat types				Total
	Natural forest	Wooded grassland	Grassland	Agro-forestry land	
Abundance per habitat	342	614	414	312	1682
Mean abundance per plot	7.13±0.66 ^c	12.79±1.57 ^{bc}	25.87±4.99 ^a	19.50±5.53 ^{ab}	
Species richness per habitat	39	94	51	45	137
Mean species richness per plot	3.56±0.26 ^b	4.64±0.35 ^{ab}	5.63±0.75 ^a	4.79±0.58 ^{ab}	
Shannon-Weiner (H')	2.63	3.78	3.04	2.84	
Evenness (J')	0.72	0.83	0.77	0.74	

Means that do not share the same small letter for habitats are significantly different ($p \leq 0.05$)

Both bird species richness and abundance data were summarized per plot and per habitat type. The relative abundance of the bird species was determined by using expression:

$$\text{Relative abundance (\%)} = \frac{n}{N} \times 100$$

where, n is the numbers of individuals of particular recorded species and N is the total number of individuals of recorded species. One-way ANOVA was used to test for significant variation in species richness and abundance per plot between habitats and group information was obtained from Tukey test. Shannon-Weaver diversity index (H') and evenness were used to compute the species richness and diversity of birds in each habitat types. Shannon-Wiener diversity index:

$$H' = \sum P_i (\ln P_i)$$

where, P is proportion of individual species. Shannon-Wiener evenness index:

$$J' = H'/H'_{\max}$$

where, $H'_{\max} = \ln(S)$, H' is the Shannon-Wiener diversity index, H'_{\max} is the maximum possible diversity, S is the number of species in a particular habitat. The Sorenson's similarity index was used to compare the species richness among habitat types. Sorenson's similarity coefficient²⁴:

$$\text{SOR} = 2a/(2a+b+c)$$

where, a is number of species common to both habitat, b is number of species unique to habitat 1 and c is number of species unique to habitat 2. All computations were done using MINITAB 17 software²⁵.

RESULTS

Species composition and relative abundance: A total of 1682 individuals of birds from 14 orders, 47 families and 137 species were recorded (Table 1) (Appendix 1). Accipitridae (12 species) was the most abundant family followed by Columbidae and

Muscicapidae, each 9 species. Anatidae, Ardeidae, Trogonidae and Zosteropidae are among the rarest families represented by single species each. The grassland habitat had the highest number of average species richness (5.63 ± 0.75 , N = 16) and individuals (25.87 ± 4.99 , N = 16) per plot, while the natural forest had least average species richness (3.56 ± 0.26 , N = 40) and individuals per plot (7.13 ± 0.66 , N = 40) (Table 1). There was significant difference in average species richness ($F_{3,127} = 4.85$, $p = 0.003$) and individuals ($F_{3,127} = 10.38$, $p = 0.000$) per plot between the grass land and natural forest habitat types.

In terms of relative abundances, Abyssinian dark headed oriole (*Oriolus monacha*) (8.56%) had the highest relative abundance (19.17%) followed by helmeted guinea fowl (*Numida meleagris*) (7.02%) and black saw wing swallow *Psalidoprocne pristopectera* (6.54%) (Table 2) (Appendix 1). Green backed eremomela (*Eremomela canescens abyssinica*), Klaas's cuckoo (*Chrysococcyx klaas*), Isabline wheatear (*Oenanthe isabellina*), Siberian stone chat (*Saxicola maurus*) and Pallied harrier hawk (*Circus macrourus*) had the least relative abundance of 0.06% each (Appendix 1).

Species diversity: The highest Shannon-Weiner diversity index ($H' = 3.78$) and evenness index ($J' = 0.83$) were recorded from the wooded grassland habitat while the lowest diversity index ($H' = 2.63$) and evenness index ($J' = 0.72$) were from the natural forest (Table 1). The highest Sørensen species similarity index was recorded between the wooded grassland and agro-forestry land habitat types (0.345) and the lowest was recorded between natural forest and grassland habitat types (0.240) (Table 3).

Bird species dominance: Based on the relative abundance computation, Abyssinian dark headed oriole (*Oriolus monacha*) was the dominant one (8.56%) when all habitat types considered together (Table 2). When each habitat type was considered separately, in decreasing order Abyssinian dark headed oriole (*Oriolus monacha*) (28.07%), helmeted guinea fowl (*Numida meleagris*) (18.94%), black saw wing swallow *Psalidoprocne pristopectera* (12.21%) and black and

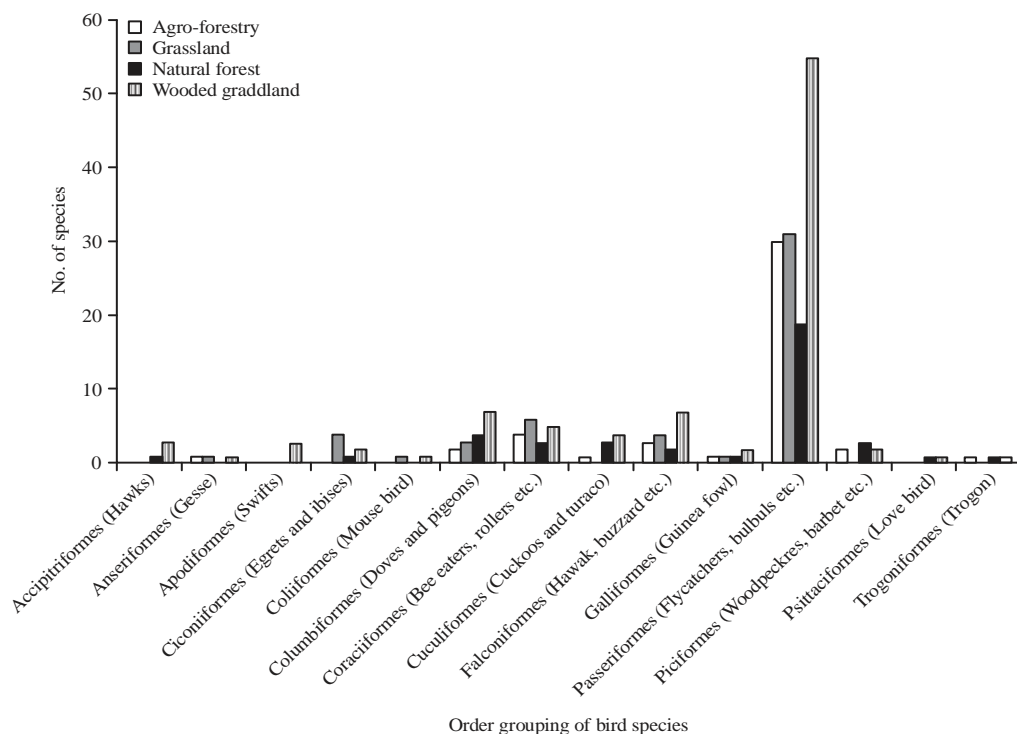


Fig. 2: Birds orders abundance and distributions among four habitat types (Agro-forestry, grassland, natural forest and wooded grassland) in and around Wondo Genet forest

Table 2: Top five ranking dominant species among four habitat types and across the study area based on relative abundance

Common name	Habitat types									
	Natural forest		Wooded grassland		Grassland		Agro-forestry land		Across the study area	
	RA	R	RA	R	RA	R	RA	R	RA	R
Abyssinian dark headed oriole	28.07	1	2.93	8	1.93	10	7.05	4	8.56	1
Helmeted guinea fowl	0.00	-	0.00	-	15.94	1	16.02	2	7.01	2
Black saw wing swallow	0.29	15	12.21	1	8.21	4	0.00	-	6.54	3
Black and white manikin	0.00	-	2.61	10	0.00	-	22.43	1	5.11	4
Barn swallow	0.00	-	2.61	10	13.04	2	0.00	-	4.16	5
Common bulbul	1.17	11	5.86	3	0.97	16	1.28	9	3.80	6
Yellow fronted parrot	15.20	2	1.46	13	0.24	17	0.00	-	3.69	7
Wattled ibis	0.29	15	1.94	12	10.63	3	0.00	-	3.39	8
Silvery cheeked hornbill	5.26	5	1.46	13	4.35	7	0.64	11	2.79	9
Rock martin	0.00	-	7.00	2	0.00	-	0.00	-	2.56	10
Grey backed <i>Cameroptera</i>	11.40	3	0.16	20	0.00	-	0.00	-	2.38	11
Common fiscal	0.00	-	0.32	19	7.97	5	0.64	11	2.20	12
African citril	0.00	-	0.65	17	0.00	-	9.61	3	2.02	13
Abyssinian wax bill	0.00	-	5.04	4	0.00	-	0.00	-	1.84	14
White backed vulture	0.29	15	4.72	5	0.00	-	0.32	12	1.84	14
Augur buzzard	0.00	-	0.16	20	1.2	13	7.05	4	1.66	16
White cheeked turaco	5.84	4	0.32	19	0.00	-	0.00	-	1.31	18

RA: Percent relative abundance and R: Rank

white manikin (*Manacus manacus*) (22.43%) dominated in the natural forest, grassland, wooded grassland agro-forestry land, respectively (Table 2).

Distribution: Among the 14 orders surveyed, Passeriformes (flycatchers, bulbuls, oxpeckers, chats, warblers etc.),

Columbiformes (doves and pigeons), Falconiformes (hawks, buzzard, falcon, vultures, eagle and kit) and Coraciiformes (bee eaters, horn bills and roller and king fisher) were relatively well distributed across the four habitat types than the rest (Fig. 2). Passeriformes relatively had highest distribution and abundance across the four habitat types

Table 3: Sorensen bird species similarity index among four habitat types (Agro-forestry, Grassland, Natural forest and wooded grassland) in and around Wondo Genet forest

Habitat types	Habitat types			
	Agro-forestry land	Grassland	Natural forest	Wooded grassland
Agro-forestry land				
Grassland	0.288			
Natural forest	0.259	0.240		
Wooded grassland	0.345	0.318	0.265	

when compared to Columbiformes, Falconiformes and Cuculiformes that had greater distribution and abundance only in the wooded grassland habitat types (Fig. 2). However, Coraciiformes and Columbiformes had greater distribution in the grassland habitat types next to Passeriformes. Columbiformes, Coraciiformes and Cuculiformes were more abundant in the natural forest habitat types next to Passeriformes. Columbiformes, Coraciiformes and Falconiformes were more abundant in the agro-forestry habitat types (Fig. 2).

DISCUSSION

Relatively high species diversity of avian fauna in the area could be attributed to the various habitat types (vegetation types) that constitute the area and these could provide them different array of foraging opportunities and nesting sites. It can also be attributed to relatively better protection of the habitat types due the presence of the college (WGCFNR) unlike the degraded surrounding environment. About 35 years ago¹⁸, recorded 111 species from Wondo Genet forest but sampling had not been carried out in all the habitat types used for this study. Similarly, a comparable number of species (118 avian species belonging to 41 families and 13 orders) were recorded from broad lived montane forest of South Western Ethiopia¹³. Furthermore¹¹, recorded 101 species in to 44 families in the montane forest of Zegie peninsula and nearby islands of lake Tana which is comparable to the present study area diversity. Even though, the bird assemblage of the area is poorly known to science and not fully protected, it has to be recalled that the area is one of the 73 national IBA sites¹⁷, hence the higher bird species diversity and richness is expected.

The significance difference in average species richness and abundance between the grassland and natural forest could be as a result of difference in vegetation types that could have created a difference in food sources and nesting opportunities. The natural forest is dominated by few tree species that don't have attractive fruits for frugivores bird species, the seeds could also be unattractive to gramivores species¹⁶ and the abundance of insects could also be

relatively fewer than grassland. As a result, only forest bird species could inhabit the natural forest. On the other hand, the grassland habitat could provide relatively diverse array of food sources for different species of birds to feed on. Since the grassland habitat is the nearest to the built up areas (the college infrastructure) where there are fruiting trees, grains, relatively abundant insects could have attracted many species. Studies elsewhere have indicated that the bird diversity is higher in near human settlement areas due to the accessibility of heterogeneous habitats for forage and nesting^{26,27}. For instance, a study carried out in similar broad leaved montane forest of South Western Ethiopia revealed that bird species abundance was higher in heterogeneous human settlement areas than the homogenous relatively intact natural forest¹³.

The highest relative abundance of the near endemic Abyssinian dark headed oriole (*Oriolus monacha*) was probably due to the availability of the forest patch that provides its unique nesting and foraging requirements. The patch of natural forest is the only remnant afro-montane forest still relatively intact in the region that serves as a wildlife refuge¹⁶. It has been reported that Abyssinian dark headed oriole inhabits highland forest between 900 and 2000 m a.s.l., where it optimally attains its favorite berries, fruits and caterpillars²⁸. Since, *Oriolus monacha* is a forest specialist species, it could be confined to the natural forest habitat types unlike money other species recorded from the area that tend to concentrate in heterogeneous human modified habitat ignoring the homogenous natural forest. Similar observation has been made in a study carried out in Tanzania, where by forest specialists were only confined to the homogenous forest ignoring the heterogeneous human modified habitat types²⁹. The relatively higher abundance of helmeted guinea fowl (*Numida meleagris*) in the overall study area and highest abundance in the grassland habitat could be due to its feeding habit, habitat preference and behavior. The grassland could provide wide array of forage such as grains, seeds, insects and reptiles that the species is evolutionary adapted to feed on. It is also generally known that the species prefer open, dry grassland and savannah with scattered trees or shrubby cover and avoid thick forest, marshes and bare

land³⁰. The helmeted guinea fowl display relatively social, gregarious behavior occurring in flocks during foraging, this could increase the bird citation as compared to many other solitary bird species in the study area³⁰. A study carried out in South Africa revealed helmeted guinea fowl must live in group so as to survive in the wild, especially where habitat disturbance is a common phenomenon and the number of predators is high³¹. Furthermore, it could be due to relatively protected area of the grassland habitats types that could provide refuge from all the threats as compared to heavily populated grassland converted to agricultural land in the surrounding environment of the study area. Similarly Buechley *et al.*³² found out that granivores birds abundance is higher in coffee farms habitat than intact natural forest in South Western Ethiopia, suggesting that modified habitats provides extra niches for species colonization. The rare occurrence of pleurctic migrants such as Isabline wheatear (*Oenanthe isabellina*), showing up only during few months of the year could be due to its migrant behavior that only winters in the tropics for few months from January to early April. The wetlands (Abijata-Shala National Park) adjacent to the present study areas are known as a bird sanctuary for inter-African and Palearctic migrants³³. As a result, those migrants, especially non obligate wetland specialists, could rarely visit the study area as potential wintering habitat.

The variation in species diversity and species evenness at various habitats may be due to the difference in availability of food and nesting sites⁹. Species richness of different feeding guilds might respond differently to changes in vegetation structure and complexity across tropical ecosystems³⁴. The highest diversity in the wooded grassland habitat could be due to the heterogeneity in vegetation types (grass, shrubs and trees)³⁵ and its nature of bordering crop lands. The heterogeneous vegetation provides various nesting, foraging opportunities for different types of bird species^{35,36} and could boost the birds' species diversity. As the number of vegetation layer increases, the number of available niches for avian also increases and so does the diversity of avian species¹³. The nature of wooded grassland surrounded by farm land could also boost the species diversity and abundance acting as nesting and roosting refuge for the cropland rooming birds. Various studies on birds have indicated that bird species abundance and richness are factors of better foraging opportunities and nesting sites^{7-10,12,13,37}. For example, studies carried out in bale mountains National Park⁹ and Abijata-Shalla lakes National Park³⁸ in Ethiopia have indicated that birds abundance and richness is higher in less distributed areas where the

vegetation cover is relatively better than severely degraded areas like over grazed habitats by livestock and deforested habitats³⁹.

The highest species similarity index between wooded grassland and agro-forestry land could be due to the adjacent occurrence of the two habitat types and similarity in vegetation types. Since they occur in similar locality and have similar vegetation types could be inhabited by similar bird species often interchanging between the habitat types. Furthermore, due to the nature of similarity in vegetation types the two habitat types could present equivalent foraging opportunities and nesting sites. Studies have indicated that vegetation cover has been reported to have a strong influence on avifauna diversity⁴⁰⁻⁴².

The variation in species dominance among the habitat types could also be attributed to the food and nesting site preferences, the type of the bird species and the level of threats variations in the habitat types. Studies have indicated that the distribution patterns of bird species normally follow the spatial structure of the environment and habitat requirement of the bird species^{34,35,40}. As the vegetation changes along environmental gradients so does the bird species richness and abundance⁴¹. Studies carried out in Tanzania³⁰ and Northern Bale mountains⁹ have shown that bird species habitat preference is a factor of vegetation structure and composition and disturbance. For instance, the study carried out in coastal forests of Tanzania has shown that the forest specialist birds are restricted to forests, while forest generalist switch between forest habitat and other habitats while forest visitors only rarely visits the forest, indicating that habitat preferences of the bird species governed by vegetation structure and composition²⁹.

The dominance of highland biomes like Abyssinian dark headed oriole (*Oriolus monacha*), yellow fronted parrot, grey backed camaroptera and white-cheeked turaco in the natural forest could be due to presence of berries, fruits, caterpillars and nesting requirements that the highland forest biome bird species are adapted to feed^{32,33,43}. Bird species habitat preference is a function preferred food availability, suitable cover and the extent of disturbance in a particular habitat type. Even though, the natural forest is less preferred by most bird species due its natural of homogeneity that provide only small array of food types, those species are forest specialists that are mostly confined to the forested habitat types. This could be due to the fact that the forest habitat gives sufficient cover and food requirements for those forest specialists. A study carried out in the coastal forests of Tanzania has indicated that the forested areas are strictly occupied by forest specialists, while it was avoided by many other species²⁹.

CONCLUSION

The study area despite small in size appears to support an extremely rich and diverse bird community. The area is important bird refuge for the surrounding locality avian fauna where they get better protection and foraging and nesting opportunities. It can be concluded that the area has good potential for bird watching tourism that can integrate economic gain with biodiversity conservation. Even though the present study area is relatively well protected due to the presence the college (WGCFNR), still some activities of the collage and the surrounding communities should be controlled to ensure the conservation of birds. For example, the forest and grassland management techniques being carried out by the college should take account the conservation of the bird species. The college should bring out clearly the issue of bird conservation in the forest, grassland and agro-forestry land management plan. The recurrent anthropogenic fire in the wooded grassland set by

illegal surrounding livestock herders that tend to reduce the foraging and nesting opportunities of the bird species should also be banned.

SIGNIFICANCE STATEMENTS

The present study has found 137 birds species that inhabit the forest fragment that have been poorly documented before. In addition, the study has found out which bird species is associated to which habitat types that has never been investigated or published before. In this regard, the study has contributed its own part in filling the gap in documentation of the avian fauna of Ethiopia which is far below from complete.

ACKNOWLEDGMENT

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Appendix 1: Check list of bird species in and around Wondo Genet forest

Order	Family	Scientific name	Common name	RA	Rank
Passeriformes	Oriolidae	<i>Oriolus monacha</i>	Abyssinian dark-headed oriole	8.56	1
Galliformes	Numididae	<i>Numida meleagris</i>	Helmeted guinea fowl	7.02	2
Passeriformes	Hirundinidae	<i>Psalidoprocne pristoptera</i>	Black-saw wing swallow	6.54	3
Passeriformes	Pipridae	<i>Manacus manacus</i>	Black and white manikin	5.11	4
Passeriformes	Hirundinidae	<i>Hirundo rustica</i>	Barn swallow	4.16	5
Passeriformes	'Pycnonotidae	<i>Pycnonotus barbatus</i>	Common bulbul	3.80	6
Passeriformes	'Psittacidae	<i>Poicephalus flavifrons</i>	Yellow-fronted parrot	3.69	7
Ciconiiformes	Threskiornithidae	<i>Bostrychia carunculata</i>	Wattled ibis	3.39	8
Coraciiformes	Bucerotidae	<i>Bycanistes brevis</i>	Silvery-cheeked horn bill	2.79	9
Passeriformes	Hirundinidae	<i>Hirundo fuligula</i>	Rock martin	2.56	10
Passeriformes	Cisticolidae	<i>Camaroptera brevicaudata</i>	Grey-backed camaroptera	2.38	11
Passeriformes	Laniidae	<i>Lanius collaris</i>	Common fiscal	2.20	12
Passeriformes	Fringillidae	<i>Serinus citrinelloides</i>	African citril	2.02	13
Passeriformes	Estrildidae	<i>Estrilda ochrogaster</i>	Abyssinian wax bill	1.84	14
Falconiformes	Accipitridae	<i>Gyps africanus</i>	White-backed vulture	1.84	14
Galliformes	Phasianidae	<i>Pternistis squamatus</i>	Scaly francolin	1.72	15
Falconiformes	Accipitridae	<i>Buteo augur</i>	Augur buzzard	1.66	16
Apodiformes	Apodidae	<i>Tachymarptis melba</i>	Alpine swift	1.61	17
Passeriformes	Nectariniidae	<i>Chalcomitra senegalensis</i>	Scarlet-chested sunbird	1.61	17
Cuculiformes	Musophagidae	<i>Tauraco leucotis</i>	White-cheeked turaco	1.31	18
Passeriformes	Monarchidae	<i>Terpsiphone viridis</i>	African-paradise flycatcher	1.25	19
Passeriformes	Corvidae	<i>Corvus crassirostris</i>	Thick-billed raven	1.19	20
Passeriformes	Timaliidae	<i>Turdoides leucopygius</i>	White-rumped babbler	1.19	20
Passeriformes	Zosteropidae	<i>Zosterops poliogastrus</i>	Montane white eye	1.13	21
Columbiformes	Columbidae	<i>Streptopelia lialugens</i>	Dusky-turtle dove	1.07	22
Ciconiiformes	Threskiornithidae	<i>Bostrychia hagedash</i>	Hadada ibis	1.07	22
Columbiformes	Columbidae	<i>Columba arquatrix</i>	African-olive pigeon	1.01	23
Coraciiformes	'Meropidae	<i>Merops lafresnayii</i>	Blue-breasted bee-eater	1.01	23
Columbiformes	Columbidae	<i>Streptopelia semitorquata</i>	Red-eyed dove	0.89	24
Passeriformes	Fringillidae	<i>Crithagra mozambicus</i>	Yellow-fronted canary	0.89	24
Psittaciformes	Psittaculidae	<i>Agapornis taranta</i>	Black-winged love bird	0.77	25
Passeriformes	'Malaconotidae	<i>Dryoscopus gambensis</i>	Northern puffback	0.77	25
Passeriformes	'Ploceidae	<i>Anaplectes rubriceps</i>	Red-headed waver bird	0.77	25
Passeriformes	'Sturnidae	<i>Onychognathus morio</i>	Red-winged starling	0.77	25

Appendix 1: Continue

Order	Family	Scientific name	Common name	RA	Rank
Trogoniformes	Trogonidae	<i>Apaloderma narina</i>	Narnia's trogon	0.71	26
Coraciiformes	Bucerotidae	<i>Tockus hemprichii</i>	Hemprich's hornbill	0.59	27
Passeriformes	Sylviidae	<i>Phylloscopus trochilus</i>	Willow warbler	0.59	27
Anseriformes	Anatidae	<i>Alopochen aegyptiaca</i>	Egyptian goose	0.54	28
Falconiformes	Accipitridae	<i>Gyps rueppellii</i>	Rupell's vulture	0.54	28
Coliiformes	Collidae	<i>Colius striatus</i>	Speckled mouse bird	0.54	28
Coraciiformes	Coraciidae	<i>Coracias abyssinicus</i>	Abyssinian roller	0.48	29
Passeriformes	Muscicapidae	<i>Oenanthe cypriaca</i>	Cyprus wheatear	0.48	29
Piciformes	Picidae	<i>Mesopicos goertae</i>	Grey-headed woodpecker	0.48	29
Passeriformes	Nectariniidae	<i>Anthreptes collaris</i>	Collard-sun bird	0.42	30
Passeriformes	'Sturnidae	<i>Lamprotornis chalybaeus</i>	Greater-blue eared starling	0.42	30
Passeriformes	Ploceidae	<i>Amblyospiza albifrons melanota</i>	Gross-beak weaver	0.42	30
Cuculiformes	Cuculidae	<i>Cuculus solitarius</i>	Red-chested cuckoo	0.42	30
Passeriformes	Nectariniidae	<i>Cinnyris venustus</i>	Variable sunbird	0.42	30
Falconiformes	Accipitridae	<i>Polyboroides typus</i>	African-harrier hawk	0.36	31
Passeriformes	'Pycnonotidae	<i>Laniarius aethiopicus</i>	Ethiopian bulbul	0.36	31
Passeriformes	Motacillidae	<i>Anthus cinnamomeus</i>	Grassland pipit	0.36	31
Passeriformes	Sylviidae	<i>Sylvia curruca</i>	Lesser-white throat	0.36	31
Coraciiformes	Meropidae	<i>Merops pusillus</i>	Little bee eater	0.36	31
Passeriformes	Turdidae	<i>Turdus olivaceus</i>	Olive thrush	0.36	31
Passeriformes	Buphagidae	<i>Buphagus erythrorhynchus</i>	Red-billed oxpecker	0.36	31
Columbiformes	Columbidae	<i>Turtur tympanistris</i>	Tambourine dove	0.36	31
Passeriformes	Muscicapidae	<i>Saxicola rubetra</i>	Whin-chat	0.36	31
Passeriformes	Motacillidae	<i>Motacilla flava</i>	Yellow wagtail (flava)	0.36	31
Passeriformes	Monarchidae	<i>Muscicapa caeruleascens</i>	Ashy fly catcher	0.30	32
Passeriformes	Hirundinidae	<i>Hirundo abyssinica</i>	Lesser-striped swallow	0.30	32
Passeriformes	Passeridae	<i>Passer griseus</i>	Northern grey headed sparrow	0.30	32
Piciformes	Lybiidae	<i>Pogoniulus schrysoconus</i>	Yellow-fronted thinker bird	0.30	32
Passeriformes	Turdidae	<i>Turdus pelios</i>	African thrush	0.24	33
Passeriformes	Platyστεiridae	<i>Batis minor</i>	Black-head batis	0.24	33
Passeriformes	Phasianidae	<i>Coturnix coturnix</i>	Common quail	0.24	33
Passeriformes	Laniidae	<i>Lanius collaris</i>	Grey-backed fiscal	0.24	33
Apodiformes	Apodidae	<i>Apus niansae</i>	Nyanza swift	0.24	33
Ciconiiformes	Threskiornithidae	<i>Threskiornis aethiopicus</i>	Sacred Ibis	0.24	33
Passeriformes	Monarchidae	<i>Melaenornis chocolatina</i>	Abyssinian-slaty flycatcher	0.18	34
Apodiformes	Apodidae	<i>Cynsiurus parvus</i>	African-palm swift	0.18	34
Passeriformes	Nectariniidae	<i>Cinnyris pulchella</i>	Beautiful sunbird	0.18	34
Passeriformes	Sylviidae	<i>Sylvia atricapilla</i>	Black cap	0.18	34
Ciconiiformes	Ardeidae	<i>Bubulcus ibis</i>	Cattle egret	0.18	34
Passeriformes	Corvidae	<i>Corvus rhipidurus</i>	Fan-tailed raven	0.18	34
Falconiformes	Accipitridae	<i>Necrosyrtes monachus</i>	Hooded vulture	0.18	34
Coraciiformes	Meropidae	<i>Merops nubicus</i>	Northern-carmine bee eater	0.18	34
Passeriformes	Fringillidae	<i>Crithagra donaldsoni</i>	Northern-grosbeak canary	0.18	34
Passeriformes	Campephagidae	<i>Campephaga flava</i>	Red-shouldered cuckoo shrike	0.18	34
Passeriformes	Buphagidae	<i>Buphagus erythrorhynchus</i>	Red-billed oxpecker	0.18	34
Columbiformes	Columbidae	<i>Streptopelia capicola</i>	Ring-necked dove	0.18	34
Passeriformes	Cisticolidae	<i>Cisticola brachypterus</i>	Shuffling cisticola	0.18	34
Columbiformes	Columbidae	<i>Columba guinea</i>	Speckled pigeon	0.18	34
Passeriformes	Fringillidae	<i>Serinus leucopygius</i>	White-rumped seedeater	0.18	34
Coraciiformes	Alcedinidae	<i>Halcyon senegalensis</i>	Wood land king fisher	0.18	34
Passeriformes	Buphagidae	<i>Buphagus africanus</i>	Yellow-billed oxpecker	0.18	34
Passeriformes	Fringillidae	<i>Lagonosticta rubricata</i>	African fire finch	0.12	35
Passeriformes	Malaconotidae	<i>Dryoscopus cubla</i>	Black-backed puffback	0.12	35
Cuculiformes	Cuculidae	<i>Centropus monachus</i>	Blue-headed coucal	0.12	35
Passeriformes	Pipridae	<i>Lonchura cucullata</i>	Bronze manikin	0.12	35
Passeriformes	Fringillidae	<i>Crithagra tristriatus</i>	Brown-rumped seed eater	0.12	35
Passeriformes	'Sturnidae	<i>Lamprotornis chloropterus</i>	Lesser-blue eared starling	0.12	35
Cuculiformes	Cuculidae	<i>Clamator levaillantii</i>	Levaillant's cuckoo	0.12	35
Coraciiformes	Coraciidae	<i>Coracias caudatus</i>	Lilac-breasted roller	0.12	35
Piciformes	Picidae	<i>Campethera nubica</i>	Nubian woodpecker	0.12	35
Passeriformes	Muscicapidae	<i>Oenanthe pleschanka</i>	Pied wheatear	0.12	35

Appendix 1: Continue

Order	Family	Scientific name	Common name	RA	Rank
Passeriformes	Motacillidae	<i>Anthus leucophrys</i>	Plain-backed pipit	0.12	35
Passeriformes	Nectariniidae	<i>Anthreptes platurus</i>	Pygmy sunbird	0.12	35
Passeriformes	Ploceidae	<i>Quelea quelea</i>	Red-billed quelea	0.12	35
Piciformes	Lybiidae	<i>Pogoniulus pusillus</i>	Red-fronted thinker bird	0.12	35
Passeriformes	Hirundinidae	<i>Cecropis daurica</i>	Red-rumped swallow	0.12	35
Falconiformes	Accipitridae	<i>Aquila rapax</i>	Tawny eagle	0.12	35
Passeriformes	Cisticolidae	<i>Prinia subflava</i>	Tawny-flanked prinia	0.12	35
Passeriformes	Muscicapidae	<i>Thamnolaea semirufa</i>	White-winged cliff-chat	0.12	35
Piciformes	Picidae	<i>Dendropicos abyssinicus</i>	Abyssinian woodpecker	0.06	36
Passeriformes	Turdidae	<i>Zoothera piaggiae</i>	Abyssinian-ground thrush	0.06	36
Passeriformes	Monarchidae	<i>Muscicapa adusta</i>	African-dusky flycatcher	0.06	36
Passeriformes	Monarchidae	<i>Muscicapa adusta</i>	African-dusky flycatcher	0.06	36
Falconiformes	Accipitridae	<i>Accipiter tachiro</i>	African goshawk	0.06	36
Passeriformes	Nectariniidae	<i>Chalcomitra amethystina</i>	Amethyst sunbird	0.06	36
Columbiformes	Columbidae	<i>Turtur abyssinicus</i>	Black-billed wood dove	0.06	36
Passeriformes	Muscicapidae	<i>Phoenicurus ochrurus</i>	Black red start	0.06	36
Passeriformes	Sturnidae	<i>Aplonis grandis</i>	Brown-winged starling	0.06	36
Passeriformes	Muscicapidae	<i>Phoenicurus phoenicurus</i>	Common red start	0.06	36
Passeriformes	Turdidae	<i>Monticola saxatilis</i>	Common rock thrush	0.06	36
Piciformes	Lybiidae	<i>Lybius bidentatus</i>	Double-throat barbet	0.06	36
Passeriformes	Cisticolidae	<i>Cisticola lugubris</i>	Ethiopian cisticola	0.06	36
Passeriformes	Cisticolidae	<i>Eremomela canescens abyssinica</i>	Green-backed eremomela	0.06	36
Passeriformes	Campephagidae	<i>Coracina caesia</i>	Grey cuckoo shrike	0.06	36
Passeriformes	Muscicapidae	<i>Oenanthe isabellina</i>	Isabline wheatear	0.06	36
Cuculiformes	Cuculidae	<i>Chrysococcyx klaas</i>	Klaas's cuckoo	0.06	36
Columbiformes	Columbidae	<i>Aplopelia larvata</i>	Lemon dove	0.06	36
Accipitriformes	Accipitridae	<i>Accipiter minullus</i>	Little-sparrow hawk	0.06	36
Passeriformes	Motacillidae	<i>Motacilla clara</i>	Mountain wag tail	0.06	36
Passeriformes	Muscicapidae	<i>Oenanthe oenanthe</i>	Northern wheatear	0.06	36
Accipitriformes	Accipitridae	<i>Accipiter ovampensis</i>	Ovambo-sparrow hawk	0.06	36
Accipitriformes	Accipitridae	<i>Circus macrourus</i>	Pallied-Harrier hawk	0.06	36
Falconiformes	Falconidae	<i>Falco peregrinus</i>	Peregrine falcon	0.06	36
Passeriformes	Pittidae	<i>Pitta erythrogaster</i>	Red-billed pytilia	0.06	36
Passeriformes	Estrildidae	<i>Uraeginthus bengalus</i>	Red-checked cordon bleu	0.06	36
Passeriformes	Cisticolidae	<i>Cisticola erythrops</i>	Red-faced cisticola	0.06	36
Accipitriformes	Accipitridae	<i>Accipiter rufiventris</i>	Rufous-breasted sparrow hawk	0.06	36
Passeriformes	Muscicapidae	<i>Cossypha semirufa</i>	Rüppell's robin-chat	0.06	36
Passeriformes	Muscicapidae	<i>Saxicola maurus</i>	Siberian stone-chat	0.06	36
Columbiformes	Columbidae	<i>Turtur tympanistris</i>	Tambourine dove	0.06	36
Passeriformes	Hirundinidae	<i>Hirundo smithii</i>	Wire-tail swallow	0.06	36
Falconiformes	Accipitridae	<i>Milvus parasiticus</i>	Yellow-billed kit	0.06	36
Passeriformes	Estrildidae	<i>Coccyzygia quartinia</i>	Yellow-billed wax bill	0.06	36

RA: Percent relative abundance

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