

*Full Length Research Paper*

# A comparison of terrestrial bird community structure in the undisturbed and disturbed areas of the Abijata Shalla lakes national park, Ethiopia

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**A study to determine the terrestrial bird community structures in the undisturbed and disturbed areas of the Abijata Sahlla Lakes National Park was conducted during the wet and dry seasons. A representative area of 57% was randomly sampled in each of the undisturbed and disturbed habitats. A transect line of 1 or less km at a distance of 50 to 100 m on one side of the line was used to count birds. Counting was carried out in the morning and afternoon on the same line transect. Data were analyzed using Estimate S, Shannon-Wiener, Past, SPSS and Excel software. The disturbed habitat had the higher species richness but lower species diversity of birds during both seasons. However, bird species richness and diversity was high in the undisturbed habitat during the wet season. Lower species richness with higher species evenness was recorded in the disturbed habitat during this season. During the dry season, higher species richness was recorded in the disturbed habitat. The relative abundance of bird species in the two habitats at different seasons showed significant difference ( $\chi^2_{84} = 168.384, P < 0.01$ ). Blue-napped mouse bird (*Urocolius macrourus*) and village weaver (*Ploceus cucullatus*) had the highest relative abundance in the undisturbed habitats during the dry season. During the wet season, the highest relative abundance was recorded for superb-starling (*Lamprotornis superbus*). These bird species had strong guild and seasonal relationship in the area. Insectivore birds were the most abundant guild in both of the habitats. The Park's terrestrial habitat sustains various species of birds, but loss of habitat is affecting their occurrences. Urgent conservation measures could reduce habitat loss.**

**Key words:** Bird species, community structure, terrestrial habitat.

## INTRODUCTION

An increase in complexity of vegetation structure, floristic composition and heterogeneity can increase niche diversity of birds and vice versa (Leito et al., 2006). Both natural and human induced disturbances such as floods, drought, deforestation change in land use, natural resources and seasonal climatic changes affect vegetation and bird community structures (Maurer, 1981;

Wiens, 1989; Rahayuninagsih et al., 2007). The change in vegetation community structure alters the availability of nest, cover and food for birds. Furthermore, change in vegetation community structure could affect the quantity and quality of food, water and cover which in turn alters the diversity, abundance and distribution of birds (Western and Grimsdell, 1979). However, at present the vegetation community structure is increasingly disrupted mainly due to high human population growth and their impacts. Therefore, understanding the effect of habitat disturbance on bird community structure is important to

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prioritize future conservation of the species and other biodiversity that are under great pressure either due to natural or human induced disturbances. The diversity of the Ethiopian fauna is high owing to diverse climate, vegetation and terrain. Studies by Shimelis and Dellelegn (2004) indicated the occurrence of 860 species of birds in Ethiopia which makes the country the richest in the mainland Africa. Of the 860 species, 16 are endemic to Ethiopia (EWNHS, 1996). Some of the bird species in Ethiopia are globally threatened and biome restricted assemblages and need conservation. Most of these Ethiopian fauna occur within its protected areas (PAs). Some of these PAs are within the Ethiopian rift valley (ERV) areas. One of the PAs, the Abijata Shalla Lakes National Park (ASLNP) is important as it supports both aquatic and terrestrial biodiversity with its diverse avian fauna (Sissay, 2003). However, the past 30 years of high human population growth in Ethiopia has forced the people to settle within and around most of its PAs including the ASLNP (Jacobs and Schroederr, 2001). As a result, the previously intact natural resources of this Park have been highly disturbed (Jacobs and Schroederr, 2001).

It is because of intensive grazing and trampling by large number of cattle, the habitat of ASLNP has been degraded to the extent that shallow topsoil is exposed to wind erosion. Before humans had settled within and around the Park, the terrestrial ecosystem of ASLNP was covered by *Acacia tortilis* dominated woodland habitats. However, current studies have shown land-use and land cover changes over the past decades (Abdi, 1993; Senbeta and Tefera, 2002; Mengesaha et al., 2009). The ASLNP with its mosaic ecosystems of various types of natural resources of subsistence and commercial significance has attracted multiple stakeholders. These stakeholders have various use interest over the natural resources of the Park where some are interested in charcoal production, others in sand and salt extractions, and still others in timber for construction and fire wood collection (Mengesha et al., 2009). These have degraded the original woodland habitats of the Park. Mengesha et al. (2009) have shown 12% loss of woodland vegetation cover, 14% increase in shrubland and 2% in open area from 1973 to 2000. These have altered the original vegetation composition, the community structure of birds and tourism potential of the Park. Consequently, some of the bird species are at the verge of extirpation and others are threatened. Therefore, it is predicted that disturbances might have altered the species richness and diversity of birds in the ASLNP. This was indicated by Maurer et al. (1981) and Koròan (2004) in other habitats. The undisturbed habitat of the ASLNP was fenced, close to the head quarters of the Park and less disturbed by man, with relatively intact vegetation. Therefore, we hypothesized that the bird community structures in the disturbed and undisturbed, fenced head quarter area,

habitats were different in the ASLNP. The temporal and spatial patterns of bird abundance within an ecosystem in terms of both numbers of individuals and species indicate the highly seasonal nature of food resources (Tilahun et al., 2001; Mengesha and Bekele, 2008). This was determined by the flush of vegetation and subsequently of insect herbivores. Moreover, harsh environmental conditions have substantial effect on separable group of bird community (Thomson et al., 2003).

Many bird species migrate to either a long or short distances to take advantage of global difference of seasonal climate change and optimize the availability of food sources and breeding habitats. The seasonal variation in the amount of rainfall and temperature and spatial and temporal microhabitat conditions are known to affect the availability of various food items for birds. Based on species sensitivity to the type of habitat, these could alter the diversity, abundance and distribution of birds in an area. Therefore, we predicted that bird species community structure in the ASLNP would show variation at different seasons in the undisturbed and disturbed habitats. Change in structural and compositional diversity of native vegetation would alter composition of bird community (Fleishman et al., 1990; Leito et al., 2006; Acevedo and Aide, 2008). This could be the case in the disturbed habitat that was prone to loss of its native vegetation. Trophic structure reflects the importance of various food resources and variation in trophic structure may reflect variation in availability of food resources among communities (Blake, 1983). The separation of guilds and individual species in time, space and diet contribute to the maintenance of relatively diverse avian fauna (Abrams and Griffiths, 1981). Seasonal migration and prey availability that vegetation structure in part plays a role has determined bird community functional structure. Furthermore, bird relative abundance and density could also be affected by habitat changes. We, therefore, predict that the feeding guild and relative abundance of birds in the disturbed habitat varies from the undisturbed habitat in the ASLNP. Species monitoring for conservation planning is aided by understanding the species' sensitivity to habitat change or loss (Becker and Ágreda, 2005). With a baseline understanding that species avoid disturbed areas and prefer less disturbed areas, we can better predict the future composition of bird communities in the Park, evaluate the success of rehabilitation efforts and possibly thwart further extinctions via habitat preservation. Past studies focused on water birds of the Park. But, there are no systematic studies conducted to reveal the effect of human activities or disturbances on the terrestrial bird community structure in the ASLNP. This study aims to investigate the terrestrial bird community structure of ASLNP by comparing the relatively intact fenced headquarter area with the unfenced one where human impact is high at different seasons.

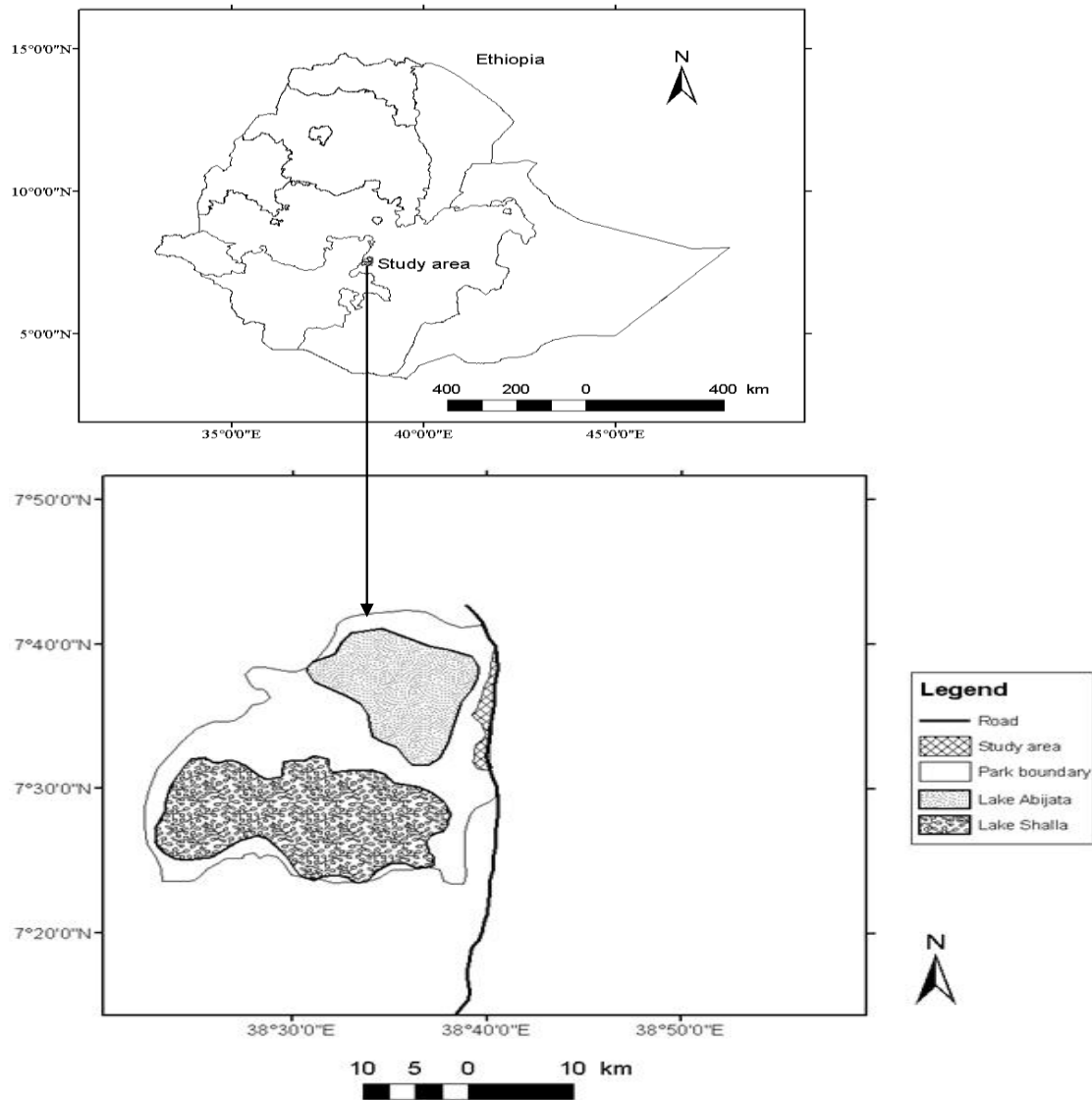


Figure 1. Map showing the location of the study area.

## MATERIALS AND METHODS

### Study area description

ASLNP is located at the centre of the Ethiopian rift valley, 207 km south of Addis Ababa between latitudes of 7°30' to 7°40'N and 38°35' to 38°45'E (Figure 1). It covers an area of 887 km<sup>2</sup> at an elevation ranging between 1,540 and 2,075 m asl. The National Park encompasses three lakes: Abijata, Shalla and Chitu, and varying shoreline and woodland vegetation surrounding the lakes. The woodland vegetation covers 382 km<sup>2</sup> (43%) of *Acacia* woodland. The two big lakes, Abijata and Shalla cover an area of about 506 km<sup>2</sup> (57%) including Chitu Lake with an area of over 500 m<sup>2</sup> with four nesting islands and spots of hot-springs (Tefrea and Almaw, 2002). The present study site occurs in the north of the Park where 1 km<sup>2</sup> is fenced to farm ostrich within the Park boundary and the surrounding unfenced areas of gentle slope originally

dominated by *A. tortilis* (Figure 1). The climate of the Park lies within the eco-climatic zone III "Upper kola" with a moisture between 45 and 52 that is periodically drought (Gemechu, 1977; Tefrea and Almaw, 2002). The average rainfall within the Park is 500 mm per annum. The main rain season is between late January and early April but there are considerable variations from year to year. The temperature of the Park is normally in the ranges of 16 to 24°C. However, it can range up to 45°C during the warm months (May to June) (Tefrea and Almaw, 2002). The ASLNP is significant and serves as wintering, breeding and transit for large number of terrestrial and aquatic birds. The Park possesses high bird species diversity, endemic and abundant wetland birds and large concentration of birds in Lake Abijata (Urban, 1969, 1980). It consisted of 200,000 water birds including globally threatened species (Sissay, 2003). A total of 436 bird species was recorded from the Park (Tefrea and Almaw, 2002). Of these, 144 bird species were wetland and 292 were terrestrial species. The ASLNP was

established to conserve the spectacular number of birds that uses the lakes and associated terrestrial habitats. It was intended to maximize the tourism potential of the area for the spectacular birds and scenery of both lakes fringed with the terrestrial vegetation that characterize the beauty of the area. The Park also harbours human settlement as well. As a result, an extensive area of the Park was disturbed for expansion of agricultural land and livestock grazing. Data collection was carried out during the dry season and part of the short rainy season (March to April), and during the wet season (July to August). Representative sampling unit of 0.57 km<sup>2</sup> which accounts to 57% in each of the undisturbed (fenced) and disturbed area was sampled. The sample area was selected following the regular/sytematic sampling strategy described in Sutherland et al. (2004). A systematic random sampling within 1 km<sup>2</sup> based on different vegetation types was carried out in the undisturbed and disturbed habitats. Along the 1997, 1995, 1993 km main road from Shashemene to Addis Ababa in the disturbed habitat, a sampling unit of 1 km<sup>2</sup> to the northeast corner of the Park was randomly selected. In order to reduce the biasness that arise due to closeness of the two habitats and migration, this sampling unit was selected at 8 km far away from the undisturbed one. A randomly selected 5 transect lines, from east to west; in each of the two habitats was used to determine the species richness, diversity, abundance and guild for these bird species. The length of the transect line was, 400, 500, 600, 650, 700 m long in each of the disturbed and undisturbed habitats depending on the boundary of the study area. The sighting distance was 50 to 100 m along the sampling units on one side of the transect line but varied based on the types of habitat and bird species (Grimsdell, 1978; Norton-Griffith, 1978; Pomeroy, 1992; Bibby and Burgess, 1992; Sutherland, 1996; Bibby et al., 1998; Mengesha and Bekele, 2008). Feeding habits of the observed bird species were recorded and food consumed was identified whenever possible (Stuart and Stuart, 2000). Data collection was carried out early in the morning from 6: 00 to 10:00 h and late in the afternoon from 4:00 to 6:30 h replicating the same transect. Photographs were taken to count too many birds that were not easily identified in the field. For identification of birds, our own experiences and field guides such as Williams and Arlott (1980), Perlo (1995), Sinclair and Ryan (2003) and Stevenson and Fanshawe (2009) were used. The experiences of Park experts were also used in the identification of birds. Observed species was identified and recorded on data sheet prepared for this purpose. Data on the vegetation structure of similar habitat were collected and analyzed (Regassa, 2005). Five transects were laid by Regassa (2005) to assess and describe the vegetation community composition in the same study area along an environmental gradient. Along each transect, quadrats of size 1 x 1 m, 5 x 5 m and 10 x 10 m were laid to asses herbaceous, shrubby and woody vegetation, respectively. Plant specimens were collected in triplicate and identified with the aid of flora volumes for Ethiopia and Eritrea. The oldest plant life form classification system recognized five life forms based on the position of the overwintering buds relative to the ground level. In most subsequent classifications, the life form classes are defined based on multiple criteria. The life-form of the mature plant is classified according to the system of Raunkiaer (1934) as modified by Govaerts et al. (2000). For the purpose of this study, the plant species life forms in both disturbed and undisturbed habitats were divided into four general life forms.

## DATA ANALYSIS

For plant classification, TWINSPLAN (two ways indicator) species analysis was used by Regassa (2005) for classification of vegetation community was adopted for this study. For the analysis

of the correspondence of habitat, guild and seasonal relationship Past was used (Ryan et al., 1995). Data on species richness between samples and diversity were computed using Estimate S 8.20 (Cowell, 2006). The analysis was computed in a randomization with replacement of the species, sample and abundance triplets. The overall bird species diversity and evenness was analyzed using Shannon - Wiener index of diversity (Krebs, 1999). SPSS 15 software package and Excel descriptive statistical package were used to analyze the relative abundance, feeding guilds and density of birds at different seasons.

## RESULTS

### Plant communities

From the six plant communities identified in east of Lake Abijata, two plant community types (Community I and II) occurred in this study area. Community type I, *A. tortilis* - *Dicrostachys cinariaea* which was mainly the characteristics of the undisturbed habitat, and Community type II, *D. cinariaea*, *Cynodon dactylo don*, a mixed woody species and herbaceous plants covered the disturbed habitat. In the latter, *A. tortilis* and *D. cinariaea* dominated the tree shrub and shrub - herbaceous layers (Table 1). When the mean cover abundance of vegetation communities was computed with the mean abundances of birds, it negatively correlated with correlation coefficient of -0.2880 in the undisturbed habitat, but positively correlated with the disturbed habitat. The undisturbed habitat of the Park consisted of plant species of different life forms that is woody, shrub, herbaceous and grass species (Table 2 and Figure 6). *A. tortilis*, *Tagets minuta*, *Asparagus* spp. and *Hetropogon contortus* were the dominant plant species of the different plant forms of this habitat (Table 2) while in the disturbed habitat *Acacia senegal*, *Rus natalensis*, *Comelina longifolia* and *Cenchrus ciliaris* were the dominant life forms (Table 2 and Figure 7). The various plant life forms were observed to provide fruits, flowers and seeds for bird species and their prey species.

### Bird communities

A total of 101 bird species was recorded during the dry and wet seasons in the undisturbed and disturbed habitats of ASLNP (Table 3). During the dry season, 80 bird species were recorded of which 44 were recorded in the undisturbed and 62 in the disturbed habitats (Table 3). Conversely, during the wet season, 69 bird species were recorded. Of these, 48 species of birds were recorded in the undisturbed habitat and 47 in the disturbed habitat (Table 3). When the two habitats were compared using the computed mean of Chao 2 and Jackknife 2, bird species richness was high in the disturbed habitat but bird species diversity was high in the undisturbed habitat of the ASLNP (Table 4).

**Table 1.** Synoptic table of the ASNP vegetation with diagnostic species having high mean cover abundance value and fidelity. Dominant species in each community are in bold (Regassa, 2005).

Species	Community types					
	I	II	III	IV	V	VI
<i>Acacia tortilis</i>	<b>5.11</b>	3.00	0.14	0.68	0.00	0.00
<i>Dichrostachys cinerea</i>	<b>2.67</b>	<b>4.25</b>	0.16	0.00	0.00	0.00
<i>Cynodon dactylon</i>	0.00	<b>3.25</b>	<b>3.92</b>	3.12	3.10	4.27
<i>Harpachne schimperi</i>	0.44	1.50	<b>2.00</b>	<b>3.42</b>	0.00	0.00
<i>Eragrostis tenuifolia</i>	0.00	0.50	1.76	<b>2.95</b>	3.00	1.60
<i>Sporobolus spicatus</i>	0.00	0.00	0.32	0.00	<b>5.00</b>	3.07
<i>Cyperus laevigatus</i>	0.00	0.00	0.00	0.00	0.00	<b>5.67</b>
<i>Acacia albida</i>	2.56	1.38	0.16	1.11	0.00	0.00
<i>Acacia oerfota</i>	2.56	2.88	0.32	0.00	2.10	0.00
<i>Hibiscus micranthus</i>	2.11	1.50	0.43	0.21	0.00	0.00
<i>Indigofera volkensii</i>	1.67	0.00	0.30	0.00	0.90	0.00
<i>Tagetes minuta</i>	1.56	2.50	0.35	1.11	0.60	0.00
<i>Medicago polymorpha</i>	1.44	1.25	0.22	0.16	0.00	0.00
<i>Bidens pilosa</i>	1.33	2.63	0.57	0.63	0.00	0.00
<i>Digitaria abyssinica</i>	0.33	1.88	1.03	1.37	3.20	0.33
<i>Commelina longifolia</i>	0.33	0.00	0.05	1.37	0.20	0.00
<i>Indigofera spicata</i>	0.22	1.00	0.30	0.32	1.90	0.00
<i>Digitaria ternate</i>	0.00	0.88	0.57	0.16	2.10	0.00
<i>Cenchrus ciliaris</i>	0.00	0.00	0.24	0.53	1.90	0.13
<i>Setaria pumila</i>	0.00	0.00	0.46	0.53	2.30	0.00
<i>Chloris gayana</i>	0.00	1.13	0.59	0.16	3.30	0.20
<i>Sporobolus festivus</i>	0.00	0.00	1.24	1.37	3.10	0.20
<i>Aristida adoensis</i>	0.00	0.25	1.38	0.53	0.20	0.00
<i>Indigofera spinosa</i>	0.00	0.00	0.92	0.79	0.20	0.00
<i>Sida schimperiana</i>	0.00	0.00	0.49	0.74	0.40	0.00
<i>Cynodon aethiopicus</i>	0.00	0.00	0.97	0.63	0.00	2.53
<i>Eragrostia papposa</i>	0.00	0.63	0.59	0.00	0.70	1.13

**Table 2.** Comparison of life form of some major plant species recorded in the undisturbed and disturbed habitats of the ASLNP.

Plant forms	Species	Habitat	
		Disturbed Mean cover abundance	Undisturbed Mean cover abundance
Woody	<i>Acacia tortilis</i>	5.11	5.55
	<i>Acacia senegal</i>	5.00	12.00
	<i>Acacia alba</i>	2.56	0.00
	<i>Acacia seyal</i>	4.4	4.22
	<i>Dicrostachus cinerea</i>	2.67	2:00
	<i>Acacia aerofota</i>	2.56	0.50
	<i>Balanities aegyptica</i>	2.68	4.45
	<i>Croton dichogamus</i>	0.44	2.00

Table 2. Contd.

	<i>Hibiscus micunthus</i>	2.11	2.00
	<i>Indigofera volkensii</i>	1.67	1.30
	<i>Tagetes minuta</i>	1.56	1.55
	<i>Medicago polymor</i>	1.44	2.00
Shrub	<i>Bedns pilosa</i>	1.33	2.34
	<i>Asparagus spp.</i>	1.50	1.00
	<i>Hypestes forshaolii</i>	1.32	2.10
	<i>Rus natalensis</i>	1.22	5.20
	<i>Boscia salicifolia</i>	1.24	1.30
	<i>Maerua trifphylla</i>	0.44	2.00
Herbaceous	<i>Crciterostigima plantaginum</i>	0.33	3.00
	<i>Comelina longifolia</i>	0.33	0.80
	<i>Cynodon dycyolen</i>	0.55	2.00
Grass	<i>Cenchrus ciliaris</i>	0.88	25.7
	<i>Eragrostis papposa</i>	8.10	4.05
	<i>Hetropogon contortus</i>	13.6	12.00

Table 3. Bird species recoded their relative abundance and feeding habits during the dry and wet seasons in undisturbed and disturbed habitats.

Common name	Scientific name	Relative abundance			
		Dry		Wet	
		Undisturbed	disturbed	Undisturbed	disturbed
Abyssinian Roller♦Om	<i>Coracias abyssinicus</i>	0.0015	-	0.0045	0.0004
African Grey Flycatcher♦In	<i>Bradornis microrhynchus</i>	0.0579	0.0022	0.0122	0.0227
African Grey Hornbill♦F	<i>Tockus nasutus</i>	-	-	0.0091	0.0093
African Mourning Dove♦F	<i>Streptopelia decipiens</i>	0.0093	0.0486	0.01107	0.0507
African Paradise Flycatcher ♦In	<i>Terpsiphone viridis</i>	0.0031	-	0.0221	0.0093 m
African Pigmy Falcon▼P	<i>Polihieax semitorquatus</i>	-	-	-	0.0004
African Sacred Ibis♦Om	<i>Threskiornis aethiopicus</i>	0.0031	0.0072	0.0065	-
African Thrush● Om	<i>Turdus peiols</i>	-	0.0099	-	-
Bearded Woodpecker ○In	<i>Dendropicoc namaquus</i>	-	0.0171	-	0.0004
Beautiful sunbird♦ Nec	<i>Cinnyris pulchellus</i>	0.0125	0.0071	-	-
Black Billed Wood Hoopoe♦Om	<i>Phoeniculus somaliensis</i>	0.0078	0.0071	-	-
Black Sparrow hawk●P	<i>Accipiter melanoleucus</i>	0.00469	-	-	-
Black- Cheeked Waxbill▲S	<i>Estrilda charmosyna</i>	0.00469	-	-	-
Black- Headed Batis ♦In	<i>Batis minor</i>	-	-	-	0.0093
Black Headed Oriole ○F	<i>Oriolus larvtaus</i>	0.0469	-	-	-
Black Kite ■P	<i>Milvus migrans</i>	-	-	-	0.0004 pm
Black-Faced Sand grouse▼S	<i>Pterocles decoratus</i>	0.0062	-	-	0.0091
Blue-Capped-Cordon-Blue ♦ s	<i>Uraeginthus cyanocephalus</i>	0.0078	0.9065	0.0011	0.0004
Blue-napped Mouse Bird▲S	<i>Urocolius macrourus</i>	-	0.9065	-	-
Bohm's Flycatcher▲In	<i>Muscicapa boehmi</i>	0.0055	-	-	-
Buff –billed Warbler ○ In	<i>Phyllolias puchella</i>	-	-	-	0.0004
Cape Crow ▲P	<i>Corvus capensis</i>	0.0015	-	-	-
Cape Turtle Dove ♦F	<i>Streptopelia capicola</i>	0.0031	0.0022	0.0796	0.0227

Table 3. Contd.

Cattle Egret ▲In	<i>Bubulcus ibis</i>	0.0172	-	0.0021	-
Chestnut Sparrow ■Om	<i>Passer eminiibey</i>	0.0172	-	0.0021	-
Crowned Lapwing ■In	<i>Vanellus cronoatus</i>	-	-	0.0175	0.0134
Cut-Throat Finch ♦S	<i>Amadina fasciata</i>	0.0453	0.0071	0.0641	-
Dark-Caped-Bulbul ●In	<i>Pycnonotus tricolor</i>	0.0078	0.0122	0.0041	-
Diderick Cucokoo ▼In	<i>Chrysococcyx caprius</i>			0.0175	-
Eastern Yellow-Billed hornbill ♦F	<i>Tockus flavirostris</i>	0.0062	0.0071	0.0075	0.0186
Egyptian Vulture Δ Om	<i>Neophron percnopterus</i>	-	-	-	0.0004 m
Eurasian Hoopoe ■Om	<i>Upupa upops</i>	-	-	0.0175	- pm
Fan-tailed Raven ○P	<i>Corvus rhipidurus</i>	0.0015	-	-	-
Fawn-Coloured -Lark ▲In	<i>Calendulauda africnoides</i>	0.0031	-	-	-
Gambaga Flycatcher ▲In	<i>Muscicapa gambagae</i>	0.0141	0.0071	0.0091	0.0134
Grater Blue-Eared Starling ►om	<i>Lamprotornis chalybaeus</i>	0.0015	-	-	0.0006
Grey- Headed Bush Shrike ▼In	<i>Malaconotus blanchoti</i>	0.0015	-		
Grey Heron ▲P	<i>Ardea cinerea</i>			-	0.0004
Grey Wagtail ▲In	<i>Motacilla cinerea</i>	0.0031	0.0442	0.0045	0.0321 pm
Grey Woodpecker ●In	<i>Dendropicos goertae</i>	-	-	-	0.00315
Hartlaub's Bustard ○Om	<i>Eupodotis hartaubii</i>	-	-	0.0065	0.0186
Helmeted Guineafowl ♦Om	<i>Numida meleagris</i>	-	-	0.0045	-
Hemprich's Hornbill ○F	<i>Tockus hemprichii</i>	-	-	-	0.00315
Jackson's Hornbill ○F	<i>Tockus jacksoni</i>	-	-	0.0065	0.0186
Jacobin Cuckoo ▲In	<i>Clamator jacobinus</i>	0.0001	-	-	- m
Lappet-faced Vulture ▲ Scv	<i>Torgos tracheliotus</i>	0.0109	0.0099	0.0021	0.0004 V
Lead colored Flycatcher ▼In	<i>Myloparus plumbeus</i>	-	-	0.0045	-
Lesser Masked Weaver ▲S	<i>Ploceus intermedius</i>	0.0031	-	-	-
Lilac- Breasted Roller ▲P	<i>Coracias caudatus</i>	0.0004	-	-	- m
Little Bee-Eater ◆In	<i>Merops pusillus</i>	0.0109	0.0099	0.0021	0.0004
Long-crested Eagle ●P	<i>Lophaetus occipitalis</i>	-	0.0022	-	-
Marico Sunbird ■Nec	<i>Cinnyris mariquiensis</i>	0.0141	-	0.0065	0.0134
Montane Night Jar ● In	<i>Caprimulgus ploiocephalus</i>	0.0031	0.0271	0.0091	0.0134
Namaqua Dove ◆F	<i>Oena capensis</i>	0.0469		0.0021	0.0186 m
Northern Black Flycatcher ◆In	<i>Melaenornis edolioides</i>	-	-	-	0.0321
Northern Grey- Headed Sparrow ►In	<i>Passer griseus</i>	0.0015	-	-	-
Northern Red- Billed Hornbill ♦F	<i>Tockus erythrorhynchus</i>	0.0015	0.0122	-	-
Nubian Woodpecker ΔIn	<i>Campethera nubica</i>	0.0031	0.0022	-	-
Ostrich◆Om	<i>Struthio camelus</i>	-	0.0049		
Pale Chanting Goshwak ●P	<i>Melierax canorus</i>	0.0156	-	-	-
Pale Flycatcher ▲In	<i>Bradornis pallidus</i>	0.0015	-	-	-
Pied Crow ▲P	<i>Corvus albus</i>	-	-	-	0.0734
Red -Billed Buffalo Weaver ►Inv	<i>Bubalorins niger</i>	-	0.093	0.0175	0.0962 m
Red-Billed Fire-Finch ▼S	<i>Lagonosticta senegala</i>		-	-	0.0734
Red-cheeked Cordonblue ○S	<i>Uraeginthus benalus</i>	-	0.093	0.0175	0.0962
Red-Billed Oxpecker ▲Inv	<i>Buphagus erythrohynchus</i>	-	-	0.0021	-
Red-Eyed Dove ΔF	<i>Streptopelia semitorquata</i>	0.0422	0.0293	-	-
Red-tailed Shrike ▼In	<i>Lanius isabellinus</i>	-	0.0099	-	- m
Rufous Chatterer Δ Inv	<i>Turdoides rubiginosa</i>	0.0109	0.0099	-	-
Rufous Crowned Roller◆Inv	<i>Coracias naevius</i>	0.0015	0.0022	0.0041	- R/m
Ruppl's Starling ◆Om	<i>Lamprotornis purpuropterus</i>	0.0062	0.0293	0.0135	0.0311

Table 3. Contd.

Slate Coloured Boubou ▼ In	<i>Laniarius funerbirs</i>	-	-	0.0045	-
Sooty Falcon ▼ P	<i>Falco concolor</i>	-	-	0,0045	- un
Southern Grey Shrike ▼ In	<i>Lanius meridionalis</i>	-	-	-	0.0004 m
Southern Red Bishop ♦ S	<i>Euplectes orix</i>	0.1158	0.1951	0.0211	0.0093
Southern White Crowned Shrike ■ In	<i>Eurocephalus angutimens</i>	-	-	-	0.0004
Speckled Mousebird ♦ F	<i>Colius striatus</i>	0.0469	0.0071	0.0021	0.0134
Speckled Pigeon ▼ F	<i>Columba guinea</i>	0.0469	-	0.0311	0.0004
Sedge-Warbler ▼ In	<i>Acrocephalus schoenobaenus</i>	-	-	0.0134	- pm
Square-Tailed Drongo ♦ In	<i>Dicrurus ludwigii</i>	0.0109	0.0171	0.0233	0.0321
Steel-Blue Whydah ▼ P	<i>Vidua hypocherina</i>	-	-	0.0021	- un
Striped King Fisher ○ P	<i>Halcyon chelicuti</i>	-	-	-	0.0004
Superb starling ♦ Om	<i>Lamprotornis superbus</i>	0.0719	-	0.01307	0.0004
Spur-Winged Lapwing ♦ In	<i>Vanellus nspinosus</i>	0.0469	-	0.0021	-
Tawny Eagle ♦ P	<i>Aquila rapax</i>	0.0109	-	-	- m
Tawny Flanked Prinia ▲ In	<i>Prinia subflava</i>	0.0031	-	-	-
Upcher's Warbler ♦ In	<i>Hippolais languida</i>	0.0031	0.0193	0.0045	0.0227 un/pm
Van Der Decken's Hornbill ♦ F	<i>Tockus deckeni</i>	0.0469	0.0022	-	-
Village Weaver ♦ S	<i>Ploceus cucullatus</i>	0.1517	0.1829	0.0486	0.0548
Watteled Starling ► Om	<i>Creatophora cinerea</i>	0.0469	0.0243	-	0.0362
White Bellied Go-way-Bird ► F	<i>Criniferoides leucogaster</i>	0.0375	0.0071	0.0375	0.0093
White- Headed Buffalo-Weaver ■ In	<i>Dinemellia dinemelli</i>	0.1064	0.0122	0.1552	0.0186
White-backed Vulture ○ Sc	<i>Gyps africanus</i>	-	-	0.0241	-
White-bellied Bustard ○ Om	<i>Eupodotis senegalensis</i>	-	-	-	0.0004
White-browed Sparrow-Weaver ♦ S	<i>Plocepasser mahali</i>	0.0375	0.0071	0.0375	0.0093
White-helmet Shrike ▼ In	<i>Prionops plumatus</i>	-	0.0066	-	0.0134
White-winged Black Tit ► In	<i>Parus leucmelas</i>	0.0469	0.0469	-	-
Willow Warbler ♦ In	<i>Phylloscopus trochilus</i>	-	-	-	0.0134 m
Yellow Wagtail ▲ In	<i>Motacilla flava</i>	0.0015	0.0022	-	- pm
Yellow-Bellied Eremomela ▲ In	<i>Eremomela icteropygialis</i>	0.0109	-	-	-
Yellow-spotted Petronia ▲ In	<i>Petronnia pyrgita</i>	0.0469	0.0022	-	-

♦ = both during dry and wet seasons in undisturbed and disturbed habitats; ▲ = Dry season disturbed habitat; ● = dry season undisturbed habitat; ○ = Wet season undisturbed habitat; ▼ = Wet seasons disturbed habitat; ■ = both dry and wet seasons disturbed habitat, Δ = dry season in both disturbed and undisturbed habitats, ► = both dry and wet seasons undisturbed habitat, - unrecorded. Om = Omnivore, F = frugivore, In = insectivore, S = Seed eater, Nec = Nectivore, Sc = scavenger = predator, Inv = Invertebrates, Pm = Palaeric migrant, m = local or inter African migrant, un/pm = uncommon Palaeric migrant, un = uncommon/m = Rare migrant and v = vulnerable.

Table 4. Bird species richness and diversity in the undisturbed and disturbed habitats.

Chao 2 mean		Chao 2 95% CI lower bound		Chao 2 95% CI upper bound		Jack 2 mean		Shannon mean		Simpson mean	
Dis	Und	Dis	Und	Dis	Und	Dis	Und	Dis	Und	Dis	Und
273.5	208.3	168.1	168.1	574.42	54.4	0	0	2.1	2.5	6.1	9.7
767.6	722.4	592.3	529.3	1608.7	1608.7	768.6	55.2	2.7	3.2	10.3	17.9
1732.4	1505.0	1255.3	1255.9	3033.8	3033.9	129.8	113.7	3.2	3.6	15.4	26.3
3037.7	2455.7	2010.5	2010.5	4518.6	4518.6	196.9	172.1	3.5	3.8	20.4	34.1
4730.4	3821.8	3823.3	3823.3	6836.9	6836.9	259.2	232.8	3.8	4.1	25.6	42.7

Und = undisturbed habitat, Dis = disturbed habitat.



**Table 5.** Bird species richness and diversity in the undisturbed and disturbed habitats during the wet season.

ICE		Chao 2		Chao 2 lower bound (95%)		Chao 2 upper bound (95%)		Shannon mean		Simpson mean	
Und	Dis	Und	Dis	Und	Dis	Und	Dis	Und	Dis	Und	Dis
44.8	1.0	54.4	1.0	44.8	1.0	137.8	3.1	1.61	1.0	4.5	1.0
148.7	1.0	178.4	1.0	148.7	1.0	379.2	1.9	2.2	0.0	10.3	1.0
317.4	1.0	382.4	1.0	317.3	1.0	732.7	1.5	2.6	0.0	10.2	1.0
536.9	1.0	648.2	1.0	536.5	1.0	1163.8	1.3	2.8	0.0	10.9	1.0
800.8	1.0	989.8	1.0	800.8	1.0	1687.2	1.2	2.9	0.0	11.5	1.0

Und = undisturbed habitat, Dis = disturbed habitat.

**Table 6.** Richness and diversity of birds species during the dry season in undisturbed and disturbed habitats.

ICE		Chao 2		Chao 2 lower bound (95%)		Chao 2 upper bound (95%)		Shann-on mean		Simpson mean	
Und	Dis	Und	Dis	Und	Dist	Und	Dis	Und	Dis	Und	Dis
54.4	47.8	54.4	47.7	26.1	22.0	137.8	129.6	2.7	1.6	5.7	3.7
178.4	162.9	178.4	162.9	90.9	8.9	379.2	358.7	4.4	2.2	10.8	6.57
382.4	357.2	382.4	357.2	207.4	190.2	732.7	679.8	6.6	2.6	15.9	9.7
648.2	619.4	648.2	619.4	37017.0	350.4	1163.8	1120.8	8.7	2.9	20.9	12.7
989.8	950.4	989.8	950.4	589.3	568.3	1687.2	1628.2	10.8	3.2	25.9	15.6

Und = undisturbed habitat, Dis = disturbed habitat.

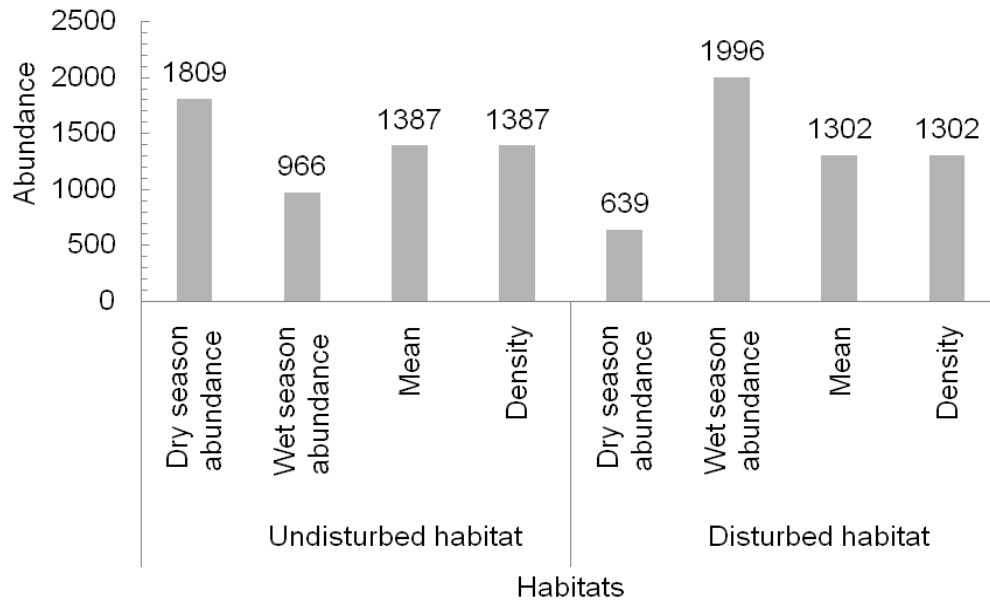
**Table 7.** Equitability of bird species in the disturbed and undisturbed habitats.

Seasons	Habitat	Number of species	Equitability H/Hmax
Dry	Undisturbed	44	0.602
	Disturbed	60	1.00
Wet	Undisturbed	48	0.79
	Disturbed	47	1.00

Moreover, the result showed high bird species richness and diversity during both the wet and dry seasons in the undisturbed habitat of the Park (Tables 5 and 6). However, the wet season disturbed habitat showed even distribution of bird species (Table 7). The estimated density of birds was also higher in the undisturbed habitat of the Park (Figure 2). White-browed Sparrow Weaver (*Ploceus mahmali*) followed by Superb-starling (*Lamprotornis superbus*) were relatively the highest population recorded in the disturbed habitat during the wet season (Table 3). During this season, Red-cheeked cordon blue (*Uraeginthus benalus*) followed by Red-billed Fire-finch (*Lagnosticta senegalensis*) were recorded in the highest proportion in the undisturbed habitat (Table 3). Blue-napped mousebird (*Urocolius macrourus*) occurred in highest proportion in the undisturbed habitat followed by Southern red-bishop (*Euplectes orix*) during

the dry season (Table 3). Nevertheless, Village Weaver (*Ploceus cucullatus*) occurred in highest proportion in the disturbed habitats followed by the Southern red-bishop during the dry season (*Euplectes orix*) (Table 3). The relative abundance of bird species in the two habitats at the different seasons showed significant difference ( $\chi^2_{84} = 168.384, P < 0.01$ ).

The undisturbed and disturbed habitats possessed proportionally significantly different number of individuals of a population of different species. When the percent relative abundances of birds in the undisturbed and disturbed habitats during the dry and wet seasons were combined, most of the bird species were proportionally rare with relative abundance of 76% below 0.05. The high even distribution of bird species occurred in the disturbed habitat during the wet season (Table 7). During the wet season, in both the disturbed and undisturbed habitats



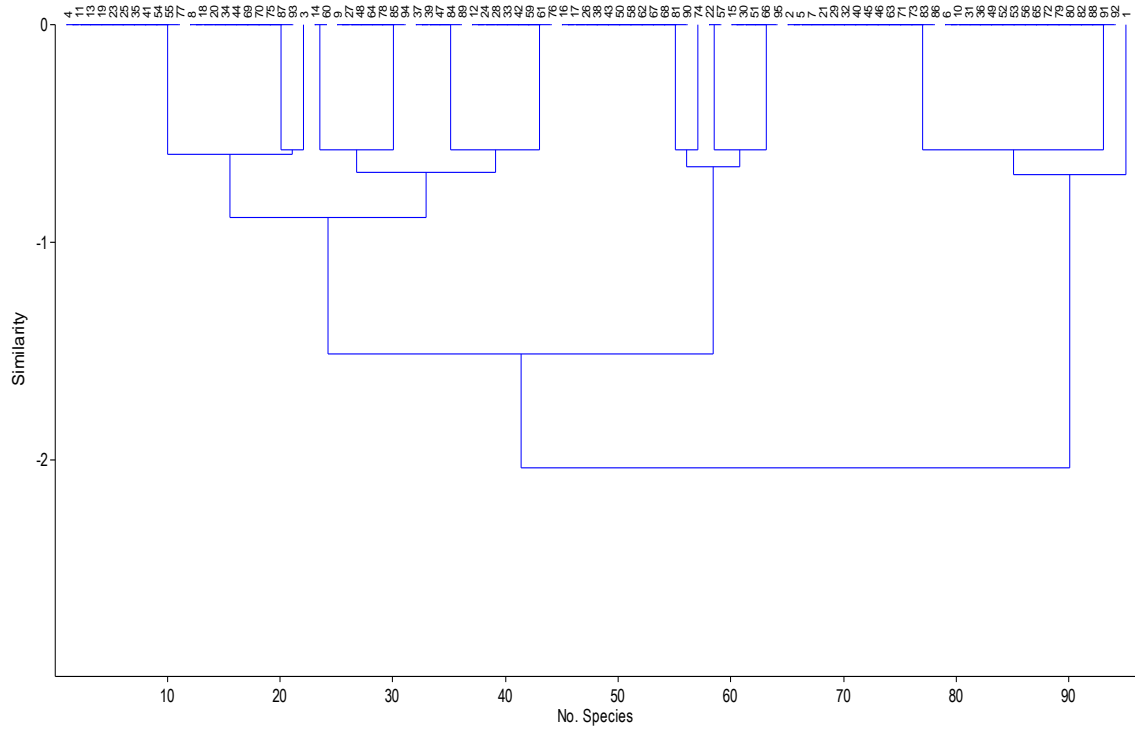
**Figure 2.** Density and estimated abundance of bird species during the wet and dry seasons in the undisturbed and disturbed habitats.

fourteen communities were formed as related to habitat, guild and season (Table 3 and Figure 3) where as nine bird communities organized along the same environmental gradient during the dry season (Table 3 and Figure 4). Bird species in the ASLNP showed strong guild and seasonal relationship followed by habitat and guild (Table 8). An insectivore bird species was the most abundant guild during both the dry and wet seasons in both the disturbed and undisturbed habitats (Table 3 and Figure 5). During in the dry season, the highest, 24 insectivore bird species was recorded in the disturbed habitat followed by 18 in the undisturbed habitat during the wet season (Table 3 and Figure 5). Omnivore bird species were the second most abundant guild in the disturbed habitats during wet seasons with the highest record of 15 species while the highest frugivore bird species (10) was recorded in the undisturbed habitat during the wet season (Figure 5). Seed-eaters or granivores were high in the disturbed habitat (8 species) during the dry season and in the undisturbed habitat, 8 species) during the wet season. Nectivore and scavengers were the least abundant guilds in the Park (Figure 5).

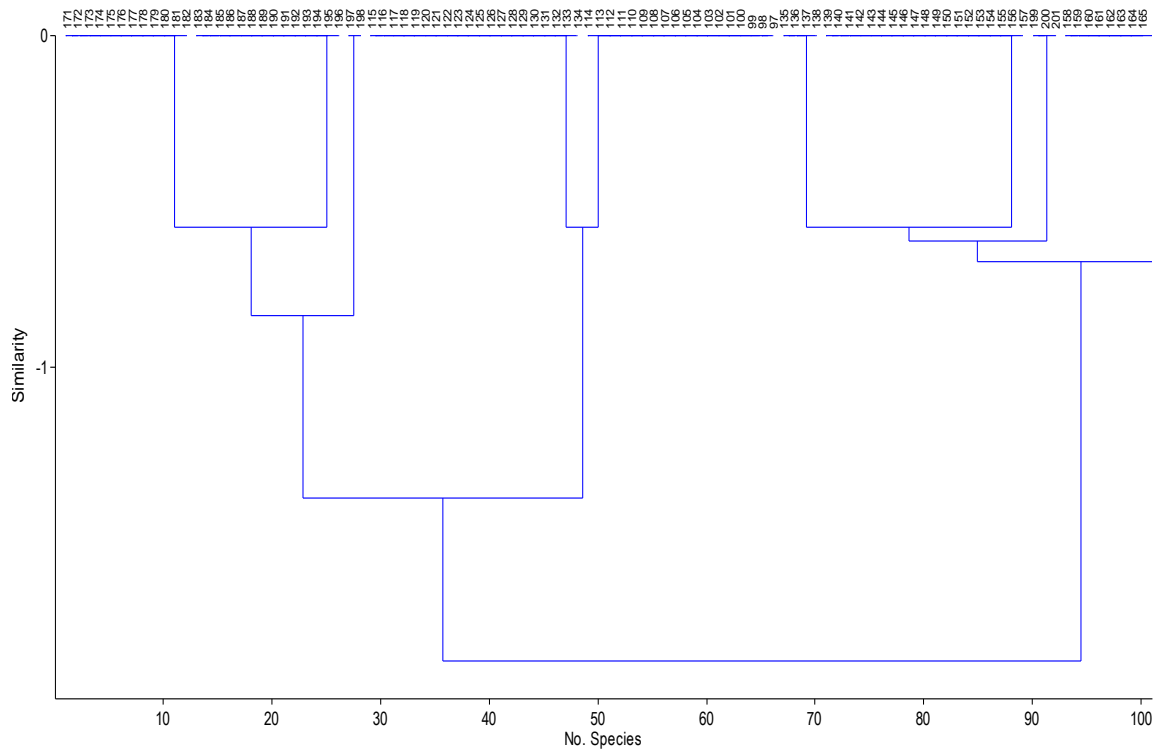
## DISCUSSION

Bird community structures were known to be affected by several factors (Rahayuningsih et al., 2007). Similarly, habitat diversity and change, seasonal variations in

climate and natural resources have affected the terrestrial bird species community structure of the ASLNP. Thus, higher species richness of birds in the disturbed habitat and lower in the undisturbed habitat could be attributed to the difference in the vegetation community structure of the two habitats that determine food, water and cover availability. The disturbed habitat had diverse plant species mixed with the remnant original vegetation community (Figures 2 and 7). This could be the reason for high bird species richness in this habitat. The relatively intact *A. tortilis*, *D. cinariaea* dominated community had higher diversity in the ASLNP (Figure 6). There were more number of bird communities types during the wet season as compared to the dry season in both the undisturbed and the disturbed habitats ( Figures 3 and 4). This might be due to the seasonal variation in the structure and types of plant communities that contributed to the high diversity of bird species. Conversely, alteration of the shrub, tree and canopy layers might have caused a reduction in the total resource availability for birds (Ding et al., 1997; Ukmar et al., 2007). Regassa (2005) described that high human and livestock populations have negatively affected the soil and vegetation structures particularly in the disturbed habitat of the ASLNP including the *A. tortilis*, *D. cinariaea* community. This might have reduced the availability of those plant species that provided fruits, nectar and determined prey species availability for birds. These could have reduced the diversity in the disturbed habitat of the Park. The heterogeneous vegetation cover in the disturbed habitat



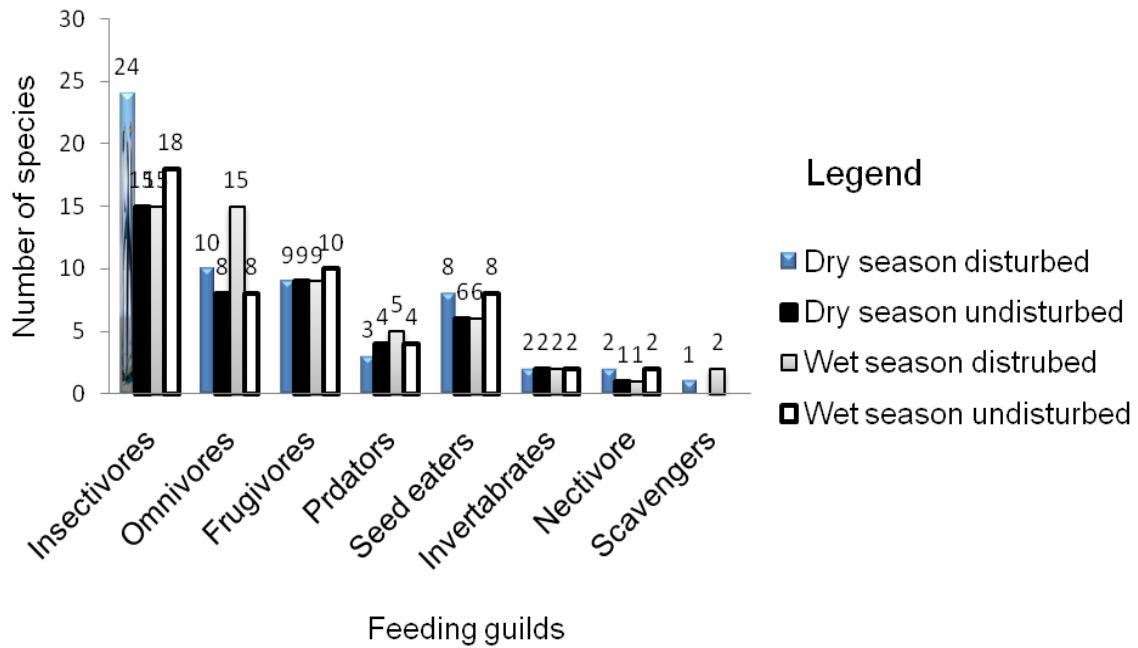
**Figure 3.** Bird species community organization as related to habitat, guild and seasonal relationships during the wet season.



**Figure 4.** Bird species community organization as related to habitat guild and seasonal relationships during the dry season.

**Table 8.** Pearson’s correspondence for habitat, guild and season during the dry and wet seasons.

	Habitat	Guild	Season
Habitat		0.550934	0.158233
Guild	0.0423091		0.826399
Season	0.0999008	-0.0155659	



**Figure 5.** Feeding guilds of bird species in the undisturbed and disturbed habitat during the wet and dry seasons.

(Table 2 and Figure 7) might provide various species of prey insects for insectivore birds. This might have resulted in the highest insectivore bird species. Similarly high abundance of the original or native vegetation cover of the undisturbed habitat (Figure 6) with its understory cover in the ASLNP supported different species of insects that fed on nectars and other parts of the plants, might have contributed to the high diversity and density of bird species in this habitat. This could also lead to the highest omnivore bird species in the ASLNP. In line with this, Abrams and Griffiths (1981) suggested that the distribution of bird species was determined ultimately by prey type and availability, and movements associated with breeding regimes.

The highest abundance of omnivore bird species in the undisturbed habitat was also partly associated with diverse plant species that provided various food types for these birds. The high original vegetation communities in the undisturbed habitat and the more diverse and various

plant species life forms in the disturbed habitats that provided better food and cover following rainfall could have contributed to high species richness and diversity during the wet season. This agrees with the work of Mengesha and Bekele (2008) in Alatish National Park where diversity was high during the wet season compared to the dry season. Moreover, the higher species richness recorded during the season in the undisturbed habitat in part might be due to the seasonal variation in climate where migratory bird species might have occupied the area in search of suitable climate. The intact vegetation with high woody species cover of the undisturbed habitat could have attracted more birds and could be the reason for high species richness and diversity of birds during the dry season. The high evenness indices in the disturbed habitat during the dry season might be related to the presence of enough food sources in the habitat that meet the requirement and preference of these birds. It could also be associated with the increase in shrub and open



**Figure 6.** The undisturbed habitat of the Abijata Shalla Lakes National Park.



**Figure 7.** The disturbed habitat of Abijata Shalla Lakes National Park.

land in the disturbed habitats. This is in agreement with Girma et al. (2009) that showed increase in shrub and open habitats and decrease in woody vegetation in the disturbed habitat thereby increasing evenness of birds.

The availability of food might be due to the availability of rain during April and May 2010 resulting in vegetation bearing flowers and fruits. This also agrees with Rahayuningsih et al. (2007) and Mengesha and Bekele

(2008). Seasonal variations in food sources where woody and other plant species bloom during the wet and short rain season could be the reason for the relatively higher density of birds in the undisturbed habitat. Moreover, migrants (Palearctic and inter-African) that could have occurred in one season and disappeared in the other could have contributed to the variations in evenness, density and in the estimated population sizes of the species (Table 3). This is in line with Becker and Ágreda (2005) that showed migrants from North America, common during the dry season contributed to turnover of species. They further indicated that avian species richness was not correlated with food resource diversity or abundance. Thus food availability and abundance were not the only factors for diversity and abundance of birds in an area. The dynamics of sink population were affected by the size of the source areas to sink patches and the nature surrounding matrix (Wiens, 1989).

At landscape level, species nest and roost in one habitat and forage in another extensive habitat several kilometers away from the breeding site. Wiens (1989) also indicated that the response of birds to habitat disturbance will be determined by species-specific habitat or space requirement. Therefore, habitat differences and species specific factors could also be involved in the high bird species diversity of the undisturbed area of ASLNP compared to the disturbed one. The low predator species record that reduces predation risk could be the reason for high density and higher relative abundance of few dominant species in the undisturbed habitat. This was similar to the work of Shochat et al. (2004) and Freeley and Terborgh (2008) where at the population level, reduced predation increased densities. The highest relative abundance of Blue-napped mouse bird, in undisturbed, and the Southern Red-bishop in disturbed habitats, during the dry season might be due to the availability of fruits for the former and seeds of grasses for the latter. These were evident since the Blue-napped mouse bird was frequently observed feeding on fruit bearing plants in undisturbed habitat and the Southern Red-bishop feeding on the seed of tall grasses. This could be an important factor because these bird species were absent and in low relative abundance during the wet season in their previous range. The highest proportion of Village Weaver in the disturbed habitats during the wet season, in contrast to the dry season, could also be associated with abundance of seed and insect food for the birds in the habitat during this season. This agrees with Mengesha and Bekele (2008) that indicated the effect of seasonal food variability and habitat suitability on bird species relative abundance and distribution in Alatish National Park in Ethiopia. Red-cheeked Cordon Blue and Red-billed Fire-finch feed on seeds of fallen grasses, herbs and insects (Hamed and Evans, 1984). Accordingly, the abundant seeds of fallen grasses and herbs for Red-cheeked Cordon Blue and Red-billed Fire-

finch during the wet season might have resulted in the highest proportion of these species in the undisturbed habitat. Observation during the study period also proved that these birds were feeding on seeds of grasses and herbs in an undisturbed habitat (Table 1). Superb-starling and White-browed Sparrow-weaver feed on insects, seeds, fruits and fleshy leaves, grasses, wheat and maize. These diverse feeding habits could be the reason for the highest population recorded in the disturbed habitat during the wet season. Superb-starling was also known to be pests of agricultural importance. Observation during the study period confirmed such feeding habit as they were feeding following farmers who were ploughing their land. Perhaps these might have contributed to the highest abundance for these bird species in the disturbed habitats.

The cause for most of the bird species to be rare in the disturbed habitat, during both seasons, could be the disturbance that has affected the population size of woody plant species leading to the decline and rarity of bird species. This is in line with the work of many authors including Germaine et al. (1998), Sekercigoulu and Sodhi (2007) and Wu et al. (2009). The overall high proportion of bird species recorded in the undisturbed habitat compared to the disturbed habitat was in line with related work on bird community composition in fragmented and less fragmented habitats such as Germaine et al. (1998) and Wu et al. (2009). At present, settlers with their livestock, agriculture, commercial charcoal production, sand and salt extraction have disrupted the whole habitats of ASLNP that was historically covered by *A. tortilis* dominated woodland vegetation (Abdi, 1993; Senbeta and Tefrea, 2002; Mengesha et al., 2009). The relative abundance of birds was expected to be similar due to the presence of remnant original vegetation types such as *A. tortilis* and other resources that support species in the two habitats. Nevertheless, the relative abundance of birds in the undisturbed and disturbed habitats was significantly different. Food abundance, availability, variety and preferences could be the reason for the differences in the relative abundance of bird species of the two habitats. Similarly, Germaine et al. (1998) also indicated the abundance of bird trends to be correlated with habitat changes. Furthermore, the disturbed habitat had lost most of its original vegetation type to be replaced by secondary growth woodland type that was dominated by *A. senegal*. This might have resulted in the significant difference in the relative abundance of the two habitats.

## CONCLUSION AND RECOMMENDATIONS

The terrestrial ecosystem of ASLNP consisted of different species of birds, revealing the importance of the habitat. However, this ecosystem, particularly the disturbed

habitat where low bird species diversity occurred is under great pressure due to deep rooted anthropogenic factors. Therefore, urgent conservation measure that would aim in the better wildlife habitat management and rehabilitation programmes may help to conserve terrestrial bird species of the Park.

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