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RESEARCH ARTICLE

SEASONAL DIVERSITY OF URBAN BIRDS: THE CASE OF BAHIR DAR CITY, ETHIOPIA

Abeba Alemu[1], Nega Tassie[1,*] and Dessalegn Ejigu[1]

ABSTRACT: Although the most direct impact of cities on biodiversity is the change in land cover associated with urban growth, large number of species have been recorded to live, and even thrive, within urban centers. The present study was conducted from August 2018 to March 2019 and aimed to investigate the seasonal diversity and habitat association of birds in Bahir Dar city. Semi-forest, wetland, waste dumping site and residential area were habitats identified based on topographic map and ground truthing survey. A total of 100 point count stations within 10 plots of the semi-forest habitat and 550 line transects within 55 blocks of open habitats were used to collect data. Diversity indices, chi-square and ANOVA were employed for data analyses. A total of 186 bird species belonging to 21 orders and 59 families were recorded. The highest diversity of bird species was observed in the residential area during the wet season (H' = 3.78) and the lowest was in waste dumping site during the dry season (H' = 2.11). Test of association between season and habitat types as a function of birds' abundance also confirmed the presence of strong association between season and birds abundance. Availability of food, water and nesting sites were the main players to determine the diversity and abundance of birds within Bahir Dar city. The study area supports large number of bird species that confirms the area's potential for bird watching tourism. Therefore, there must be a collaborative work with the city administration for protecting the urban ecosystem to conserve the biodiversity therein.

Key words/phrases: Bahir Dar city, Birds, Diversity, Habitat association, Relative abundance.

INTRODUCTION

The growth of cities and the process of urbanization worldwide has been a predominant cause of species extinction (McKinney, 2002). Threats to biodiversity are particularly inherent to such rapid urbanization, which raises concern over the future of the already reduced diversity in settings surrounding urban neighbourhoods (Evans *et al*., 2011). Among all biodiversity, birds are one of the most common wildlife in urban areas such

[1] Department of Biology, Bahir Dar University, P.O. Box 79, Bahir Dar, Ethiopia. E-mail: nega7719@gmail.com
*Author to whom all correspondence should be addressed

as neighbourhoods and cities, and many bird populations have been declining as a result of landscape changes due to urban expansion (Strohbach *et al*., 2009).

Waste volume is growing faster than urbanization rates and its generation rates will be more than double in the next twenty years, especially in low income countries (Hoornweg and Bhada-Tata, 2012). Air, soil and water pollution due to emissions from industry, traffic and heating, or nutrient loads to water bodies cause changes in biogeochemical cycle and primary production (Grimm *et al*., 2008). Their effects may expand well beyond city boundaries and once entered to the food chain, they can be detrimental for a wide range of organisms (Eeva *et al*., 2003).

In urban areas bioaccumulation of heavy metals has already been demonstrated in many common bird species (Bichet *et al*., 2013). The detrimental, synergistic effects of such pollutants on birds is known that young individuals are more sensitive, suffering from higher mortality, reduced body mass and reduced reproductive success (Janssens *et al*., 2003).

The most characteristic components of urbanized landscapes are buildings (Arnold and Zink, 2011). Buildings are usually associated with increased human activity, pets, pollution, elevated noise and light levels, reduced vegetation that results in heat island effect and thus might be avoided by species susceptible to disturbance. However, more tolerant species may gain benefits from their presence (Miller *et al*., 2001). The proximity of buildings, for example, may serve as a thermal shelter for overwintering species (Raupp *et al*., 2010) and certain bird species preferentially roost or breed in houses. Collision mortality in birds is also highly increased by the presence of buildings. Long distance migrants are especially vulnerable to such risks during their annual spring and fall routes; nevertheless, a recent study on North American birds failed to find positive correlation between collision mortality and long-term population trends (Arnold and Zink, 2011). With increasing building density, the surface covered by vegetation gets necessarily reduced and spatially more fragmented, adversely affecting the distribution, abundance and species richness of many native animal taxa.

The destruction of natural habitats due to urban development can have negative impacts on native species (Czech *et al*., 2000). Urban cores, for example, have lower bird diversity than surrounding natural areas as native bird species are replaced by few non-native species that are associated with humans (Marzluff, 2005). Heterogeneous landscapes may favour certain species and promote local diversity (Atchison and Rodewald, 2006). Indeed, at intermediate to large spatial scales, species richness increases with human population density, because non-native species are added to the local species pool (Pautasso, 2007).

Over larger spatial scales, the environmental conditions of urban landscapes may be more similar to each other than to adjacent natural landscapes, likely supporting similar species (Groffman, 2014). In addition, high human densities may be associated with greater concentrations of resources that are similar across space and stable through time. These resources such as food, water, and shelter could provide a buffer against environmental conditions and support similar species at similar abundances irrespective of geographical location. In fact, food subsidies have been shown to increase the abundance of urban specialists (McKinney, 2002).

The diversity of both plant and animal species might be affected by many factors including expansion of agricultural activity, pollution, overgrazing, deforestation, waste disposal, disturbance of breeding habitat and climate change (Aerts *et al*., 2008). These activities have detrimental effect on ecosystem functions (Kingsford, 2000). Changes in physiology and phenology of species, geographic distributions, and in some cases, extinction are the consequences of such disturbances (Girma Mengesha *et al*., 2011). In Ethiopia, many aquatic and terrestrial ecosystems that provide biological and ecological importance are threatened and require series legislative conservation actions. Thus, knowledge regarding the ecology and conservation of aquatic and terrestrial fauna and flora at local level is important to devise effective management plans. To the best of our knowledge, there is not a single study carried out in the whole Bahir Dar city except a study conducted in the modified habitats of Bahir Dar Gulf of Lake Tana and the island of Debre Maryam (Shimelis Aynalem *et al*., 2008). Our study therefore provides policy makers and conservationists with scientific information about the ecological status of birds in Bahir Dar city and how species are distributed in the city in relation to the urban layout.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Bahir Dar city, the capital of Amhara National Regional State (ANRS), which is located about 565 km away northwest of Addis Ababa. The city is located at 37°23′ E, and 11°36′ N (Fig. 1). It covers a total area of 28 km^2 and flanked by Lake Tana to the North, Woreb rural kebele to the East, Meshenti town to the West, and Tissisat Falls to the South. The average elevation of Bahir Dar is 1,800 m a.s.l. The city is one of the leading tourist destinations in Ethiopia with a variety of attractions such as Lake Tana and Lake and its Islands considered sacred and provide refuge and shelter for many plant and animal species of local and international significance. The city is known for its wide avenues lined with palm trees and variety of flower beds. The natural vegetation mainly consists of a few remnants of different tree species, bushes and grasses. Papyrus is dominant along the coastlines of Lake Tana and Blue Nile River. Eleven years (2008–2018 rainfall data showed that the highest average monthly rainfall is 417.19 mm in July, and the lowest 1.37 mm in January and the average monthly minimum and maximum temperature is 7.72°C in December and 31.36°C in March, respectively.

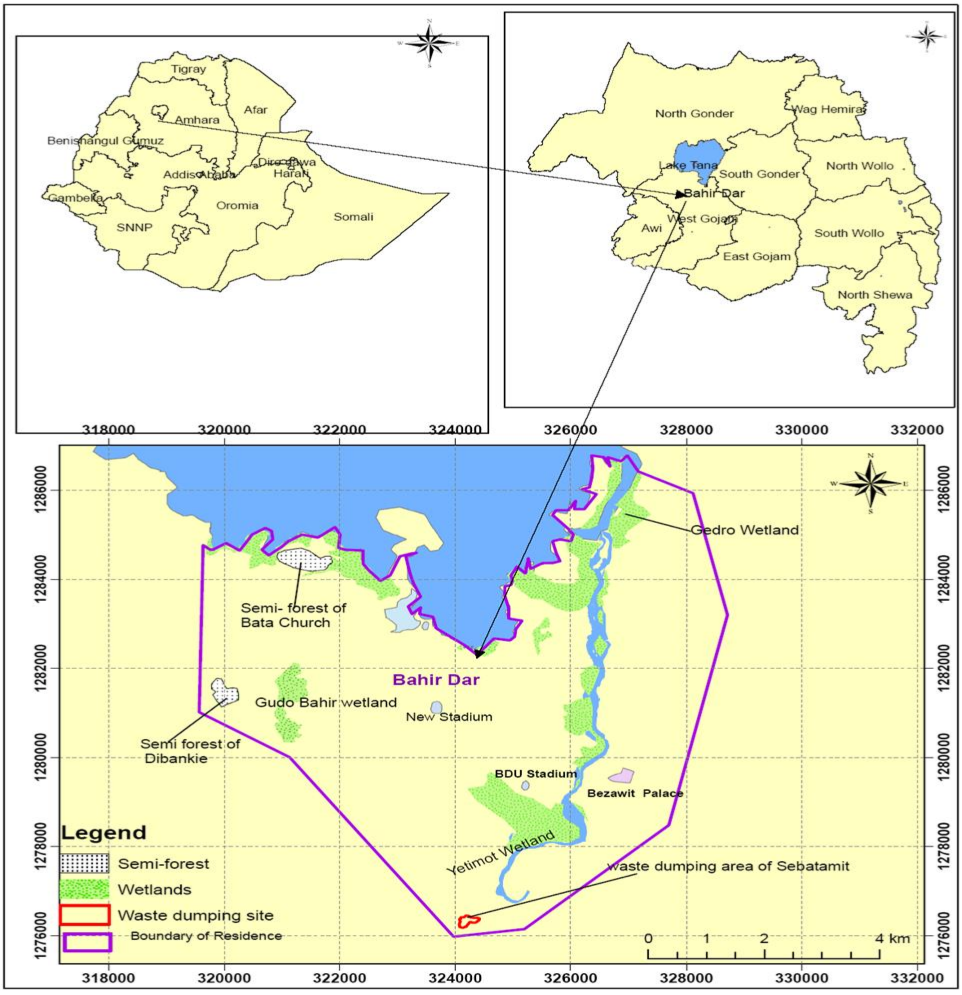

Fig. 1. Map of the study area, Bahir Dar.

Sampling design

A reconnaissance survey was carried out during the first two weeks of August, 2018. The survey was to collect information on the flora and fauna, and to determine the size of the study area. Stratified random sampling technique was employed. The study area was classified in to four habitat types. These included residential area (4572 ha), characterized by buildings, city parks, greeneries; wetland (lake shore and offshore) area (460.60 ha), waste dumping sites (5.28 ha), which is a landfill area used as a garbage dump; and semi-forest areas (25.20 ha). Sampling plots and blocks were established in each habitat type. Data in open habitats; residential area, wetlands and waste dumping site were collected using line transect method, and point transect in the semi forest habitat (Bibby *et al*., 2000). The number of sampling points and lines within each plot and block was determined relative to the size of habitats and type of vegetation cover. As a result, a total of 65 plots consisting of ten sampling points and line transects were established (Table 1). Roads between residential blocks and kebeles were used as a transect line. A distance of 150 m and 20 m was maintained between transects in the wetland and dumping site study habitats, respectively.

Table 1. Allocation of plots/blocks and sampling points and transect lines based on area coverage of each habitat type.

Sample type	Habitat classification			
	Semi-forest	Residential	Wetland	Waste dumping site
Number of plots	10	40	10	5
Number of lines	-	400	100	50
Number of points	100	-	-	-

Data collection

In order to minimise the effect of time and weather conditions on bird detectability, point counts were undertaken only between 06:00 am and 09:00 am and late in the afternoon between 3:00 pm and 6:00 pm, when most of the avian species are active under calm weather conditions (Canterbury *et al*., 2000). During counting, the ending point in the morning is the beginning point in the late afternoon. Data collection was carried out from August 2018 to March 2019 covering both wet and dry seasons. Wet season data were collected from August to October, and dry season from January to March. Bird identifications and counting of individuals were conducted by direct observations aided with binoculars and field guidebooks (Perlo, 2009; Redman *et al*., 2009). In the semi-forest habitat where the vegetation is relatively dense, observations were made by standing in the middle of the point station observing 360° round quietly and gently up to a distance of 30 m radius of the station. The observer upon reaching a point stands still for about 2–5 minutes to allow birds to settle in case of any disturbance. In between each point count station, a minimum distance of 100 m was maintained using GPS track to avoid double counting of birds (Vielliard, 2000). Bird species were identified by using their feather colours, beak shape, legs and overall body size (Wenny *et al*., 2011). Photographs and videos were taken to confirm the species which were difficult to identify on site. A total of 12 observations per season were carried out in the residential area and six observations were undertaken in each of the remaining three habitats per season. The data were collected for about 60 days in both seasons.

Data analysis

Analysis of counts and associations in different habitats was carried out using ANOVA to determine whether there are any statistically significant differences between the count means of species in the study habitats, and chi-square test to see whether distributions of species among the habitats differ. Shannon-Weiner (Shannon and Weaver, 1949), Simpson Diversity (Simpson, 1949) and Simpson's community similarity indices were used to evaluate the diversity of bird species in different habitats of the study area using R version 4.0.0 (R Core team, 2020).

Species diversity index

The Shannon Weiner diversity index $-(\sum P_i \ln P_i)$ (where pi is the proportion of individuals belonging to the *i*th species) was used to identify the diversity of bird species at the four habitats. This index was selected because it provides an account for both abundance and evenness (Magurran, 1988). It does not also disproportionately favour some species over the others as it considers all species according to their frequencies.

Species richness (S) is defined by:

$$S = \sum n$$

Where, n is number of species in a community.

Species evenness (E) was used to evaluate by Shannon's equitability index (E) which is calculated by: $E = H' / H_{max}$

Where, H_{max} is defined as ln(S), H' is the Shannon-Wiener diversity index.

Similarity index

Similarity of species diversity between habitat types was calculated as:

SI = 2C/A+B

Where, SI = Simpson's similarity index;

A = Number of species that occur in habitat A;

B = Number of species that occur in habitat B;

C = Number of common species that occur in both habitats.

The relative abundance of bird species in each habitat was calculated by:

Relative abundance = Total number of individuals of a particular species *100

Total number of individuals of all species

Relative abundance values were used to ordinally categorize each species under the following five abundance categories (Bibby *et al*., 2000) (Table 2).

Table 2. Relative abundance score categories.

Relative abundance value	Relative abundance score	Abundance category
< 0.1	1	Rare
0.1–2.0	2	Uncommon
2.1–10.0	3	Frequent
10.1–40.0	4	Common
> 40	5	Abundant

RESULTS

Species composition

A total of 186 species of birds belonging to 21 orders and 59 families were recorded in the study area (Appendix 1). Two species, white-cheeked turaco (*Tauraco leucotis*) and Ethiopian siskin (*Serinus nigriceps*) are endemic to Ethiopia; four species black-winged lovebird (*Agapornis taranta*), Abyssinian oriole (*Oriolus monacha*), wattled ibis (*Bostrychia carunculata*) and banded barbet (*Lybius undatus*) are endemic to Ethiopia and Eritrea. The maximum number of species was recorded in the family Ploceidae (12 species), followed by Columbidae (10 species), Accipitridae (9 species), and Estrildidae (8 species). The order Passeriformes was represented by the highest number of families (85) and the lowest number of families was recorded for the order Apodiformes, Cuculiformes, Phoenicopteriformes, Caprimulgiformes, Psittaciformes, Coliiformes, and Strigiformes (1 family each) (Fig. 2).

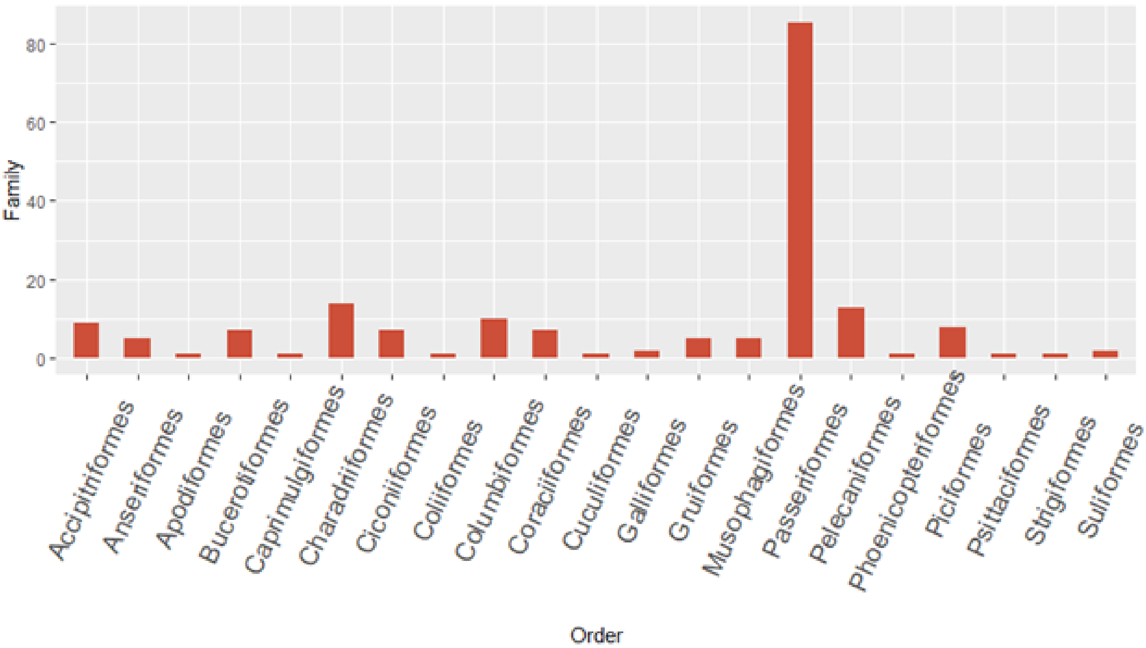

Fig. 2. Avian species composition in the study area.

Species diversity

The highest diversity of bird species was observed in residential area during the wet season (H'= 3.78), and the lowest was observed in waste dumping site during the dry season (H'= 2.11). The highest uniform population distribution was found in the semi-forest area (E = 0.89), and the lowest was in waste dumping site during both seasons (E = 0.65). Species richness was the highest in residential area (152 species) and the lowest was recorded in waste dumping site (38 species) (Table 3). Bird community similarity was the highest between wetland and waste dumping site (0.54) and the lowest was between semi-forest and wetland area (0.23) during the wet season (Appendix 2).

Table 3. Species diversity indices in the study area.

Habitat	Season	No. of species	No. of individual	H'	H'max	E
Semi- forest	Wet	61	3545	3.66	4.11	0.89
	Dry	34	978	3.1	3.53	0.88
	Common	68	4523	3.71	4.21	0.88
Residential	Wet	130	19418	3.78	4.87	0.78
	Dry	90	9727	3.22	4.5	0.72
	Common	152	29145	3.75	4.11	0.83
Wetland	Wet	61	1400	3.4	4.11	0.83
	Dry	40	1042	2.89	3.69	0.78
	Common	67	2442	3.33	4.2	0.79

Habitat	Season	No. of species	No. of individual	H'	H'max	E
Waste dumping site	Wet	33	1934	2.45	3.64	0.68
	Dry	24	1611	2.11	3.22	0.66
	Common	38	3545	2.4	3.66	0.65

H'= Shannon-Wiener Diversity Index; RI = richness index; E=. Evenness, H'max (lnS)

Relative abundance

Large number of species (95) was grouped under rare category, while small number of birds was grouped under frequent category (12 species). This value showed a statistically significant difference among the four habitats ($F_{(3,472)} = 9.61$, $P<0.001$), and between dry and wet seasons ($F_{(1,474)} = 5.59$, $P<0.05$). The overall abundance of species showed a statistically significant difference among the four habitats ($F_{(3,472)} = 9.05$, $P<0.05$); but not between seasons ($F_{(1,474)} = 1.16$, $P>0.05$). Test of association between season and habitat types as a function of birds abundance has also confirmed the presence of strong association between season and habitat types ($\chi^2 = 529.82$, $P<0.05$).

DISCUSSION

The present study recorded 186 species of birds, most of which are species that are locally rare and uncommon and could be associated to large home range, niche and habitat degradation (Ryan and Owino, 2006). The variation might be related with availability of food, the degree of threats/disturbances found in the area and other ecological requirements of birds. According to Mehra *et al*. (2017), bird species richness, distribution and abundances are directly or indirectly affected by spatial variations and rate of anthropogenic activities.

The highest number of bird species (152) was recorded in the residential area characterized by buildings, city parks, greeneries, among others, that attract birds to the urban environment. Birds which have been the focus of the majority of urban ecology studies often have access to a multitude of food sources due to human activities including supplementary foods (Galbraith *et al*., 2015), refuse thrown away by humans in cities which provide easy source of food (Nyari *et al*., 2006; Burgin and Saunders, 2007). High diversity and availability of food in urban habitats compared to natural ones may be a primary reason why some urban birds thrive (Coogan *et al*., 2017).

Furthermore, the proximity of buildings may serve as a thermal shelter for overwintering prey species that serve as a food source for birds (Raupp *et* *al*., 2010) and certain bird species preferentially roost or breed in houses. In fact, food subsidies have been shown to increase the abundance of urban specialists (McKinney, 2002). In the urban and surrounding suburban environment native plant communities are being replaced with managed systems of altered landscape structure, influencing ecological and environmental relationships. Managed urban areas tend to increase plant species richness largely due to exotic plantings (Pavlik and Pavlik, 2000). This might also have contributed to an increase in bird community composition shifts in response to exotic plantings within the residential area of the city

Besides, areas suitable for humans are also generally suitable for urban birds and human activities might increase the habitat diversity of urban area through introduced species and promoted landscape heterogeneity (Araujo, 2003). At intermediate to large spatial scales, species richness increases with human population density, because non-native species are added to the local species pool (Pautasso, 2007). In addition, high human densities may be associated with a higher supply of resources that are stable through time. While urban growth of any type reduces bird distributions, compact city development within existing residential areas substantially minimize these reductions at the city scale (Fuller *et al*., 2010). Urban-sensitive species particularly benefited from compact development because large green spaces are left intact, whereas the distribution of non-native species is expected to expand as a result of sprawling development (Sushinsky *et al*., 2013).

Although the study had expected high species diversity in semi-forest and wetland areas, the result was not as expected. The destruction of wetland habitats due to urban agriculture and overgrazing have affected breeding, roosting and feeding grounds of wetland birds that resulted in reduction in diversity and richness of birds. This is similar with the findings of Shimelis Aynalem and Afework Bekele (2008) that reported reduced bird species richness and density attributable to human disturbance, especially livestock grazing. A study conducted by Brouwer *et al*. (2003) also revealed that the most important threat for wetland birds is the degradation of wetlands which are ideal habitats for roosting and thermoregulation. Likewise, the reduction of wetland bird diversity is attributed to the degradation of wetlands and the loss of suitable upland habitats that surround wetlands reducing value to wetland dependent birds (Bellrose and Trudeau, 1998).

In semi-forest area the observed species was lower than expected (68 species). This might be due to changes in floristic complexity, and cover and densities of vegetation as this habitat is found within and in the vicinity of the city. The result of this study concurs with the findings of Schlossberg and King (2008) who revealed that removal or reduction of vegetation reduces the total area of contiguous habitats available to birds and increases the isolation of the habitat which results in fragmentation. The fragmented habitat provide ways to various predators that can successfully exploit by eating bird eggs, young and even adults which impact birds diversity. This observation was also reported by Doggart *et al*. (2005) that a decrease in plant community exposes birds to their predators, reduces food supply and breeding sites, which results in an intense competition within and between species that causes decrease in diversity and abundance. Generally, as vegetation cover increases toward the rural parts of a city, species diversity increases and in areas of intermediate disturbances (i.e., suburban development), diversity also increases (Daniels and Kirkpatrick, 2006).

In this study, species diversity and abundance was low in waste dumping site. This is similar with the finding of Matejczyk *et al*. (2011) who reported that the presence of materials like glasses, metals, wire, plastic, paints, different toxics and dangerous pathogens in waste dumping sites affect wildlife diversity and abundances, particularly avian species. Likewise, Dobson and Foufopoulos (2001) observed that waste dumping sites could be a source of emerging pathogens transmitted from the species that use these sites to other species - as a result, species diversity and abundance decline. Moreover, this result is supported by Battin (2004) who described that high risk of poisoning, foreign bodies ingestion and pathogen infection may make these places ecological traps with negative consequences for several species.

Similarly, the lowest species evenness was recorded in waste dumping site (E=0.65) as many urban birds used to forage on food left by humans. Reliance on human food source may become particularly important when other foraging choices become restricted. However, predators can reach higher numbers in urban waste dumping areas because of supplemental food. Thus, supplemental food resources that attract predators can have a significant effect on the persistence of small bird populations in the area which confirms the presence of different species but least in abundance. Freedom from persecution and an adequate food supply may allow raptors to inhabit the waste dumping site.

Alpha diversity which is measured using Simpson's index values showed 52% of community similarity between semi forest and residential area and 54% between waste dumping site and wetland habitats (Appendix 2). The semi forest and residential areas possess relatively higher similarity. This may be due to the fact that built-up areas, including institutional grounds, residential neighbourhoods, and informal settlements, possess plant communities that are more or less similar in type with the plants found in the semi-forest habitat which attract common birds to both habitats. Likewise, the close proximity of wasteland habitats to the waste dumping site might have contributed for these two habitats to possess relatively large number of shared species.

CONCLUSION

The study has documented exceptionally large number of bird species (186). This implies other economically and ecologically important fauna might be using the area. This confirms that the landscape of Bahir Dar's city administration is a critical urban environment for wildlife protection and development. The distribution of birds in different habitats in the study area is attributable to the presence of urban foraging sites, remnant forests, greeneries, city parks and buildings that serve as breeding sites and microhabitats that provide obstructive cover to lower the risk of predation. Therefore, proper management and protection of urban environments including Bahir Dar city is one potential area of wildlife protection that benefits cities eco-tourism development.

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Appendix 1. List of bird species recorded in the study area during wet and dry seasons, (+) species endemic to Ethiopia and Eritrea, (*) species endemic to Ethiopia.

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
Abdim's stork	*Ciconia abdimii*	Ciconiidae	Ciconiiformes		x	
Abyssinian oriole (+)	*Oriolus monacha*	Oriolidae	Passeriformes			X
Abyssinian white-eye	*Zosterops abyssinicus*	Zosteropidae	Passeriformes			X
African citril	*Crithagra citrinelloides*	Fringillidae	Passeriformes		x	
African darter	*Anhinga rufa*	Anhingidae	Suliformes			X
African fire finch	*Lagonosticta rubricata*	Estrildidae	Passeriformes	X		
African fish eagle	*Haliaeetus vocifer*	Accipitridae	Accipitriformes			X
African grey hornbill	*Lophoceros nasutus*	Bucerotidae	Bucerotiformes		x	
African hoopoe	*Upupa africana*	Upupidae	Bucerotiformes		x	
African jacana	*Actophilornis africanus*	Jacanidae	Charadriiformes			X
African mourning dove	*Streptopelia decipiens*	Columbidae	Columbiformes		x	
African open bill	*Anastomus lamelligerus*	Ciconiidae	Ciconiiformes			x
African paradise-flycatcher	*Terpsiphone viridis*	Monarchidae	Passeriformes			x
African pygmy-kingfisher	*Ispidina picta*	Alcedinidae	Coraciiformes		x	
African spoonbill	*Platalea alba*	Threskiornithidae	Pelecaniformes			x
African thrush	*Turdus pelios*	Turdidae	Passeriformes			x
African wattled plover	*Vanellus senegallus*	Charadriidae	Charadriiformes			x
African-hill babbler	*Pseudoalcipe abyssinica*	Sylviidae	Passeriformes		x	
Baglafecht weaver	*Ploceus baglafecht*	Ploceidae	Passeriformes		x	
Banded barbet (+)	*Lybius undatus*	Lybiidae	Piciformes		x	
Bar-breasted firefinch	*Lagonosticta rufopicta*	Estrildidae	Passeriformes		x	
Bare-faced go away bird	*Corythaixoides personatus*	Musophagidae	Musophagiformes		x	
Beautiful sunbird	*Cinnyris pulchellus*	Nectariniidae	Passeriformes	x		
Black-billed barbet	*Lybius guifsobalito*	Lybiidae	Piciformes			x
Black-billed wood hoopoe	*Phoeniculus somaliensis*	Phoeniculidae	Bucerotiformes			x

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
Blackcap	*Sylvia atricapilla*	Sylviidae	Passeriformes	x		
Black crake	*Amaurornis flavirostra*	Rallidae	Gruiformes			x
Black-crowned crane	*Balearica pavonina*	Gruidae	Gruiformes			x
Black and white mannikin	*Lonchura bicolor*	Estrildidae	Passeriformes		x	
Black kite	*Milvus migrans*	Accipitridae	Accipitriformes		x	
Black stork	*Ciconia nigra*	Ciconiidae	Ciconiiformes		x	
Black-headed batis	*Batis minor*	Platysteiridae	Passeriformes		x	
Black-headed heron	*Ardea melanocephala*	Ardeidae	Pelecaniformes			x
Black-headed forest oriole	*Oriolus monacha*	Oriolidae	Passeriformes			x
Black-headed siskin (*)	*Spinus notatus*	Fringillidae	Passeriformes		x	
Black-tailed godwit	*Spinus notatus*	Fringillidae	Passeriformes		x	
Black-winged lovebird (+)	*Agapornis taranta*	Psittaculidae	Psittaciformes			x
Black-winged plover	*Vanellus melanopterus*	Charadriidae	Charadriiformes		x	
Black-winged red bishop	*Euplectes hordeaceus*	Ploceidae	Passeriformes		x	
Black-winged stilt	*Himantopus himantopus*	Recurvirostridae	Charadriiformes			x
Blue-breasted beeeater	*Merops variegatus*	Meropidae	Coraciiformes			x
Blue-headed coucal	*Centropus monachus*	Cuculidae	Cuculiformes			x
Blue-spotted wood dove	*Turtur afer*	Columbidae	Columbiformes			x
Bronze mannikin	*Lonchura cucullata*	Estrildidae	Passeriformes			x
Brown-backed woodpecker	*Dendropicos obsoletus*	Picidae	Piciformes	x		
Brown-throated wattle-eye	*Platysteira cyanea*	Platysteiridae	Passeriformes			x
Bruce's green pigeon	*Treron waalia*	Columbidae	Columbiformes			x
Cape rook	*Corvus frugilegus*	Corvidae	Passeriformes			x
Cardinal woodpecker	*Dendropicos fuscescens*	Picidae	Piciformes	x		
Caspian plover	*Charadrius asiaticus*	Charadriidae	Charadriiformes	x		
Cattle egret	*Bubulcus ibis*	Ardeidae	Pelecaniformes		x	
Clapperton's Francolin	*Francolinus*	Phasianidae	Galliformes		x	

Common name	Scientific name	Family	Order	Season Dry	Wet	Both
	clappertoni					
Collared sunbird	*Hedydipna collaris*	Nectariniidae	Passeriformes	x		
Common bulbul	*Pycnonotus barbatus*	Pycnonotidae	Passeriformes			x
Common fiscal	*Lanius collaris*	Laniidae	Passeriformes			x
Common green shank	*Tringa nebularia*	Scolopacidae	Charadriiformes		x	
Common martin	*Delichon urbicum*	Hirundinidae	Passeriformes		x	
Common ringed plover	*Charadrius hiaticula*	Charadriidae	Charadriiformes			x
Common sandpiper	*Actitis hypoleucos*	Scolopacidae	Charadriiformes			x
Copper sunbird	*Cinnyris cupreus*	Nectariniidae	Passeriformes	x		
Common swift	*Apus apus*	Apodidae	Apodiformes		x	
Cut-throat finch	*Charadriiformes*	Estrildidae	Passeriformes			x
Double-toothed barbet	*Lybius bidentatus*	Lybiidae	Piciformes			x
Dusky-turtle dove	*Streptopelia lugens*	Columbidae	Columbiformes		x	
Eastern grey plantain eater	*Crinifer zonurus*	Musophagidae	Musophagiformes			x
Egyptian goose	*Alopochen aegyptiaca*	Anatidae	Anseriformes			x
Emerald-spotted wood dove	*Turtur chalcospilos*	Columbidae	Columbiformes		x	
Ethiopian boubou	*Laniarius aethiopicus*	Malaconotidae	Passeriformes			x
Ethiopian swallow	*Hirundo aethiopica*	Hirundinidae	Passeriformes			x
Eurasian hoopoe	*Upupa epops*	Upupidae	Bucerotiformes			x
Fan-tailed raven	*Corvus rhipidurus*	Corvidae	Passeriformes			x
Fork-tailed drongo	*Dicrurus adsimilis*	Dicruridae	Passeriformes		x	
Glossy ibis	*Plegadis falcinellus*	Threskiornithidae	Pelecaniformes		x	
Great egret	*Ardea alba*	Ardeidae	Pelecaniformes			x
Greater flamingo	*Phoenicopterus roseus*	Phoenicopteridae	Phoenicopteriformes		x	
Greater honey guide	*Indicator indicator*	Indicatoridae	Piciformes		x	
Greater-blue eared starling	*Lamprotornis chalybaeus*	Sturnidae	Passeriformes			x
Grey wagtail	*Motacilla cinerea*	Motacillidae	Passeriformes			x
Grey-backed camaroptera	*Camaroptera brevicaudata*	Cisticolidae	Passeriformes		x	

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
Grey-backed fiscal	*Lanius excubitoroides*	Laniidae	Passeriformes			x
Grey-headed kingfisher	*Halcyon leucocephala*	Alcedinidae	Coraciiformes			x
Grey-headed woodpecker	*Picus canus*	Picidae	Piciformes			x
Greyish eagle-owl	*Bubo cinerascens*	Strigidae	Strigiformes	x		
Groundscraper thrush	*Psophocichla litsitsirupa*	Turdidae	Passeriformes	x		
Hadada ibis	*Bostrychia hagedash*	Threskiornithidae	Pelecaniformes			x
Hamerkop	*Scopus umbretta*	Scopidae	Pelecaniformes			x
Helmeted guineafowl	*Numida meleagris*	Numididae	Galliformes		x	
Hermprich's hornbill	*Lophoceros hemprichii*	Bucerotidae	Bucerotiformes			x
Hooded vulture	*Necrosyrtes monachus*	Accipitridae	Accipitriformes			x
Isabelline shrike	*Lanius isabellinus*	Laniidae	Passeriformes			x
Isabelline Wheatear	*Oenanthe isabellina*	Muscicapidae	Passeriformes			x
Knob-billed duck	*Sarkidiornis melanotos*	Anatidae	Anseriformes			x
Lappet-faced vulture	*Torgos tracheliotos*	Accipitridae	Accipitriformes		x	
Laughing dove	*Spilopelia senegalensis*	Columbidae	Columbiformes			x
Lesser jacana	*Microparra capensis*	Jacanidae	Charadriiformes		x	
Lesser Blue-eared Starling	*Lamprotornis chloropterus*	Sturnidae	Passeriformes		x	
Lesser-masked weaver	*Ploceus intermedius*	Ploceidae	Passeriformes		x	
Lesser-striped swallow	*Cecropis abyssinica*	Hirundinidae	Passeriformes		x	
Little bee-eater	*Merops pusillus*	Meropidae	Coraciiformes			x
Little egret	*Egretta garzetta*	Ardeidae	Pelecaniformes		x	
Little weaver	*Ploceus luteolus*	Ploceidae	Passeriformes		x	
Little-ringed plover	*Charadrius dubius*	Charadriidae	Charadriiformes		x	
Spur-winged lapwing	*Vanellus spinosus*	Charadriidae	Charadriiformes		x	
Long-tailed cormorant	*Microcarbo africanus*	Phalacrocoracidae	Suliformes		x	
Marabou stork	*Leptoptilos crumenifer*	Ciconiidae	Ciconiiformes			x
Marsh sandpiper	*Tringa stagnatilis*	Scolopacidae	Charadriiformes			x
Mocking cliff chat	*Thamnolaea cinnamomeiventris*	Muscicapidae	Passeriformes			x

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
Mosque swallow	*Cecropis senegalensis*	Hirundinidae	Passeriformes	x		
Mountain thrush	*Turdus plebejus*	Turdidae	Passeriformes			x
Namaqua dove	*Oena capensis*	Columbidae	Columbiformes		x	
Northern crombec	*Sylvietta brachyura*	Macrosphenidae	Passeriformes			x
Northern wheatear	*Oenanthe oenanthe*	Muscicapidae	Passeriformes	x		
Northern-black flycatcher	*Melaenornis edolioides*	Muscicapidae	Passeriformes			x
Northern-masked weaver	*Ploceus taeniopterus*	Ploceidae	Passeriformes		x	
Northern-red bishop	*Euplectes franciscanus*	Ploceidae	Passeriformes		x	
Nyanza swift	*Apus niansae*	Apodidae	Caprimulgiformes		x	
Pied crow	*Corvus albus*	Corvidae	Passeriformes			x
Pied kingfisher	*Ceryle rudis*	Alcedinidae	Coraciiformes			x
Pied wagtail	*Motacilla aguimp*	Motacillidae	Passeriformes		x	
Pied wheatear	*Oenanthe pleschanka*	Muscicapidae	Passeriformes	x		
Pin-tailed whydah	*Vidua macroura*	Viduidae	Passeriformes			x
White-cheeked turaco	*Tauraco leucotis*	Musophagidae	Musophagiformes		x	
Purple heron	*Ardea purpurea*	Ardeidae	Pelecaniformes		x	
Red-billed duck	*Anas erythrorhyncha*	Anatidae	Anseriformes		x	
Red-billed firefinch	*Lagonosticta senegala*	Estrildidae	Passeriformes			x
African Grey hornbill	*Tockus nasutus*	Bucerotidae	Bucerotiformes		x	
Red-billed oxepecker	*Buphagus erythrorhynchus*	Buphagidae	Passeriformes			x
Red-breasted wheatear	*Oenanthe bottae*	Muscicapidae	Passeriformes			x
Red-cheeked cordon-bleu	*Uraeginthus bengalus*	Estrildidae	Passeriformes			x
Red-chested swallow	*Hirundo lucida*	Hirundinidae	Passeriformes	x		
Red-collard widowbird	*Euplectes ardens*	Ploceidae	Passeriformes		x	
Red-eyed dove	*Streptopelia semitorquata*	Columbidae	Columbiformes			x
Red-fronted tinkerbird	*Pogoniulus pusillus*	Lybiidae	Piciformes		x	
Red-knobbed coot	*Fulica cristata*	Rallidae	Gruiformes		x	
Red-winged prinia	*Prinia erythroptera*	Cisticolidae	Passeriformes	x		
Ring-necked dove	*Streptopelia capicola*	Columbidae	Columbiformes			x

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
Rock martin	*Ptyonoprogne fuligula*	Hirundinidae	Passeriformes	x		
Rouget's rail	*Rougetius rougetii*	Rallidae	Gruiformes		x	
Ruppell's robin chat	*Cossypha semirufa*	Muscicapidae	Passeriformes			x
Ruppell's starling	*Lamprotornis purpuroptera*	Sturnidae	Passeriformes			x
Ruppell's vulture	*Gyps rueppelli*	Accipitridae	Accipitriformes			x
Sacred ibis	*Threskiornis aethiopicus*	Threskiornithidae	Pelecaniformes			x
Saddle-billed stork	*Ephippiorhynchus senegalensis*	Ciconiidae	Ciconiiformes			x
Scarlet-chested sunbird	*Scarlet-chested sunbird*	Nectariniidae	Passeriformes			x
Silvery-cheeked hornbill	*Bycanistes brevis*	Bucerotidae	Bucerotiformes			x
Speckled mousebird	*Colius striatus*	Coliidae	Coliiformes			x
Speckled pigeon	*Columba guinea*	Columbidae	Columbiformes			x
Spectacled weaver	*Ploceus ocularis*	Ploceidae	Passeriformes	x		
Spur-winged goose	*Plectropterus gambensis*	Anatidae	Anseriformes			x
Spur-winged plover	*Vanellus spinosus*	Charadriidae	Charadriiformes			x
Squacco heron	*Ardeola ralloides*	Ardeidae	Pelecaniformes			x
Striped kingfisher	*Halcyon chelicuti*	Alcedinidae	Coraciiformes			x
Swainson's sparrow	*Passer swainsonii*	Passeridae	Passeriformes			x
Tawny eagle	*Aquila rapax*	Accipitridae	Accipitriformes		x	
Tawny-flanked prinia	*Prinia subflava*	Cisticolidae	Passeriformes		x	
Thick-billed raven	*Corvus crassirostris*	Corvidae	Passeriformes			x
Variable sunbird	*Cinnyris venustus*	Nectariniidae	Passeriformes			x
Vatelline masked weaver	*Ploceus vitellinus*	Ploceidae	Passeriformes		x	
Village indigobird	*Vidua chalybeate*	Viduidae	Passeriformes			x
Village weaver	*Ploceus cucullatus*	Ploceidae	Passeriformes			x
Violet-backed starling	*Cinnyricinclus leucogaste*	Sturnidae	Passeriformes			x
Eastern Violet backed	*Anthreptes orientalis*	Nectariniidae	Passeriformes	x		

				Season		
Common name	**Scientific name**	**Family**	**Order**	**Dry**	**Wet**	**Both**
sunbird						
Wattled crane	*Grus carunculata*	Gruidae	Gruiformes		x	
Wattled ibis (+)	*Bostrychia carunculata*	Threskiornithidae	Pelecaniformes			x
White wagtail	*Motacilla alba*	Motacillidae	Passeriformes			x
White-backed vulture	*Gyps africanus*	Accipitridae	Accipitriformes			x
White-bellied go away bird	*Corythaixoides leucogaster*	Musophagidae	Musophagiformes			x
White-cheeked turaco	*Tauraco leucotis*	Musophagidae	Musophagiformes		x	
White-faced whistling duck	*Dendrocygna viduata*	Anatidae	Anseriformes			x
White-headed vulture	*Trigonoceps occipitalis*	Accipitridae	Accipitriformes			x
White-rumped babbler	*Turdoides leucopygia*	Leiothrichidae	Passeriformes			x
Willow warbler	*Phylloscopus trochilus*	Phylloscopidae	Passeriformes			x
Wire-tailed swallow	*Hirundo smithii*	Hirundinidae	Passeriformes		x	
Wood sandpiper	*Tringa glareola*	Scolopacidae	Charadriiformes		x	
Woodland kingfisher	*Halcyon senegalensis*	Alcedinidae	Coraciiformes			x
Woolly-necked stork	*Ciconia episcopus*	Ciconiidae	Ciconiiformes			x
Yellow wagtail	*Motacilla flava*	Motacillidae	Passeriformes			x
Yellow white eye	*Zosterops nigrorum*	Zosteropidae	Passeriformes	x		
Yellow-billed egret	*Ardea brachyrhyncha*	Ardeidae	Pelecaniformes			x
Yellow-billed kite	*Milvus aegyptius*	Accipitridae	Accipitriformes			x
Yellow-billed oxpecker	*Buphagus africanus*	Buphagidae	Passeriformes	x		
Yellow-billed stork	*Mycteria ibis*	Ciconiidae	Ciconiiformes			x
Yellow-crowned bishop	*Euplectes afer*	Ploceidae	Passeriformes		x	
Yellow-fronted canary	*Crithagra mozambica*	Fringillidae	Passeriformes		x	
Yellow-mantled widowbird	*Euplectes macroura*	Ploceidae	Passeriformes		x	
Zebra waxbill	*Amandava subflava*	Estrildidae	Passeriformes	x		

Table 2. Similarity index of bird species among different habitat types during wet and dry seasons.

	Semi-forest		**Residential**		**Wetland**		**Waste dumping**	
	Wet	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Semi-forest	1	1	0.52	0.40	0.23	0.24	0.27	0.24
Residential area	-	-	1	1	0.40	0.28	0.35	0.30
Wetland	-	-	-	-	1	1	0.54	0.47
Waste dumping site	-	-	-	-	-	-	1	1