Avian Diversity and Bird-Aircraft Strike Problems in Bahir Dar International Airport, Bahir Dar, Ethiopia

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Abstract

Background

Bahir Dar International Airport is known by its rich avifaunal diversity, and bird-aircraft collisions is becoming a serious problem in the area. Study on bird-aircraft strike problems in Bahir Dar International Airport was carried out from February - August 2020. The study area was classified into four habitat types based on its vegetation structures namely: bushland, grassland, wetland, and modified habitat. Point and transect count methods were used to collect data on diversity and abundance of birds. Interviews to people working at the Airport were used to gather information about the incident and prevention of bird-airport strike problems. Shannon-Wiener diversity, Simpson's similarity indices, ANOVA, and chi-square tests were used for data analysis.

Results

A total of 80 bird species belonging to 15 orders and 40 families were identified in the present study area. The highest species diversity (H'=3.59) and species evenness (E=0.96) were recorded in the modified habitat during the wet season. The majority of birds in the present study area were uncommon species both during the dry (85.5%) and wet (84.8%) seasons. Birds pose severe threats to aircrafts in Bahir Dar International Airport. Bird-aircraft strike problem has mainly been prevented by expelling of birds using different techniques, which is found to be encouraging from the perspective of conservation of birds.

Conclusion

Bahir Dar International Airport is rich in its avifauna that requires the Aviation Authority to work in collaborative with different organizations to avoid bird-aircraft strike problems without affecting conservation of birds in the area.

Background

Birds are vital components of the biodiversity, and they are one of the best known and highly valued organisms in the natural world [1]. In addition to their ecological and economic values, birds also play a vital role as bio-indicators and biocontrol agents [2]. Although they occupy most of the earth's surface, majority of birds are found only in a particular regions and habitats[3].

Ethiopia's topographic diversity and variability of altitudes and climate are the main reasons that made the country as one of the few avian biodiversity rich countries in the world [4]. However, the rise of natural and human induced disturbances greatly affects the structural and compositional diversity of native vegetations. This in turn affects the availability of various food items for birds that subsequently influences on the diversity, abundance, and distribution of birds in the area [5].

Ethiopia harbors over 860 species of birds and representing 9.5% of the world's and 39% of Africa's bird species of which 19 species are endemic to Ethiopia, three are rare, 14 other bird species are shared with Eritrea and 31 are globally threatened [3]. In addition, over 1230 Important Bird Areas (IBAs) have already been identified in Africa, of these 73 are in Ethiopia [1].

Several variables have been found to influence avian species diversity and abundance, including food availabilities, temperature, and competition [3]. Urban environments provide birds with considerable quantities of food and roosting sites [7], and airports are one of the structural features in urban environments. The natural environment and human activities inside and in immediate vicinity of airports provide a wide variety of natural and human made habitats for birds that offer them with diverse food items, nesting and roosting sites, shelter, and other facilities [8].

Bird strike is one of the serious concerns for economic and flight safety reasons [9]. The first recorded fatality due to bird-aircraft collision occurred in 1912 [10], and the incidents were uncommon during the beginning of the aviation industry, resulted in relatively little damage. However, the number and frequency of bird-aircraft collisions increased significantly over the last decades due to an increase in the number of flight operations combined with increasing numbers of birds of prey and small gregarious bird species, especially during migration [1]. More than one hundred bird species have been recorded to cause bird strike problems worldwide [12]. Bird strike caused an annual loss of about 1.2 billion USD in the global aviation industry [7]. The Ethiopian Airlines annually loses more than five million birr to maintain equipment damaged by bird strikes [13]. For example, a flock of speckled pigeons collided with Boing-737 in 1988 at Bahir Dar International Airport resulting in the death of over 30 people and a complete destruction of the aircraft [14].

The occurrence of birds at the airport depends on the attractiveness of habitats within and around the airports [15]. Bird-aircraft collisions is becoming a serious problem especially in areas where airports are in the vicinity of water bodies, farmlands, grasslands, and damping sites [16]. Therefore, the need for effective bird control measures at airports has increased through the years. It is important that the airport authorities show due emphasis by employing effective bird control measures that are appropriate for their situation [7].

There have been many studies carried out on the East African including Kenya, Uganda, and Tanzania avian ecology [17]. However, very few studies were conducted on bird strike problems in Ethiopia [18]. Bahir Dar International Airport and its surrounding areas have bird friendly habitats where diverse species of birds exist. However, the extent of bird-aircraft strike problems, and the preventive mechanisms being applied from the perspective of birds' conservation in the area are not studied. Thus, this study aimed to investigate avian diversity and bird-aircraft strike problems in Bahir Dar International Airport.

Results

Species composition

A total of 80 species of birds belonging to 15 orders and 40 families were identified in the study area. Seasonal avian diversity showed that 79 and 69 bird species were recorded during the wet and dry seasons, respectively, of which 68 species were common to both the wet and dry seasons. But 11 species of birds were recorded only during the wet season, while one species was recorded only during the dry season (Table 1).

The highest number of families were recorded for the order Passeriformes (14 families) followed by Charadriiformes (5 families), Pelecaniformes and Bucerotiformes (4 families each), and the lowest was recorded under the orders Anseriformes, Accipitriformes, Columbiformes, Coraciiformes, Ciconiiformes, Gruiformes, Galliformes' Coliiformes and Suliformes (1 family each). Moreover, order Passeriformes had the highest number of species (20 species), followed by Pelecaniformes (13 species), Accipitriformes and Columbiformes (7 species each), Anseriformes (6 species), and other orders were found to contain the lowest number of species (1 species each) (Fig.1).

In addition, the threatened status of birds was identified using International Union for Conservation of Nature (IUCN) Red List and National Red List Data Book. Among the total of 80 species of birds recorded in the study area, two species; wattled ibis (*Bastrychia earunculata*) and black-winged lovebird (*Agapornis taranta*) were endemic to Ethiopia and Eritrea, one species hooded vulture (*Necrosyrtes monachus*) was critically endangered, two species tawny eagle (*Aquila rapax)*, and Abyssinian ground horn bill *(Bucorvus abyssinicus*) were vulnerable. Out of the total species of birds recorded in the area, 14 species were migrant and the rest 66 were found to be residents.

Species diversity

Bird species diversity varied among the four habitat types. The highest species diversity (H´=3.59) was recorded in the modified habitat during the wet season, and the lowest (H´=2.78) was in the grassland habitat during the dry season. The highest species eveness (E=0.96) was obtained in the modified habitat during the wet season where as the lowest (E=0.91) was in the wetland and grassland habitats during the dry season. The highest species richness (42 species) was recorded in modified habitat during the wet season, and the lowest (21 species) was in the grassland habitat during the dry season (Table 2).

In the entire study area, higher species diversity (H´=4.14), and evenness (E=0.94) were recorded during the wet season than the dry season. Moreover, large number of individual birds were also recorded during the wet season than the dry season (Table 3).

In addition, during the dry season speckled pigeon (*Columba guinea*) was the most abundant species in the study area followed by greater blue eared glossy starling (*Lamprotornis chalbeus)* and red eyed dove (*Streptopelia semitorquata)*. During the wet season speckled pigeon (*C. guinea)* was also the most abundant species followed by black headed weaver (*Ploceus cucullatus)* and great white pelican (*Pelecanus onocrotalus)*. Thus, speckled pigeon *(C. guinea)* was found to be the most abundant bird species both during the dry and wet seasons.

Abundance of birds

There were about 5605 and 4347 individuals of birds in the area during the wet and dry seasons, respectively. However, the overall abundance of birds did not show significant difference between the wet and dry seasons ($F_{(1,146)} = 0.70, p > 0.05$). During the wet season, the abundance of birds showed significant difference among the four habitat types ($F_{(3,130)} = 4.44, P < 0.05$). Birds' abundance as a function of season and habitat type has also confirmed that season and habitat are not related ($\chi^2_{(4)} = 2, df = 1, p = 0.157$).

The relative abundance of avian species showed that most species of birds recorded during the dry (85.5%) and wet (84.8%) seasons were uncommon. Relative abundance of bird species did not show significant difference between the dry and wet seasons ($F_{(1,146)} = 0.86, P > 0.05$).

Species similarity

Simpson's similarity index (SI) of bird species in the four study habitats showed that the highest (SI=0.74) and the lowest (SI=0.54) species similarity was recorded between bushland and modified habitat during the wet season, and the dry season, respectively (Table 4).

Bird strike problems

To assess the extent of bird-aircraft strike problems in Bahir Dar International Airport, interview was conducted with 23(88.5%) male and 3(11.55)female respondents. Professionally, 20(76.9%) of the respondents were bird controllers, 4(15.4%) officers, and 2(7.7%) section heads who have several years of experiences working in the airport.

Of the total respondents, 21(80.8%) of them confirmed that they have seen bird-aircraft collision incidents in the airport. The problem was relatively frequent during summer, and it was also supported by 17(65.4%) of the respondents. Though birds are diurnal animals, majority (92.3%) of the participants responded that most bird strike problems occurred early in the morning and late in the afternoon.

Regarding bird strike occurrences, majority of the respondents replied that they encountered dead birds due to collision with aircrafts. It was also known that nearly 40 bird aircraft collisions occurred in the airport during 2020/21. The majority (88.5%) of the interviewed participants replied that bird strike incidents most frequently occurred both during the time of takeoff and landing of the aircraft.

Although 73.1% of the respondents replied that speckled pigeon (*Columba guinea*) was the most frequently bird species that causes bird strike problems in the airport. Other species of birds such as marabou stork (*Leptoptilos crumenifer*), yellow-billed kite (*Milvus aegyptius*), Egyptian goose (*Alopochen aegyptiaca*), and tawny eagle (*Aquila rapax)* were also commonly involved in the bird strike incidents at Bahir Dar International Airport. Besides birds, other wildlife species such as hyena (*Crocuta crocuta*),

Ethiopian hare (*Lepus starcki*), and common duiker (*Sylvicapra grimmia*) were also involved in aircraft strike problems.

There were a number of methods used by the airport office to avoid bird-aircraft strikes. These included selective removal of trees, mowing of grasses, surveying of birds and other animals using vehicles, removing birds' nests around the airport, draining ditches of water, use sounds of gun for large flocks of birds, discouraging birds using whips, removing dead bodies and other wastes, and establishing strong security fences along the runway to prevent large land-dwelling animals. The majority (73.1%) of the respondents confirmed that most of the preventive methods were to expelled birds away from the airfield during takeoff and landing of aircrafts.

Discussion

A total of 80 species of birds were identified during the study period. Compared to similar airports in the country such as Mekele International Airport which harbors 68 avian species [24], Bahir Dar International Airport is found to be relatively rich in its avifauna. This might be due to differences in resource availability, and proximity of the Airport to Lake Tana, which is one of the five Biosphere Reserve Areas in Ethiopia [25].

Most species of birds were observed both during the dry and wet seasons. However, there are some bird species that were observed only during the wet season. This might be due to variations in food availability and weather conditions [26]. The highest number of bird species was recorded under order Passeriformes, and the modified habitat harbors the highest number of species throughout the year, and this might be due to the availability of different food sources. The result of this study is consistent with the findings of [27] that the presence of diversified microhabitats in the modified habitat and the food shifting behavior of birds when food is scarce during the dry season would result for the highest species diversity in modified habitat both during the dry and wet seasons.

The lowest species diversity was recorded in grassland habitat during the dry season. This could be associated with scarce food availability, and the occurrence of anthropogenic disturbance in the area. This is in line with the findings of [28] and [29] who claimed that anthropogenic activities such as overgrazing, habitat degradation, and fragmentation could ultimately cause migration and local extinction of birds. According to [30], bird species abundance is directly or indirectly affected by special variation and the degree of anthropogenic activities. Furthermore, [26], explained that the distinct seasonality of rainfall and variation in the availability of food sources result changes in the species abundance of birds between the wet and dry seasons.

The highest bird species evenness was recorded in the modified habitat during the wet season, and the lowest was in wetland and grassland habitats during the dry season. This indicated that in modified habitat several successful bird species equally forage the available resources and this consequently accounted for the higher avian species evenness in the area. In contrast, in wetland and grassland habitats, few bird species out compete the available resources and become dominant in the utilization of

the available resources, which contributes for reduction in species evenness in grassland habitat. The differences in resource competition, breeding nature, foraging habit, and niche specialization among the different species of birds in each habitat result less species evenness [31–33].

The highest and the lowest number of birds were recorded in the modified habitat during the wet season and in grassland habitat during the dry season, respectively. This difference might be possibly associated with variation in resource availability among habitats and between seasons in the study area. Moreover, the difference between modified and grassland habitats could also be resulted from variation in the degree of anthropogenic disturbance between the two habitats. This result is similar with the findings of [26] who reported that variations in abundance of bird species is determined by food availability and breeding sites.

Most species of birds identified in the present study area were uncommon birds. This might be associated with better niche specialization of the uncommon species in the area. Consistent with this result, [34] described that the presence of many uncommon species in a certain area could be related to the breeding nature, large home range, and niche requirement of the species. The result of this study also agrees with the findings of [35], who reported that most of the species of birds in Bole International Airport were found to be uncommon birds.

The highest and lowest species similarly were recorded between bushland and modified habitats during the wet and dry seasons, respectively. Similarity of avian communities might be due to their geographical proximity, similar ecology, and similar extent of disturbances in the area. The lowest avian similarity could probably be due to the difference in foraging adaption and the response of birds to anthropogenic disturbance in each habitat. The result of this study is in line with the findings of [36] who described that similarity of bird species composition between habitats indicates a tendency for similar habitats to have similar species composition. In the present study, the highest and lowest species similarities between bushland and modified habitats might be due to differences in influences of seasonal variation on the two different habitats.

In Bahir Dar International Airport safety threat of birds on aircrafts and the methods applied to prevent birds' collision with aircrafts from the perspective of conservation of birds was also assessed. As a result, most of the respondents reported that they had frequently observed birds died from aircraft collisions. These airport workers might have been trained with bird-control staffs who are engaging in patrolling the airfield runway. Despite the lack of accuracy and reliability in the methods of estimating incidences of collision, it was reported that on average 40 bird-aircraft strikes occurred annually in the Airport, which did not cause for significant damage to the aircraft, but many birds were found dead in these incidents. Study conducted by [18] reported that 36 bird-aircraft strikes occurred in Bole International Airport during a year of the study period. This might be associated with a difference in the effectiveness of bird control methods used in the two airports. As reported by [37], a method applied to minimize the risk of bird strike to aircrafts consists of the limitation of the occurrence of birds in places where the competition for space between airports and birds is heaviest at airports.

It is reported that most bird-aircraft strikes in Bahir Dar International Airport took place during takeoff and landing especially early in the morning and late in the afternoon. There seems to be a clear association between the time of strike and behavior of the birds. This could be due to the more aircraft traffic density and higher activity of birds during these times of the day. Similarly, [38] reported that 93% of collision occurred during takeoff run, in the first phase of ascend and in the final stage of landing. This result is also supported by [39], where most bird-aircraft strikes happened during the day, most frequently in the morning and in the evening where birds are more active, because they move to foraging grounds or to nocturnal roosting sites.

The key informants reported that most bird-aircraft strikes in Bair Dar International Airport occurred during summer. Besides the foggy weather condition, food and other resources might be more abundant in the summer that resulted in increasing the size of the local bird population with a subsequent rise of collision frequencies in the airport. This is in line with the findings of [40], who described that the frequency and distribution of bird-aircraft strike had peaks which coincided with the period of migration of birds. Like other Airports, bird strike was reported to be a regular threat to flight operation in Bahir Dar International Airport. Birds pose a real threat to flight safety, although most collision does not end in a catastrophe. There is no aircraft free from threat due to the presence of birds [16].

It is important to remember the major catastrophic and fatal bird strike incident that occurred in Bahir Dar Airport was in 1988. Fortunately, bird strikes are tragic on rare occasions [9]. The majority of birds that are known to cause a permanent hazard to aircraft during landing and takeoff in Bahir Dar International Airport were reported to be speckled pigeons, marabou stork, yellow billed kite, Egyptian goose, and tawny eagle in their order of causing the highest to the lowest number of strikes. Most of the strike both in Bahir Dar International Airport and Bole International Airport [18] were caused by pigeons. This indicated that pigeons are the most abundant birds in both airports. Consistently, [11] suggested that one of the main factors for the increase in the frequency of bird strike is increasing number of some bird species in the area. Besides birds, land dwelling animals such as hyena and Ethiopian hare were also reported to pose strikes in the airport during departure and arrival of aircrafts. This result is supported by the findings of [41] who described that large ground dwelling animals can also be problems to aircraft operations and aircraft movements during landing and takeoff.

Despite inadequate attention given to conservation of birds around Bahir Dar International Airport, most of the methods applied to prevent bird-aircraft strike problems in this Airport were only targeted to expel birds away from the landing and takeoff areas to avoid the problem.

Conclusion

Bahir Dar International Airport is known by its relatively rich avifaunal diversity with relatively high population size of each species. This diverse avian species community is because of the availability of different habitats and sufficient resources. More importantly the proximity of the airport to Lake Tana and associated wetlands makes the area with high bird species diversity and considered it as part of the

biodiversity conservation hotspot. However, habitat change due to different anthropogenic activities notably due to livestock grazing and expansion of farmland have negatively affected the diversity and abundance of birds in the area.

Birds caused a permanent threat to aircrafts in Bahir Dar International Airport. As a result, several birds were found dead in many of the bird-aircraft strike incidents. The findings of the present study revealed that most bird-aircraft strike incidents occurred early in the morning and late in the afternoon, during which birds remain active. Hence, to minimize birds' collision with aircrafts, the airport should revise the flight schedules, and try to make less traffic load early in the morning and late in the afternoon. Thus, to minimize the problems, and to ensure conservation of birds in the area, the Aviation Authority in collaboration with different organizations should design and implement comprehensive strategies to avoid bird-aircraft strike problems without compromising conservation of birds in the area.

Methods

Description of the study area

Bahir Dar International Airport, established in 1954, is one of the International Airports in Ethiopia located 8 km to the West of Bahir Dar City, the capital of Amhara National Regional State. It is geographically located at 11°36'30"N latitude, and 37°19'30"E longitude at an elevation of 1821m a.s.l (Fig.2). Its main runway length and width are 3100 m and 45 m, respectively. The Airport and its surrounding area is dominated by grassland, bushland, wetland and modified habitats. There are a lot of tourist attraction sites around the Aairport including ancient monasteries and churches on the Islands of Lake Tana. Furthermore, the Airport's scenery with the Lake Tana and roads in the city create great pleasure to the travelers.

Ten years rainfall and temperature data of the study area showed that the highest average monthly rainfall was 391.92mm July and the lowest was 1.02mm during January, and the average monthly minimum and maximum temperatures were 6.46 °c during January and 31.87°c during April, respectively [19].

Sampling design

The study area was stratified on the basis of its habitat types, and the sampling unit within each habitat type was determined based on vegetation type, structure and the corresponding area coverage. As a result, the area was classified into four habitats namely bushland, grassland, wetland, and modified habitat. Among the four habitat types, three of them such as bushland, grassland, and modified habitat are found inside the airport whereas the wetland is located immediately outside the Airport towards the direction of Lake Tana. Line transect and point count methods were used to study diversity and relative abundance of birds [20] in and around the Airport.

Line transect method was used for relatively uniform areas of wetland and grassland habitats since the areas are open, while point count method was implemented in the relatively dense bushland and modified habitats [21]. Sampling plots and blocks were established for point and transect count methods, respectively. The number of sampling plot and blocks were determined according to the size and type of vegetation cover of the study habitats. The approximate width and length of the transect was on average 50m and 200m, respectively. Transects were separated from each other by 100m, and a total of 10 sample blocks (each comprising 5 transect lines), and 11 sample plots (each comprising 5 sampling points) were used in the densely vegetated habitat.

Bird-aircraft strike incidents and methods of its prevention were assessed by interviewing 26 respondents (23 males and 3 females) among 100 officers and field workers selected using purposive sampling method. Selection of the respondents was made based on the basis of relevance and relatedness of their duties to bird strike control activities in the study area.

Data collection

Point count method was used to collect data in the bushland and modified habitats, whereas transects were used in the wetland and grassland habitats. During point count method, suitable sites were chosen and birds were identified and counted from a fixed position within a circle of 25m radius for specific period of 10 minutes at every point. All birds seen and heard within this 25m radius were recorded. To minimize the disturbance during counting, a waiting period of 5 minutes prior to counting was applied.

Using the transect count method, birds were counted by walking at 2km/h and uniform pace throughout the whole transect. However, sometimes the speed of walking on the routes was determined by the number of birds present and the extent of difficulties in recording them.

Dry season data were collected from February – April 2020, and data for the wet season were collected from June – August 2020. Census data for both the dry and wet seasons were collected twice a day when most birds are active early in the morning (6:30-9:00 a.m.) and late in the afternoon (4:00-6:30 p.m.) for five days per month with a total of 150 survey hours during the whole study period.

Field observations were made to identify birds at species level using binocular of magnification power 10 and objective lens diameter of 50 (10 **x** 50), species identification were carried out using appropriate field guide book[22], and photographs were taken for further identification of birds. Movement pattern of birds that usually cross the runway was studied to evaluate the problems of bird to aircraft strike. The time of the day when the bird flight was the highest and activities performed by the birds such as flight direction and flock size were also recorded.

Structured interviews were employed to collect the required data to assess the status of bird-aircraft strike problems and their control methods applied in Bahir Dar International Airport. Secondary data on bird strike incidents were collected from Civil Aviation Authority Office, Bahir Dar Branch.

Data analysis

Association of birds and seasons with habitat types were analyzed using Chi-square test, and one way Analysis of Variance (ANOVA) was used to check the mean abundance of species difference among the four habitat types and between seasons. Moreover, bird species diversities in each habitats of the study area were calculated using Shannon-Wiener diversity (H'), and evenness (E) indices[3].

Shannon Wiener diversity index is calculates as:

$H' = - \Sigma Pi \times Ln (Pi)$

Where;

H' =Shannon-Wiener diversity index

Pi = the proportion of each species in the sample

Ln (Pi) = natural logarithm of this proportion

Species evenness is by Shannon's equitability index (E) which is calculated by:

$E = \frac{H'}{Hmax}$ where,

E= Shannon-Wiener evenness index

H' = Shannon-Wiener diversity index

Hmax = lns

Ln = Log normal

S = Total number of Species

Simpson's similarity index (SI) was also used to evaluate the similarity of species between two different habitats in both seasons using the following formula:
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 habitat 'A' and 'B'.

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

Relative abundance= $\frac{n}{N} \times 100$

Where,

n = Number of individual species

N = the total number of individuals of all species

Relative abundance values were used to ordinarily categorize each species under the following five abundance categories [21] (Table 5).

List Of Abbreviations

ANOVA: Analysis of Variance; IBAs: Important Bird Areas; IUCN: International Union for Conservation of Nature.

Declarations

Ethics approval and consent to participate

The study was evaluated and approved by Bahir Dar University, Science College, Research Ethical Committee, and permission is also given from Bahir Dar International Airport Office. Informed consent was obtained from all respondents who were participated during the interview and from the manager of Bahir Dar International Airport.

Consent for publication

Not applicable

Availability of data and materials

All data generated and analyzed during this manuscript preparation are available on the hands of the corresponding author.

Competing interests

All the authors declare that they have no competing interests.

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Authors' contributions

TT proposed the research idea, TT, DE and NT design the study, and participated in data collection, data organization, data analysis and preparation of the manuscript. All authors have read and approved the final manuscript.

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Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

Table 2: Species diversity of birds in the four study habitats

Habitat type	Seasons	No of species	No of individuals	H´	Hmax	E
Bushland	Dry	29	1016	3. 11	3.37	0.92
	Wet	35	1184	3.34	3.55	0.94
Grassland	Dry	21	947	2.78	3.04	0.91
	Wet	29	1073	3.22	3.36	0.95
Modified habitat	Dry	31	1145	3.20	3.43	0.93
	Wet	42	1720	3.59	3.73	0.96
Wetland	Dry	25	1239	2.94	3.22	0.91
	Wet	28	1628	3.14	3.33	0.94

Key: H'= Shannon-Weiner deiversity index, Hmax= lns, E= Shannon's equitability index

Table 3: Specie diversity of birds in the whole study area during dry and wet seasons

Seasons	No of species	No of individuals	H´	Hmax	E
Dry	69	4347	3. 89	4.23	0.92
Wet	79	5605	4.14	4.36	0.94

Table 4: Similarity of bird species among the study habitats during the wet and dry

Habitats	Bushland		Grassland		Modified habitat		Wetland	
	wet	dry	wet	dry	wet	dry	wet	dry
Bushland	1	1	0.64	0.65	0.74	0.54	0.64	0.63
Grassland	-	-	1	1	0.70	0.58	0.66	0.65
Modified habitat	-	-	-	-	1	1	0.64	0.57
Wetland	-	-	-	-	-	-	1	1

Table 5: Relative abundance score categories

Relative abundance	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

Figures

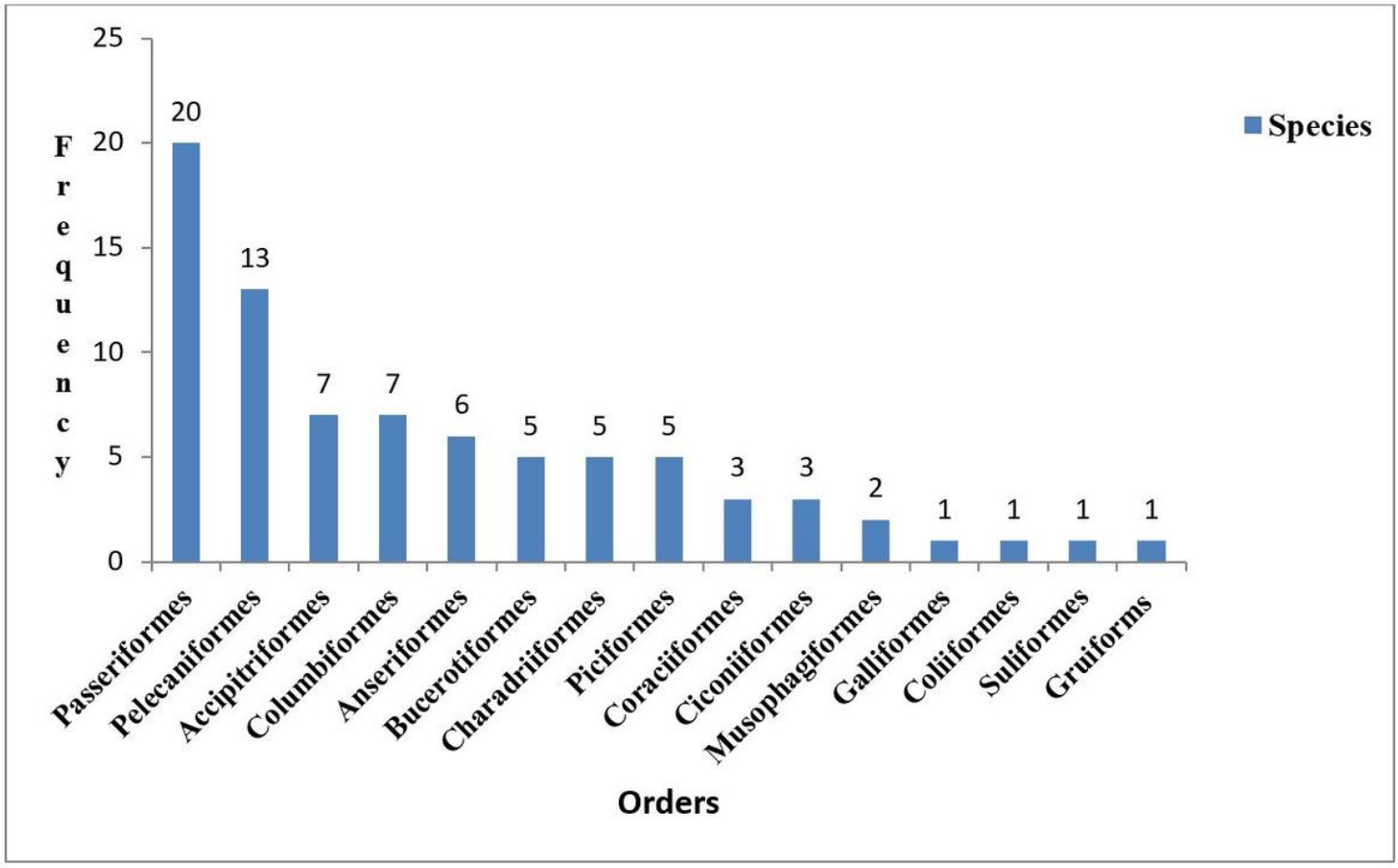

Figure 1

Frequencies of species within each order

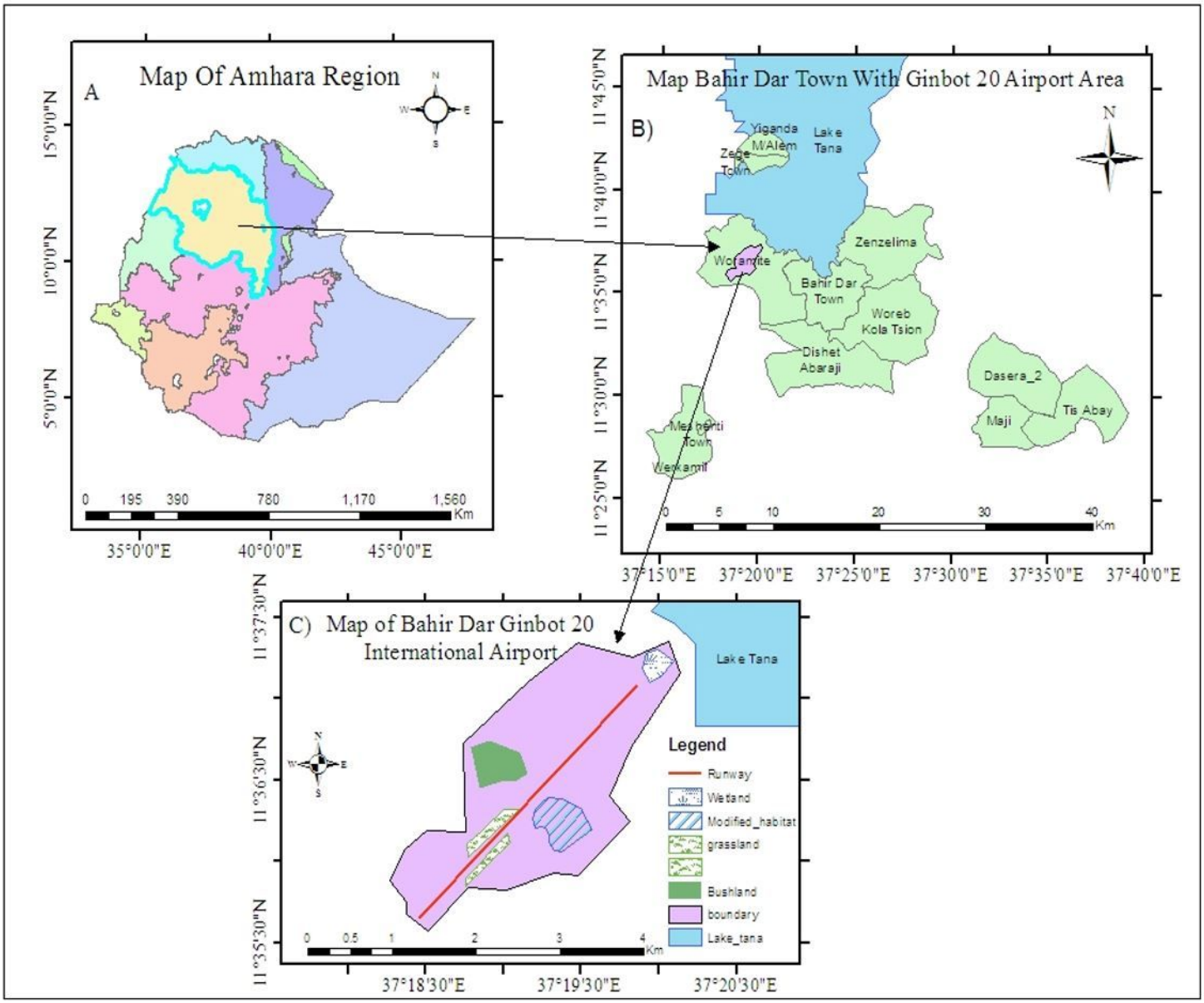

Figure 2

Location map of the study area

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarydata.docx
- Table1.jpg
- Table1a.jpg
- Table1b.jpg