BIRD DIVERSITY AND FACTORS AFFECTING BIRD ABUNDANCE AT DULLU MUNICIPALITY, DAILEKH, NEPAL

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Ecology and Environment

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Tribhuvan, University

Kirtipur, Kathmandu, Nepal

September 2021

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself and has not been submitted elsewhere for the award for any degree. All sources of information have been acknowledged explicitly by reference to the author(s) or institution(s).

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RECOMMENDATIONS

This is to recommend that the thesis entitled "Bird diversity and factors affecting bird abundance at Dullu Municipality, Dailekh, Nepal" has been carried out by Mr. Sadip Bikram Shah for the partial fulfillment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institution.

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CERTIFICATE OF ACCEPTANCE

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
asl	Above sea level
GPS	Global Positioning System
IUCN	International Union of Conservation of Nature

Abstract

Seasonality, social disturbances, and availability of ecological requirements play an essential role in bird distribution, diversity, and survivability in any ecosystem. The study was carried out in Dullu Municipality Dailekh District to identify the bird diversity and factors affecting bird abundance. The point count method was used for bird surveys during the winter and summer season of 2020. Altogether 98 bird species belonging to 11 orders and 38 families were recorded. The highest species richness was found for order Passeriformes and Muscicapidae family. Among recorded species, the higher species richness of birds was found during winter than summer season, and 52 bird species were observed at both seasons. The winter season had more diverse bird species than summer; however, these were more evenly distributed in summer than in the winter season. Among 98 species, the higher bird species were resident, followed by winter migrants, summer migrants and passage migrants. Himalayan Vulture (*Gyps himalayensis*) and Alexandrine Parakeet (*Psittacula eupatria*) were threatened species found in the study area. Forest habitats had more diverse bird species than agricultural land. Different environmental parameters such as nearest distance to the water source, canopy cover, and nearest distance to forest habitat had a significant effect on bird occurrences. The species richness was positively correlated with the nearest distance to agricultural land for both seasons; however, it decreased with increasing distance to water source and canopy cover. In Dullu Municipality presence of migratory, residential, endemic, and threatened bird species indicated the uniqueness of the bird habitat in the area; therefore, a site-specific management plan is necessary to conserve these bird species.

1. INTRODUCTION

1.1 Background

Nepal, the transition zone between the Oriental and Palearctic zoogeographic realms, supports the occurrence of diverse flora and fauna with global biodiversity hotspots (Sarkar et al. 2018, DNPWC 2018). The elevational gradient also supports the presence of various flora and fauna in altitudinal range at five distinct eco-physiographical regions, including the Himalaya (above 5,000 m asl), High Mountains (between 3,000 and 5,000 m asl), the Middle Mountains (between 1,000 and 3,000 m asl), Siwalik Hills (between 500 and 1,000 m asl) and the flat, lowlands of Tarai (< 500 m asl) (LRMP 1986, Kutal et al. 2021) and presence of 35 forest types and 118 ecosystems in Nepal (MoFSC 2009) which comprises a wide range of habitat types in tropical, subtropical, temperate, sub-alpine and alpine zones (Inskipp 1989). The climate of Nepal varied due to summer and winter seasons with significant seasonal variation (Hagen 1998), which supports the occurrence of species under different habitat structures (Sarkar et al. 2018).

Nepal supports the occurrence of 886 bird species (DNPWC 2018) which is around 8.5% of global bird species. Among these species, one is endemic Spiny Babbler (*Acanthoptila nipalensis*), approximately 560 residential and remaining are seasonal migratory bird species (Shrestha 2016, Grimmett et al. 2016, Inskipp et al. 2016). Although higher numbers of the bird species are residents, only a small number of these birds are sedentary, and most of these are elevational migrants over short distances depending on the weather condition and food availability (Grimmett et al. 2000, Inskipp et al. 2016). Among the migratory, around 62 bird species are summer visitors mainly immigrate from the South like India, Sri Lanka, and 150 are winter visitors and 71 vagrant primarily migrating from Northern and Central Asia, and some of which are also passage migrants (Grimmett et al. 2016, Inskipp et al. 2020).

The spatial distribution of bird species, breeding success, and survival is influenced by the availability of key resources, including food, water, vegetation cover, and weather condition (Mengesha and Bekele 2008, McCain 2009, Lee et al. 2012, Adhikari et al. 2020). While using these resources, bird species become an integrated part of ecosystem services at forest and farmland ecosystems (Mulwa et al. 2012, Katuwal et al. 2021). Their usefulness to farmers is reported as for seed dispersal, snakes and harmful pests

control in crops, environment cleaning as a natural scavenger, and crop pollination (Singh 2007, Aynalem and Bekele 2009, Inskipp and Baral et al. 2010, Maas et al. 2013, Katuwal et al. 2021). Birds can also be important components of tourism industries (Areaya et al. 2013, Katuwal et al. 2020); however**,** many wildlife species are at risk of extinction in response to anthropogenic activities, including climate change, habitat alteration or loss, deforestation, wildlife trade, biological invasion, infrastructure, or combinations of these and other factors (Owens and Bennett 2000, Thomas et al. 2004, Sharma et al. 2014, Pyšek et al. 2017, Symes et al. 2018, Johnson et al. 2020).

Seasonality is one of the significant factors affecting bird diversity that influences key resources availability (Gavashelishvili and McGrady 2006, Mengesha and Bekele 2008, Katuwal et al. 2016, Pandey et al. 2020). Effects of seasonal changes can be noticed due to abiotic and biotic factors across several eco-regions, which affect the physiological changes in birds that cause bird migration to maximize the breeding success and high resource availability (Shoo et al. 2005, Thakuri and Pokhrel 2017, Amani et al. 2018, Huang et al. 2019, Pandey et al. 2020). Therefore, seasonal change is one factor that influences bird abundance through migration (Almazan et al. 2015, Werema and Howell 2016). The diversity, abundance, and distribution of birds are also affected by foraging opportunities and suitable nesting sites at the varied land cover, including forest, shrubs, grasslands, wetlands, agricultural land, and urban areas (Rahbek and Graves 2001, Price et al. 2014, Hu et al. 2017).

The knowledge of seasonal bird abundance and habitat used is crucial for bird monitoring and management plans. In addition, the knowledge of seasonal distribution and habitat use of birds are important for the conservation in the areas where anthropogenic activities are significant factors (Zhang et al. 2009, Price et al. 2014, Belay and Yihune 2017, Amani et al. 2018, Huang et al. 2019, Katuwal et al. 2021). The anthropogenic pressure and other environmental changes can affect the species' spatial distribution due to modification and habitat loss (Lee et al. 2012). Furthermore, the effects of deforestation and livestock grazing on the land cover and food requirement pose threats on the bird abundance and distribution (Mengesha et al. 2011). Therefore, understanding the factors that affect bird abundance and distribution at spatial and temporal changes is essential for planning and developing species conservation strategies.

1.2 Objectives of the study

The general objective of this study was to identify the bird diversity and factors affecting bird abundance at Dullu municipality Dailekh, Nepal.

Specific objectives

The specific objectives were:

- To categorize the seasonal variation of bird species in Dullu Municipality.
- To identify the factors affecting on bird abundance in Dullu Municipality.

1.3 Rationale of the study

Currently, many bird species are under survival threats globally due to anthropogenic pressure, habitat fragmentation, habitat loss, biological invasion, pesticide use, food shortage, water pollution and poisoning, hunting, trapping, and destruction of feeding and nesting sites (Kurosawa and Askins 2003, Baral and Inskipp 2005, Inskipp and Baral 2010, Baral et al. 2012, Belay and Yihune 2017). In addition, land use is changing, and urban areas are increasing with increased infrastructure and their expansion with loss of forest, agricultural land (Sodhi et al. 2010, Holden 2015, Delphin 2016, Rijal et al. 2020), which influenced the species occurrence (Lira 2012). Dullu lies in the tropical and subtropical climatic zone and might support varied flora and fauna because of its location and climatic variation in mid-hill regions. Currently, many infrastructural developments can be found, and some of these are under construction, which is encroaching on the natural forest and agricultural land. These might affect the occurrence of bird species. However, the occurrence of bird species and their habitat use in the rapidly growing area of Dullu Municipality is little known. These data deficiencies may create the problem of developing a policy for the conservation of species. Therefore, findings of this study help to provide the baseline data on the occurrences of bird species and existing habitats. These data can be used for the conservation of avifauna of this area concerned authorities or policymakers.

2. LITERATURE REVIEW

The scientific ornithological research work in Nepal had started in the mid-19th century by Brian H Hodgson. The first field guide book on the birds of Nepal was produced by Fleming et al. (1976); later on, Carol and Tim Inskipp contributed several works for updating the status of Nepal's birds (Baral et al. 2012). Numerous literatures are available after 1990 and are followed by the publication of BCN in the newsletter Danphe in 1992. In addition, many books are available on birds, and the rapid publications of books also help guide the tourists in Nepal.

2.1 Bird diversity and seasonal variation

Climate is a prominent characteristic of mountain ecosystems that can influence bird species richness and composition (Shoo et al. 2005). The environmental factors play a vital role in generating patterns of species richness, among which the seasonality is one of the major factors affecting the avian diversity and dynamics in several eco-regions (Gavashelishvili and McGrady 2006, Price et al. 2014), which influence the diversity because different seasons have different abiotic (temperatures, precipitation, and humidity) and biotic (food resources and species interactions) conditions that vary across several eco-regions which affect the migration of avian species (Amani et al. 2018, Huang et al. 2019).

The diversity of bird species varies with season and climatic conditions. For example, higher bird diversity in winter than in summer was recorded for Kirtipur (Poudel 2005), probably due to watershed areas like Bagmati River and Taudaha near Kirtipur. In addition, a similar condition was found in the study of Basnet et al. (2005) at Raja Rani Community forest, Morang. This study indicated that the higher species richness was found in winter followed by spring, autumn, and summer. Higher species richness in winter and spring than other seasons was recorded at Nagarjun Forest, Kathmandu (Malla 2006). Similarly, higher bird species were found in winter than summer season at Fewa Lake, Pokhara, due to higher winter migratory birds (Giri and Chalise 2008). However, bird species richness and diversity were higher in the summer than winter season at Mardi Himal in the Annapurna Conservation Area of the central Himalaya, Nepal (Pandey et al. 2020).

A higher number of species was found in the dry season than in the rainy season in a dry forest of Southwestern Mexico (Almazan et al. 2018). Maximum numbers of individuals were recorded during winter followed by summer and rainy season, whereas Muscicapidae was the most dominant family in the forest habitat of Jeolikote, District Nainital, India (Singh et al. 2018).

Seasonality affected the bird species richness in the urban area and became higher during the breeding period, i.e., in spring and summer, due to unfavorable climatic conditions, shortage of food, and predation in the winter season (Murgui 2007). Urbanization and seasonality affect the bird communities, and consequently, the higher bird species were recorded in the summer than winter season (Katuwal et al. 2018). Thakuri (2009) found a higher number of species was recorded during the spring season than the winter season from the year-round survey and high bird species of winter visitors than summer visitors. Among the migratory birds, the maximum species was recorded in early winter and was followed by summer, spring, late winter in the Lakkavalli range forest of western Ghat, India (Harsha and Hosetti 2009). However, Katuwal (2013) recorded the high species richness of birds in the post-monsoon season and low in the pre-monsoon season in Manaslu Conservation Area and suggested that the number of bird's records varied according to season. Belay and Yihune (2017) found no variation in the bird occurrence among the habitats; however, the season affected bird abundance in a woodland habitat in and around Zengo Forest, Ethiopia, during the wet and dry seasons. The variation in the bird abundance per plot was found between the dry and wet seasons in the grassland habitat (Girma et al. 2017). The abundance of migratory bird species between dry and wet seasons had varied (Girma et al. 2017). In many areas, the residential birds were higher than migratory (Thakuri 2009, Katuwal et al. 2016, Singh et al. 2018, Adhikari et al. 2019, Pandey et al. 2020) because they adapt to the local habitat. However, at Fewa Lake, Pokhara migratory birds were higher than residential due to the migratory area at the studied lake (Giri and Chalise 2008).

2.2 Threats on birds and habitats use

Nepal comprises a wide range of habitat types in tropical, subtropical, temperate, sub-alpine, and alpine zones (Inskipp 1989). Gavashelishvili and McGrady (2006) reported that the environmental factors play a vital role in generating patterns of species richness in Nepal; around 77% of breeding and 67% of wintering bird species utilize the forest or

shrubland habitat. Birds are good indicators of the ecological status of the ecosystem, structure and composition of habitat, and the impact of land-use change on biodiversity (Bolwig et al. 2006). Habitat destruction, deforestation, habitat fragmentation, intensification of agriculture, use of pesticides, hunting, lack of nesting trees and food were the main threats for avian fauna (Kurosawa and Askins 2003, Price et al. 2014, Belay and Yihune 2017, Ashoori et al. 2018, Katuwal et al. 2021). Nowadays, the natural forest is converting into modified landscapes due to the increasing population growth and demands for agricultural activity, which affect the suitable habitat by changing the landscape heterogeneity and biodiversity (Laurance et al. 2014).

In addition, the bird abundance was affected by vegetation composition, altitude, and climate because it affects the availability of food which enhances the migration (Girma et al. 2017). In Nepal, the higher bird species were inhabited in forest flowed by wetlands, grassland, cultivation, open country, scrub, near human habitation, and semi-desert (DNPWC 2011). Forest supports the occurrence of bird species; for example, disturbed forest and indigenous forest had a high species richness compared with farmlands and plantation forest (Bett et al. 2016). However, according to season, it was sometimes varied; the higher number of bird species was recorded on farmland during the dry season and forest habitats during wet seasons (Belay and Yihune 2017).

2.3 Factors affecting bird diversity

Temperature, precipitation, resource availability, tree canopy, open grass/ground, native-exotic plants, ground-story variation, human activities, green spaces, buildings, disturbance, agricultural land, forest, road, human settlement, watercourses, and reservoirs are the essential variables in predicting species diversity and distribution in different habitats (Jasmani et al. 2017, Ciach and Frochlich 2017, Juliyana and Soladoye 2018, Zhou et al. 2018, Callaghan et al. 2018, Ashoori et al. 2018, Rashidi et al. 2019, Hanle et al. 2020, Pandey et al. 2020). Jasmani et al. (2017) mentioned that the percentage of tree canopy cover, open grass/ground, native-exotic plants are the important predictors of bird occurrence, and probably these shelter them, food to the bird species.

3. MATERIALS AND METHODS

3.1 Study Area

The study area situated at Dullu Municipality (28° 45' 32" N to 28° 54' 24" N and 81° 31' 25" E to 81° 41' 29" E) at Dailkekh district of Karnali Province. The area comprises 156.77 km^2 and is located at an elevation of 570 m to 1800 m from sea level (Figure 1). The Mahabharata range surrounds Dullu Municipality. The area was famous for its recognition as the capital of the Kingdom of Sinja and Nepalese stone tabloid, which is supposed to be written in the Nepali language for the first time. The climatic weather of the area varied, and the average temperature of the site is 21°C, and the annual precipitation is about 1377 mm, whereas the highest average temperature of Dailekh is 34°C in May and the lowest is 19°C in January 2020. The study area is located in a sub-tropical region with dominated chir pine-broadleaf forest. The vegetation of the study area is Chir Pine *(Pinus roxburghii)*, Oak *(Quercus incana)*, Woolly-leaved Oak *(Q. lanata)*, Anyaar *(Lyonia ovalifolia)*, Mauwa *(Engelhardtia spicata)* and Coral Tree *(Erythrina stricta)*. The fauna of the study area includes Chukar Partridge (*Alectoris chukar*), Kalij Pheasant *(Lophura leucomelanos)*, Intermediate Egret *(Mesophoyx intermedia)*, Black Bulbul (*Hypsipetes leucocephalus*), Blue Whistling Thrush (*Myophonus caeruleus*), Crested Kingfisher (*Megaceryle lugubris*) and fish like Snow Trout (*Schizothorax nepalensis)*, Golden Mahaseer (*Tor putitora)* and Common Snowtrout (*S. richardsoni)* (Yasin 2017, Acharya and Paudel 2020).

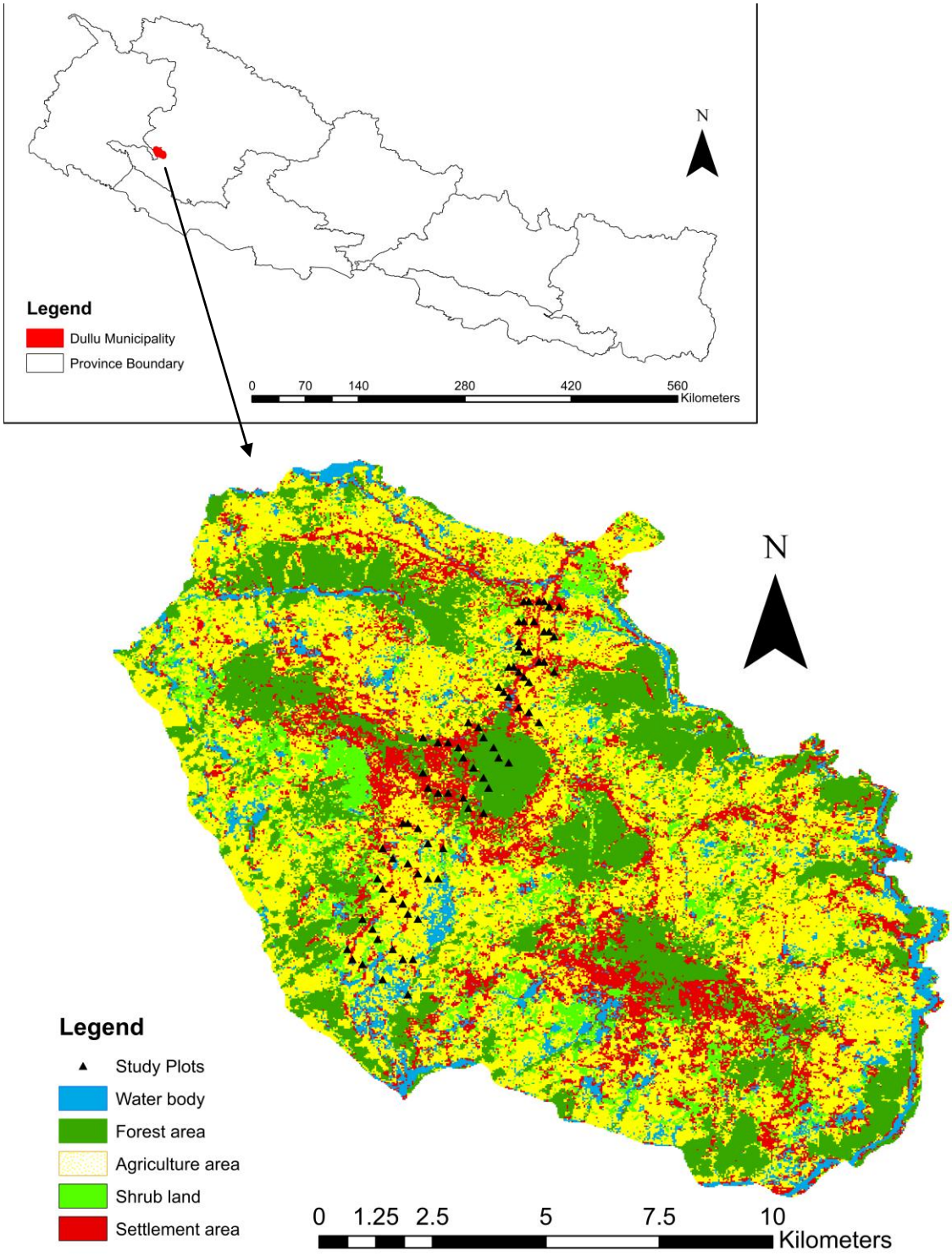

Figure 1 Map showing study area

3.2 Materials

• GPS: Global Positioning System (Garmin Etrex 10)

• Camera: Canon DS126371 with 75-135 mm telelens

• Binocular: Bushnell Falcon 10×50

• Field guide book “Birds of Nepal” (Grimmett et al. 2016)

• Record sheets

3.3 Methods

3.3.1 Bird observation

Before regular bird observation, transects and observation plots were established in October 2019 in the study area. Bird observation was carried out in the winter (2 January to 21 February 2020) and summer (3 May to 22 June 2020) seasons. A total of 21 transects were established, and the average length of the transect was 880.95 ± 187.40 m SD within the range of 500 m to 1000 m. The transect was established perpendicular to the road/footpath, and the interval between the two transects was 250 m. A circular plot of a 50 m radius was established at the interval of 250 m along the transect. Altogether 74 plots were established during this study. A point count method was applied, and the number of birds and species in both winter and summer seasons were recorded in each plot. Birds were recorded between 7:30 am to 11:30 pm in winter, and 6:30 am to 10:30 am in summer. In the beginning, a five-minute time was spent in each plot to make the area quiet so that the area becomes natural, i.e., no disturbances due to the observer's presence. The number and species of the birds were recorded for 20 minutes at every five minutes interval. Altogether 24 visits were made, spending 12 days in each season in the field. The birds were observed using Bushnell Falcon 10×50 wide-angle binocular. Birds were identified in the field, and unidentified bird pictures were taken using Canon DS126371 camera for reference. A field guidebook of Grimmet et al. (2016) was used for bird identification, and expert consultation was performed for final confirmation. The highest numbers of birds for each species recorded during 20 minutes were used for data analysis. The residential and migratory status of birds was assessed with the help of the field guidebook Grimmet et al. (2016). Threatened categories of each species were categorized using the National Red List of Nepal birds (Inskipp et al. 2017).

3.3.2 Habitat survey

For habitat utilization of bird species in the study area, habitat influencing variables such as numbers of trees, the height of each tree, tree canopy, habitat type (agricultural land or forest area) of each plot were recorded. The numbers of trees > 2 m in height were

counted, the height of each tree was measured using a clinometer, and the tree canopy by using a densitometer. The tree canopy was recorded from the center of each plot. Each plot's elevation, aspect, latitude, and longitude were also recorded using Garmin Etrex 10 GPS and clinometer. In addition, the nearest distance of each plot's center to the forest, agricultural land, road, household, and water sources was also recorded. The closest distance to these sources was measured using measuring tape; however, the distance > 500 m was measured using Geographic Information System.

3.3.3 Data analysis

Ecological analyses such as Shannon-wiener diversity and Evenness Index were calculated from the collected data. In addition, the bird species were categorized into five feeding guilds (omnivorous, insectivorous, frugivorous, carnivorous, and nectarivorous), and residential, summer migrants, winter migrants and passage migrant (Inskipp et al. 2016).

Shannon Wiener diversity index

Shannon Wiener diversity index was used to calculate the species diversity

$$H' = -\sum P_i \log P_i$$

Where $P_i = n_i/N$

H' = Index of species diversity

P_i = the proportion of individuals in the i^{th} species $= n_i/N$

n_i = Importance value for each species (number of individuals)

N = Total importance value (Total number of individuals)

Evenness index

An evenness index was used to calculate whether species were distributed evenly across seasons and different land-use types.

$$E = H'/\log S$$

Where H' = Shannon-Wiener's diversity index.

S = Species richness is the total number of species

Logistic regression was used to estimate the effects of canopy cover (%), distance to nearest settlement (m), agricultural habitat, forest habitat, distance to the nearest road (m), distance to the nearest water source (m), and elevation (m) on the richness of bird species. All combinations of variables without interactions were run. Before conducting logistic regression, correlation analysis was done between each variable to exclude those variables that were strongly correlated with $|r| > 0.7$ in the same model (Libal et al. 2011). Models were ranked by using the Akaike Information Criterion adjusted for small samples (AICc; Burnham and Anderson 2002) and used Akaike model weights to estimate the relative strength of evidence for each model. Model averaging was done using all models to estimate 95% confidence intervals for each variable and accepted statistical significance at $\alpha < 0.05$.

4. RESULTS

4.1 Bird Diversity

A total of 1911 individuals of birds belong to 98 species from 11 orders (Figure 2; Appendix 1), and 38 families (Figure 3) were recorded during this study. Order Passeriformes had the highest richness (77 species; 78.57%; 26 families) followed by Piciformes and Coraciiformes (three species; 3.06%; two families in each order), Accipitriformes Psittaciformes and Columbiformes (three species; 3.06%; one family), Galliformes (two species; 2.04%; one family), Cuculiformes; Strigiformes; Pelecaniformes and Bucerotiformes (one species; 1.02% in each family). Family Muscicapidae and Phylloscopidae had 10 bird species which was the higher number of bird species during this study (Figure 3; Appendix 3).

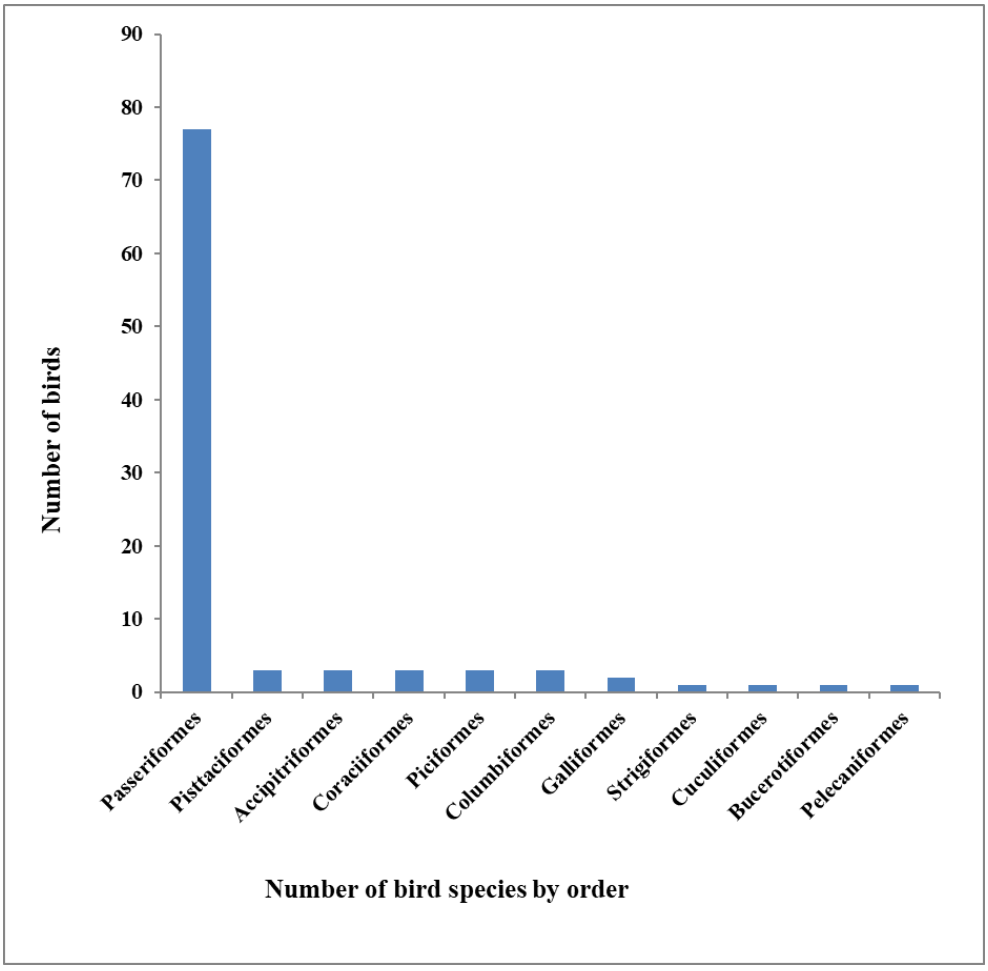

Figure 2 Number of bird species in different Orders

Among the observed birds, two species Alexandrine Parakeet (*Psittacula cupatria*), and Himalayan Vulture (*Gyps himalayensis*), are under the Near Threatened (NT) category of the IUCN Red List. Three species, Chukar Partridge (*Alectoris chukar*), Yellow-bellied Prinia (*Prinia flaviventris*), and Alexandrine Parakeet (*Psittacula cupatria*) are nationally Near Threatened species, and Hume's Bush Warbler (*Cettia brunnescens*) and Himalayan Vulture (*Gyps himalayensis*) under the Vulnerable (VU) category. The Black-throated Thrush (*Turdus atrogularis*) is under data deficient (DD) species (Table 2; Appendix 1).

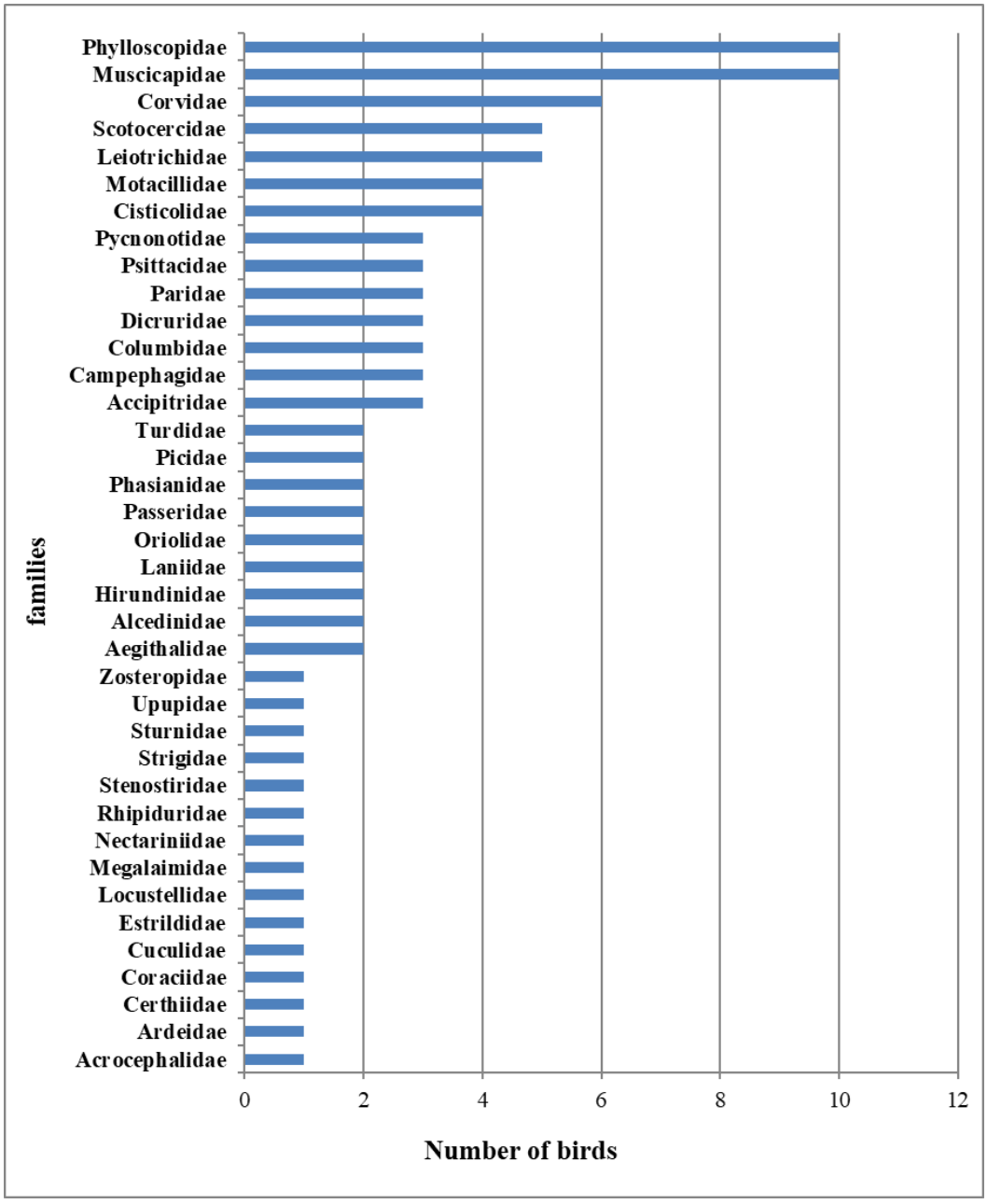

Figure 3 Bird species in different families at Dullu Municipality

The Shannon–Wiener diversity index and evenness were found 3.951 and 0.861, respectively. Resident species (n = 89) had greater species richness than migratory (n = 9) (Figure 6). Among the feeding guilds, the insectivorous were recorded as the highest number (n = 56) of bird species followed by omnivorous (n = 20), carnivorous (n = 8), granivorous (n = 6), frugivorous (n = 6) and nectarivorous (n = 2) (Figure 4; Appendix 1).

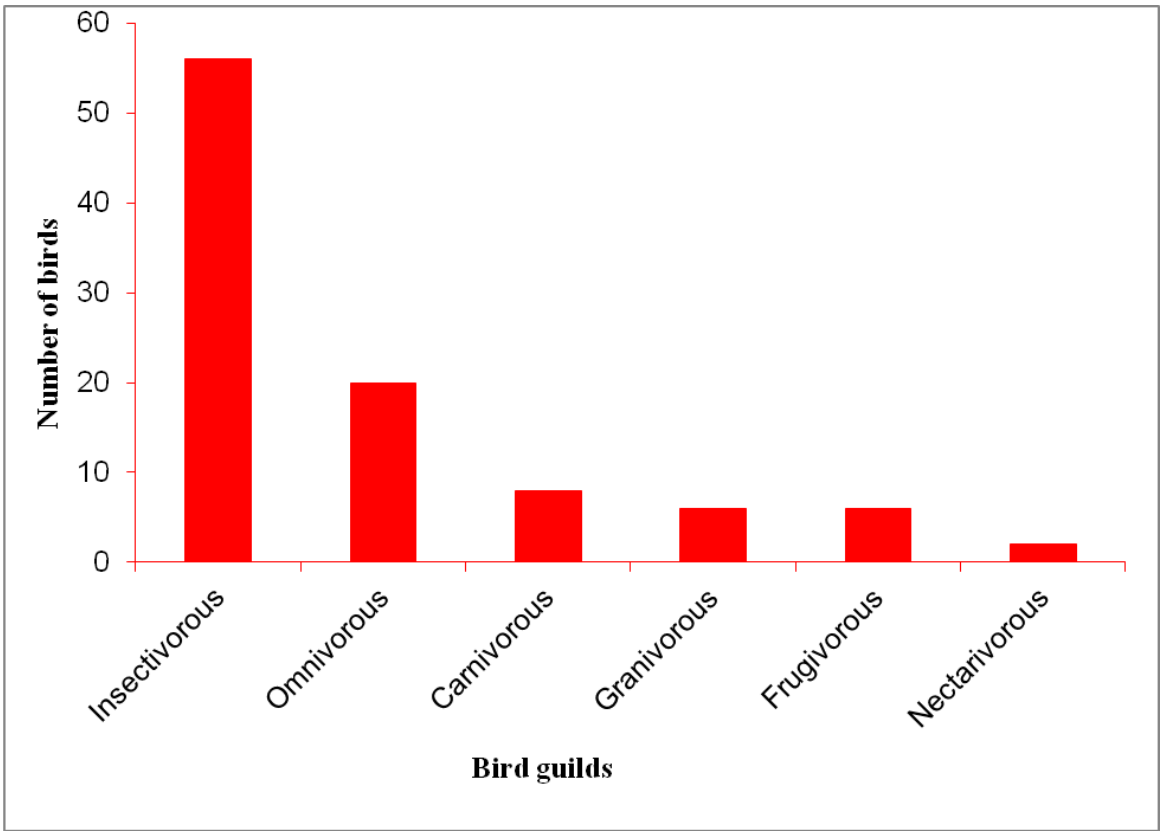

Figure 4 Bird under the bird guilds in Dullu Municipality

4.2 Bird's seasonal variation

Nine out of 11 orders of birds were recorded in both winter and summer seasons. Two order Cuculiformes and Pelecaniformes were found only in the summer season. Order Galliformes and Passeriformes were recorded higher species number 66.67% and 61.74%, respectively, in the winter season, whereas birds under Accipitriformes were recorded with a higher number (75%) in the summer season. No variation in the number of birds was recorded for order Columbiformes, Coraciiformes, Psittaciformes, Piciformes, Bucerotiformes, and Strigiformes in the summer and winter season (Figure 5).

Bird species richness was varied with seasons (summer only: 11, winter only: 35, common in both seasons: 52; Appendix 2). Higher bird abundance (n = 1071) was found in the winter season than in summer (n = 840). The Black Bulbul (*Hypsipetes leucocephalus*), Aberrant Bush Warbler (*Cettia flavolivacea*), Grey Breasted Prina (*Prinia hodgsonii*), Kaliz Pheasant (*Lophura leucomelanos*), Slaty-Headed Parakeet (*Psittacula himalayana*), Chukar Partridge (*Alectoris chukar*), Greenish Warbler (*Phylloscopus trochiloides*) and Blyth's Leaf Warbler (*Phylloscopus reguloides*) were highly abundant bird species in the winter season, whereas Barn Swallow (*Hirundo rustica*), Great Tit (*Parus major*), Rose Ring Parakeet (*Psittacula krameri*), Oriental Turtal Dove (*Streptopelia orientalis*), Common Stone Chat (*Saxicola torquata*), Red Rumped Swallow (*Hirundo daurica*), Rock Pigeon (*Columba livia*), Asian Koel (*Eudynamys scolopacea*) and Spotted Dove (*Streptopelia chinensis*) were abundant in summer season (Appendix 1, 2). Common Myna (*Acridotheres tristis*), Himalayan Bulbul (*Pycnonotus leucogenys*), Red Vented Bulbul (*Pycnonotus cafer*), House Sparrow (*Passer domesticus*), and Rufous Treepie (*Dendrocitta vagabunda*) were the most abundant bird species in both seasons (Figure 5; Appendix 2).

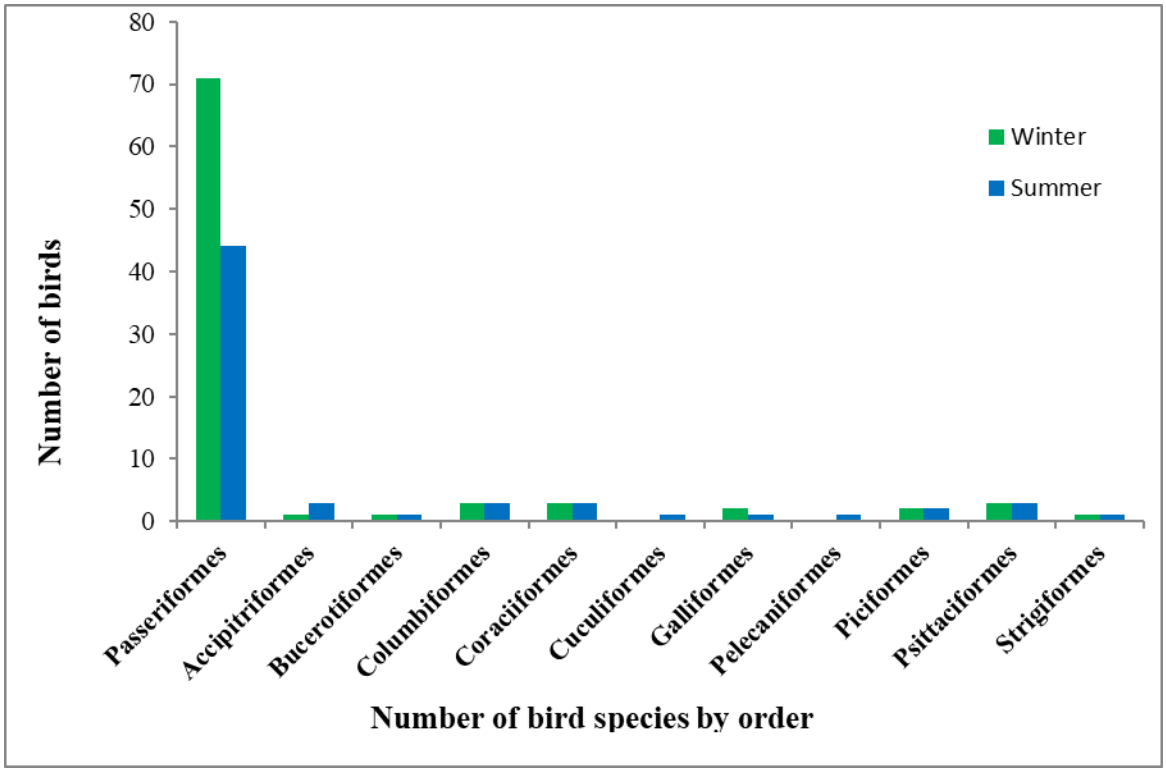

Figure 5 Occurrence of species in different season

Around 91% of bird species were resident, followed by winter migrants (7%), and the remaining (2%) were summer and passage migrants (Figure 6). Residential birds were more abundant in winter (n = 80) than summer season (n = 61). Seven winters and one summer migrant species were recorded during this study. Spiny Babbler, an endemic species were found in both seasons, and passage migrant Western Crowned Warbler was recorded only in the summer season.

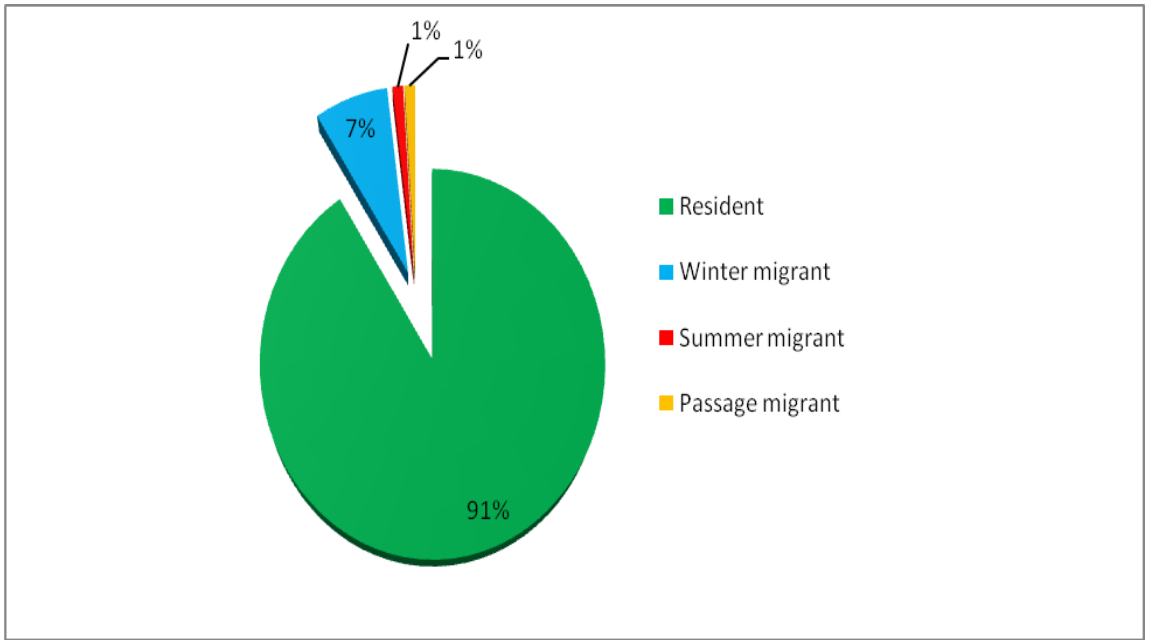

Figure 6 Status of birds passage migrants to residents in Dullu Municipality

Winter season had more diverse bird species (H = 3.793) than summer (H = 3.586), however these were more evenly distributed in summer (E = 0.866) than winter season (E = 0.849) (Table 1).

Table 1: Bird diversity index according to seasons in Dullu Municipality

Season	Species richness	Shannon Wiener diversity index	Evenness
Winter	87	3.793	0.849
Summer	63	3.586	0.866

The species accumulation curve showed that the frequency of adding new birds to the list was more in the winter than summer season (Figure 7). The curve showed a rapid rise in the winter season and a gradual rise in the summer season. At the beginning survey, every record of new species was increased, and new records decreased in upcoming observations.

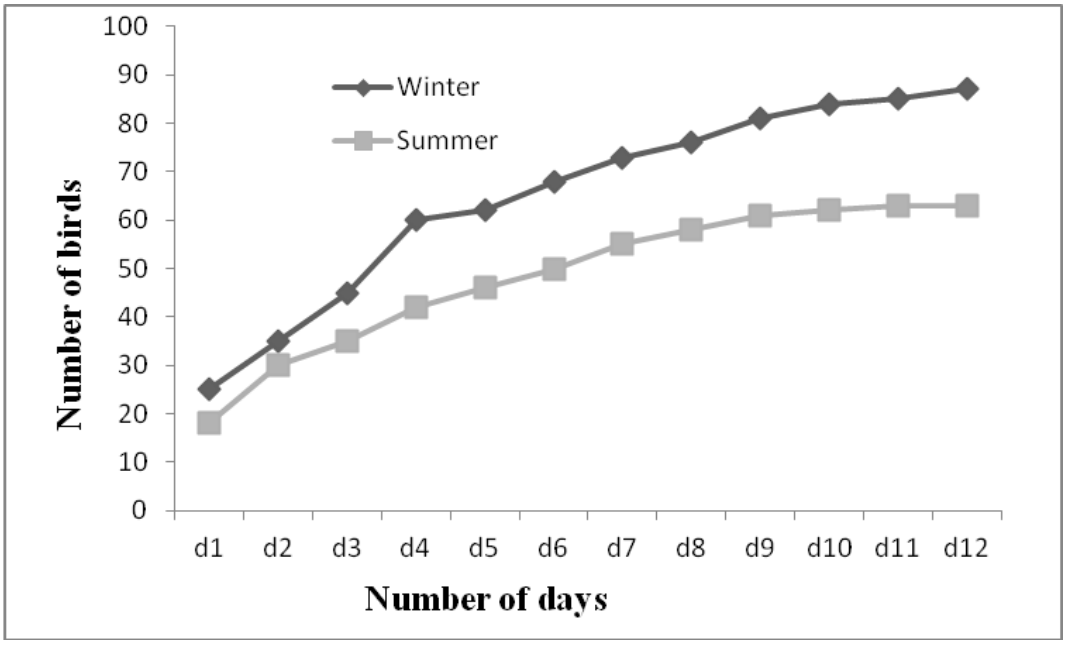

Figure 7 Species accumulation curve: The graph shows the cumulative total number of species seen during the summer and winter seasons in the study area

Among the feeding guilds, the insectivorous and omnivorous bird species were more abundant in winter than summer season except for carnivorous species (Figure 8).

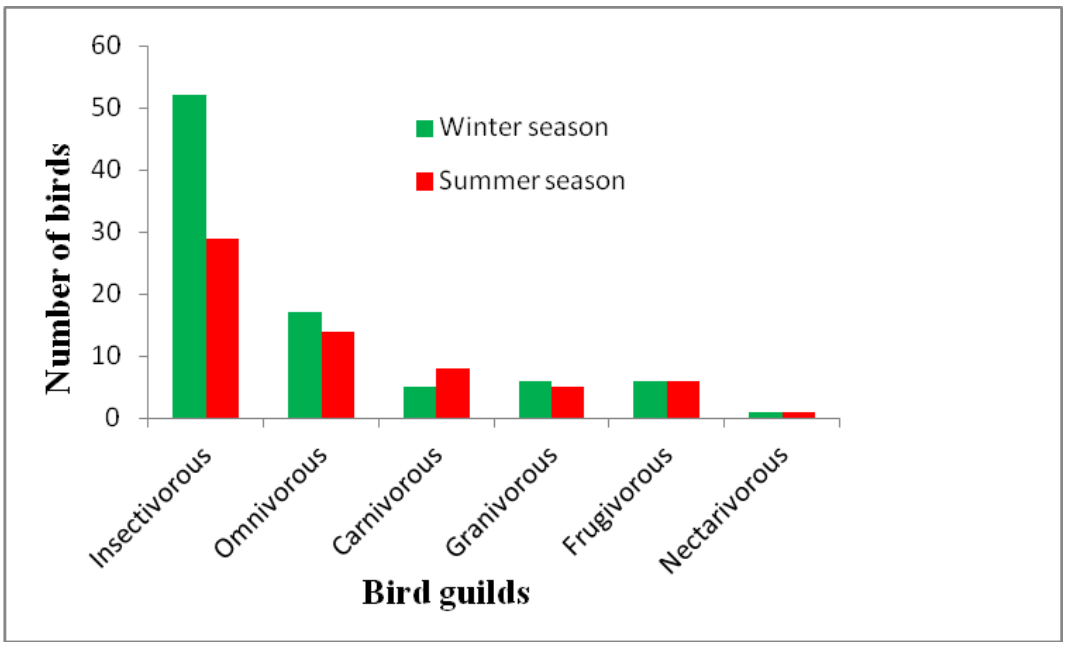

Figure 8 Bird guilds in different seasons

Among nationally vulnerable species, Himalayan Vulture was found only in summer, and Hume's Bush Warbler was found only in the winter season. Among nationally near-threatened species, Alexandrine Parakeet and Chukar Partridge were found in both

seasons, whereas Yellow-Bellied Prinia and the data deficient Black-Throated Thrush was found only in the winter season (Table 2).

Table 2: Threatened status of bird in the Dullu Municipality, Dailekh. Status based on IUCN Red List category (iucnredlist.org) and National Red list Series 2015. NT = Near Threatened, LC = Least Concern, VU = Vulnerable, Res = Resident, W = winter, Sum = summer, F = Forest, Ag = Agriculture

Name of Bird	**Scientific Name**	**International IUCN Category**	**National**	**Migration Status**	**Seasonal Occurrence**	**Habitat Occurrence**	**Feeding Guild**
Alexandrine Parakeet	*Psittacula eupatria*	NT	NT	Res	W/Sum	F/Ag	Frugivorous
Chukar Partridge	*Alectoris chukar*	LC	NT	Res	W/Sum	Ag	Omnivorous
Himalayan Vulture	*Gyps himalayensis*	NT	VU	Res	Sum	Ag	Carnivorous
Hume's Bush Warbler	*Cettia brunnescens*	LC	VU	Res	W	Ag	Insectivorous
Yellow-bellied Prinia	*Prinia flaviventris*	LC	NT	Res	W	Ag	Insectivorous

4.3 Bird diversities in agricultural and forest habitat

Forest had more diverse bird species (H = 3.81) than agriculture (H = 3.628) and also birds were more evenly distributed in Forest (E = 0.894) than agriculture (E = 0.846) (Table 3).

Table 3: Diversity index according to habitats

Habitat	Species richness	Shannon wiener diversity index	Evenness
Agriculture	73	3.628	0.846
Forest	71	3.81	0.894

In the study area, the carnivorous and nectarivorous species were more abundant in agricultural habitats than in the forest. But in the forest, the species richness of others bird species was marginally higher than the agricultural habitats except for insectivorous species (Figure 9).

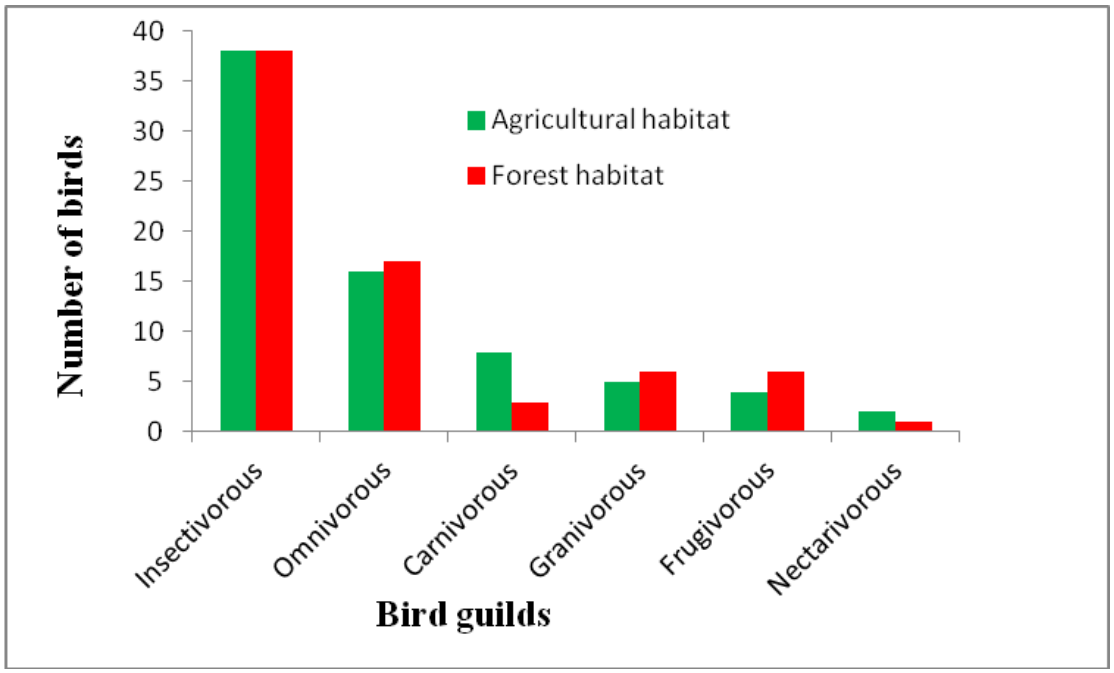

Figure 9 Bird guilds in different habitats

4.4 Factors affecting on birds abundance

The bird occurrence was varied according to season, and different factors influenced the species richness. The average number of trees in the observation plot was 22.784 ± 12.182 (mean ± SD) (range: 1 to 52), and the average tree canopy percentage was 29.932% (range: 5% to 80%). The nearest distance to road from the observation plot was 562.838 ± 291.672 m (mean ± SD) (range: 200 to 1200 m), household 366.9595 ± 282.279 m (mean ± SD) (range: 25 to 1250 m), water source 347.9054 ± 289.08 m (mean ± SD) (range: 10 to 1250 m), forest 531.351 ± 621.42 m (mean ± SD) (range: 0 to 2000 m) and agricultural land 163 ± 274.5 m (mean ± SD) (range: 0 to 1000 m) from the plot. The species richness was increased with increasing the distance to road, distance to

household, distance to the nearest forest in the summer season, and decreased in the winter season (Figure 10 a-h). The species richness was increased with the nearest distance to agricultural land for both seasons; however, it was decreased with increased distance to water source and canopy cover (Figure 10).

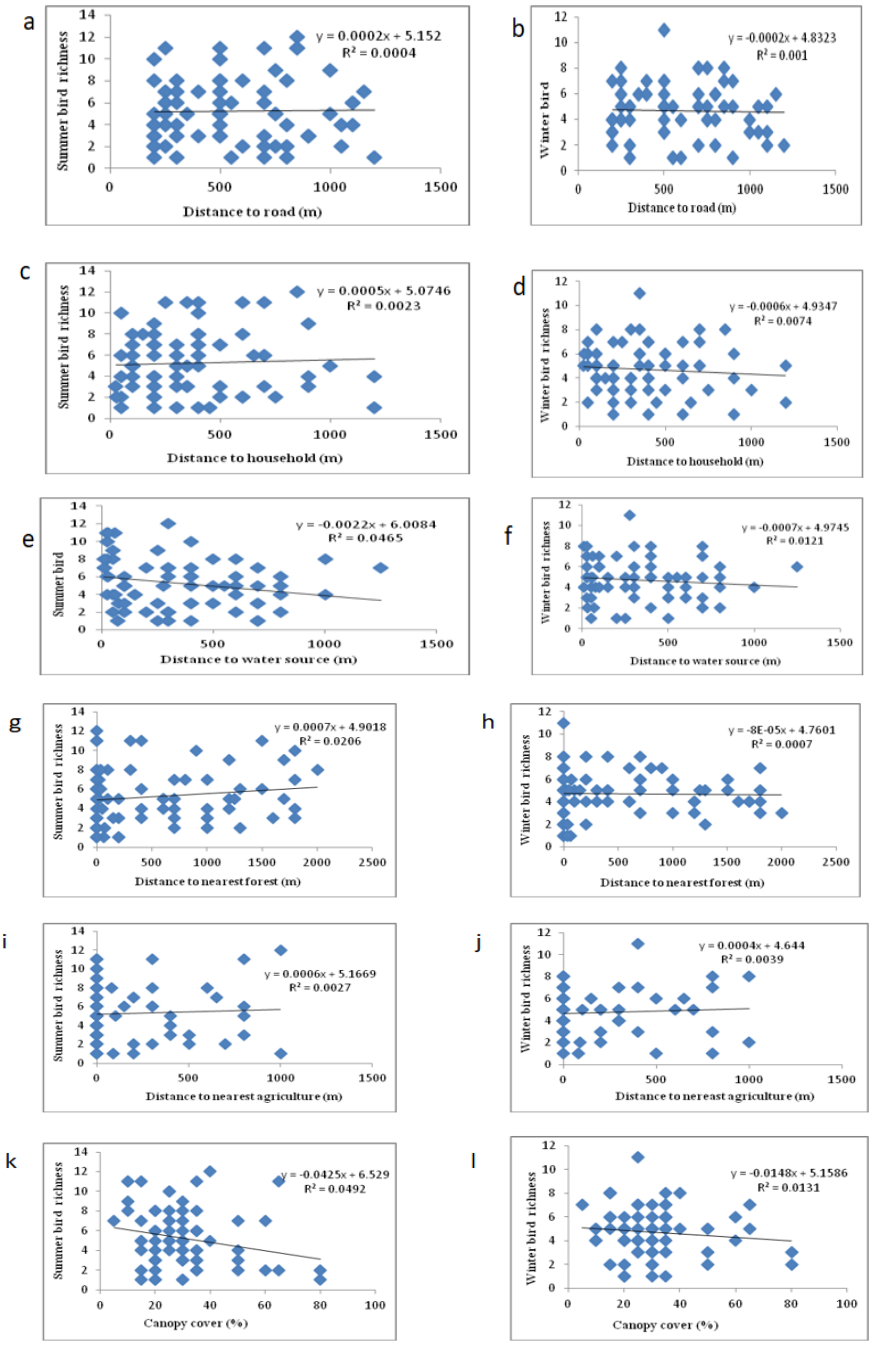

Figure 10 Logistic regression of bird species richness to different predictive variables at summer and winter seasons. Species richness with distance to the road a) summer and b) winter; distance to household c) summer and d) winter; distance to water source e)

summer and f) winter; distance to forest g) summer and h) winter; distance to agricultural land i) summer and j) winter and canopy cover k) summer and l) winter

The predictive variables were not highly correlated ($|r| < 0.7$); therefore, all variables were used for the Generalized Linear Model. The best-supported model was found with variables including canopy cover, distance to nearest water source and forest, followed by the model containing canopy cover, distance to the nearest water source, elevation, and forest (Appendix 4). The probability of bird species presence was less in plots with increasing elevation, canopy cover, distance to the water source, and distance to settlements (Table 4).

Table 4: Model-averaged parameter estimates and 95% confidence limits (CL) describing the occurrence of the bird species in Dullu Municipality, Nepal (Figure 1) during 2020. Model parameters include canopy cover (%), distance to settlement (m), Forest (m), distance to the road (m), distance to source (m), and elevation (m). Estimates were averaged from all models. *Significant effects are in bold.

Parameters	Estimate	SE	Lower LC	Upper LC	Z	p*
Intercept	2.50E+00	2.43E-01	2.02E+00	2.97E+00	10.264	**<0.001**
Canopy cover	-7.77E-03	3.66E-03	-1.49E-02	-5.93E-04	2.122	**0.034**
Distance to water source	-3.84E-04	1.70E-04	-7.17E-04	-5.02E-05	2.255	**0.024**
Forest	2.32E-01	1.06E-01	2.46E-02	4.40E-01	2.192	**0.028**
Elevation	-3.02E-04	2.66E-04	-8.25E-04	2.20E-04	1.135	0.256
Distance to road	6.72E-05	1.59E-04	-2.45E-04	3.79E-04	0.422	0.673
Distance to settlement	-4.26E-05	1.73E-04	-3.81E-04	2.96E-04	0.247	0.805

Canopy cover, distance to the water source, and forest habitat showed a significant role in bird presence (Table 4). Bird abundance increases with forest habitat, whereas bird abundance decreases with an increase in canopy cover and distance to the nearest water source.

5. DISCUSSION

In this study, the small area supports the occurrence of abundant bird species and species richness. Relatively high species diversity of avian fauna could be attributed to the various habitat types that constitute the area, probably for shelter and foraging opportunities (Girma et al. 2017). In addition, it might be due to variation in environmental factors like light, temperature, humidity, and precipitation in the mid-hill regions. In most of the habitats, the bird community changes seasonally due to resource bottlenecks for food and water availability and temperature (Avery and Riper 1989, Shoo et al. 2005). The occurrence of the highest number of birds for Passeriformes in the study area might be due to migratory birds or the residential behavior of birds in this order. Not only in this area, but the Passeriformes was also numerically dominant order in Khata corridor Forest, Nepal (Chaudhary et al. 2009), Nansebo Forest, Southern Ethiopia (Husein et al. 2019), and in Madhari Himal in Annapurna Conservation Area, Central Nepal (Pandey et al. 2020). The Muscicapidae, Phyllocopidae, Corvidae, Scotocercidae, and Leiotrichidae have higher species numbers in the study area, probably due to migratory birds, insectivorous and residential nature of the majority of birds under these families, which are dominant species in this study. These families are also prevalent in other areas, including the Kanchanjunga landscape and Western Nepal (Singh 2015, Kandel et al. 2018, Thakuri et al. 2018).

The species richness and diversity in the winter season was higher than the summer in the study area might be due to temporal variability in community structure, which can cause an increase in local movements and altitudinal migration in birds (Loiselle and Blake 1991, Barcante et al. 2017, Delany et al. 2017, Eyres et al. 2017). Seasonal variation affects the species richness and distribution (Cueto and deCasenave 2000, Katuwal et al. 2016, Katuwal et al. 2018, Neupaneet et al. 2020). Seasonal defoliation of plants in the winter season can support the occurrence of many foliage insects, the food of insectivorous birds (Katuwal et al. 2018, Tzortzakaki et al. 2018). In our study area, the insectivorous and omnivorous birds were abundant during the winter season due to the presence of migratory birds. In addition, the higher food availability in winter can be supported by the early flowering in the winter season (Harsha and Hosetti 2009, Acharya 2013). The low number of birds in the summer season might be due to migration time, observational bias due to the availability of thick leaves on trees, and the bird being less vocal during the breeding period could influence counting summer migrants (Katuwal et

al. 2018). Many birds are territorial during the breeding/summer season and also probably destroy the bird's breeding and feeding ground due to the rainy season (Desgranges et al. 2006). Generally, birds relocate to areas with a low risk of high physiological demands and increased resource availability (Beuel et al. 2016, Thakuri and Pokhrel 2017, Huang et al. 2019). In addition, photosynthetic activity and rates of biological processes in the environment can be changed by precipitation and temperature, which will influence birds' physiological tolerances (Patterson et al. 1998, Hurlbert and Haskell 2003, Wu et al. 2013).

In the study area, the higher number of winter migrants in the winter season might be due to favorable ecological and climatic conditions (Parajuli 2016). In the high and mid-mountain regions, the bird species richness decreased during the winter season above 3000 m of elevation, where the area was covered by snow and low energy available (Aryal 2013, Pandey et al. 2020). The seasonal movement patterns, local and regional habitat changes, large-scale population changes, and climatic conditions could cause variation in species abundance between seasons (Aynalem and Bekele 2008). The higher number of residential birds in the study area might be due to suitable habitat for residential species which can tolerate the local disturbances (Zhang et al. 2009).

This area also supports the occurrence of some nationally vulnerable birds, including Hume's Bush Warbler, Himalayan Vulture, and near-threatened birds, including Chukar Partridge, Yellow-Bellied Prinia, and Alexandrine Parakeet (IUCN 2018). The birds, including threatened species in the areas, can be vulnerable due to land-use practices. Generally, the land-use change influences the habitat, structure, and composition of species (Brawn et al. 2001). In the present study, bird diversity is higher in forests, and abundance is higher in low canopy cover and agricultural land. This might be due to the food and shelter available in the forest.

In addition, the area is adjunct to the agricultural land; therefore, the agro-forest can support the higher species abundance because of diverse habitats (Tanalgo et al. 2015). The species richness increases with increasing the distance to forest and distance to road, and the bird richness decreases with an increase in distance to settlement, distance to the water source, and canopy cover. Agro-forest can support the higher species richness because of diverse habitats (Tanalgo et al. 2015). In Annapurna Conservation Area, species richness is also negatively associated with distance to nearest water source and

distance to settlement (Pandey et al. 2020). Because anthropogenic pressure near human settlement can cause disturbances for the occurrence of birds (Adhikari et al. 2019), birds can fly and find the water sources easily; therefore, the distance to water sources at the local level does not matter for the occurrence of birds. A higher canopy decreases the bird species richness because it changes the microclimatic habitat, i.e., low light and low food available for birds.

6. CONCLUSION AND RECOMMENDATIONS

The Dullu Municipality supports different types of birds, including migrants, residential, endemic, and threatened species. Various environmental factors such as distance to the forest and social factors such as settlements act on the bird species occurrence. Some migratory birds are unique and need more research on why these species choose this particular habitat. In addition, an endemic species was found for both seasons, which also indicates the uniqueness of the bird habitat in the area.

Because of time and area of limitation, this study could not focus on the behavioral reason of bird migration in the area, therefore recommended for others to perform research on behavioral changes on bird migration in the Dullu area.

Globally, the bird species are declining; therefore, to prevent this trend in the Dullu area, a site-specific management plan is necessary because these areas also have vulnerable and near threatened birds.

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8. APPENDICES

Appendix 1 Checklist of Bird Species at Dullu Municipality

S.N	C.N	Scientific name	No	IUCN	National red list	MS	Habitat	Season	Feeding guild
1	Aberrant Bush Warbler	*Cettia flavolivacea*	29	LC	LC	Resident	B	W	Insectivorous
2	Alexandrine Parakeet	*Psittacula eupatria*	57	NT	NT	Resident	B	BS	Frugivorous
3	Ashy Drongo	*Dicrurus leucophacus*	3	LC	LC	Resident	A	W	Insectivorous
4	Asian Barred Owlet	*Glaucidium cuculoides*	2	LC	LC	Resident	A	BS	Carnivorous
5	Asian Koel	*Eudynamys scolopacea*	13	LC	LC	Resident	B	S	Omnivorous
6	Barn Swallow	*Hirundo rustica*	53	LC	LC	Resident	A	BS	Insectivorous
7	Bar-tailed Treecreeper	*Certhia hodgsoni*	1	LC	LC	Resident	F	W	Insectivorous
8	Black Bulbul	*Hypsipetes leucocephalus*	49	LC	LC	Resident	B	BS	Omnivorous
9	Black Drongo	*Dicrurus macrocercus*	19	LC	LC	Resident	B	BS	Insectivorous
10	Black-faced Warbler	*Abroscopus*	14	LC	LC	Resident	F	BS	Insectivorous

		schisticeps							
11	Black-headed Jay	*Garrulus lanceolatus*	3	LC	LC	Resident	B	W	Omnivorous
12	Black kite	*Milvus migrans*	5	LC	LC	Resident	B	BS	Carnivorous
13	Black Lored Tit	*Parus xanthogenys*	14	LC	LC	Resident	B	BS	Insectivorous
14	Black Redstart	*Phoenicurus ochruros*	2	LC	LC	Resident	A	W	Insectivorous
15	Black-throated Thrush	*Turdus atrogularis*	13	LC	DD	Winter migrant	A	W	Insectivorous
16	Black-throated Tit	*Aegithalos concinnus*	11	LC	LC	Resident	F	BS	Insectivorous
17	Blue Capped Redstart	*Phoenicurus coeruleocephala*	5	LC	LC	Resident	A	W	Insectivorous
18	Blue Rock Thrush	*Monticola solitarius*	12	LC	LC	Resident	B	BS	Insectivorous
19	Blue Whistling Thrush	*Myophonus caeruleus*	17	LC	LC	Resident	B	BS	Omnivorous
20	Blyth's Leaf Warbler	*Phylloscopus reguloides*	14	LC	LC	Resident	B	W	Insectivorous
21	Booted Warbler	*Iduna caligata*	8	LC	LC	Resident	A	W	Insectivorous
22	Brown Shrike	*Lanius cristatus*	2	LC	LC	Winter	B	W	Insectivorous

						migrant			
23	Buff Barred Warbler	*Phylloscopus pulcher*	2	LC	LC	Resident	F	W	Insectivorous
24	Chestnut Crowned Bush Warbler	*Cettia major*	8	LC	LC	Resident	F	W	Insectivorous
25	Chukar Partridge	*Alectoris chukar*	25	LC	NT	Resident	A	BS	Omnivorous
26	Common Chiffchaff	*Phylloscopus collybita*	4	LC	LC	Winter migrant	A	W	Insectivorous
27	Common Hoopoe	*Upupa epops*	3	LC	LC	Resident	B	BS	Insectivorous
28	Common Myna	*Acridotheres tristis*	138	LC	LC	Resident	B	BS	Omnivorous
29	Common Stonechat	*Saxicola torquata*	28	LC	LC	Resident	B	BS	Insectivorous
30	Common Tailorbird	*Orthotomus sutorius*	10	LC	LC	Resident	B	BS	Insectivorous
31	Crested Kingfisher	*Megaceryle lugubris*	2	LC	LC	Resident	A	BS	Carnivorous
32	Dusky Warbler	*Phylloscopus fuscatus*	4	LC	LC	Winter migrant	B	W	Insectivorous
33	Great Barbet	*Megalaima virens*	5	LC	LC	Resident	F	BS	Frugivorous
34	Great Tit	*Parus major*	27	LC	LC	Resident	B	BS	Insectivorous

35	Green Backed Tit	*Parus monticolus*	19	LC	LC	Resident	F	BS	Insectivorous
36	Greenish Warbler	*Phylloscopus trochiloides*	14	LC	LC	Winter migrant	B	W	Insectivorous
37	Grey Breasted Prinia	*Prinia hodgsonii*	33	LC	LC	Resident	A	BS	Insectivorous
38	Grey Bush Chat	*Saxicola ferreus*	14	LC	LC	Resident	A	BS	Insectivorous
39	Grey Hooded Warbler	*Seicercus xanthoschistos*	21	LC	LC	Resident	B	BS	Insectivorous
40	Grey Sided Bush Warbler	*Cettia brunnifrons*	2	LC	LC	Resident	F	W	Insectivorous
41	Grey Treepie	*Dendrocitta formosae*	24	LC	LC	Resident	B	BS	Omnivorous
42	Grey-capped Pygmy Woodpecker	*Dendrocopos canicapillus*	2	LC	LC	Resident	F	W	Insectivorous
43	Himalayan Bulbul	*Pycnonotus leucogenys*	135	LC	LC	Resident	B	BS	Omnivorous
44	Himalayan Vulture	*Gyps himalayensis*	2	NT	VU	Resident	A	S	Carnivorous
45	House Crow	*Corvus splendens*	6	LC	LC	Resident	A	S	Omnivorous
46	House Sparrow	*Passer domesticus*	61	LC	LC	Resident	B	BS	Granivorous

47	Hume's Bush Warbler	*Cettia brunnescens*	3	LC	VU	Resident	A	W	Insectivorous
48	Hume's Leaf Warbler	*Phylloscopus humei*	2	LC	LC	Resident	F	W	Insectivorous
49	Indian Golden Oriole	*Oriolus kundoo*	3	LC	LC	Summer migrant	A	S	Omnivorous
50	Indian Roller	*Coracias benghalensis*	4	LC	LC	Resident	A	BS	Insectivorous
51	Intermediate Egret	*Mesophoyx intermedia*	3	LC	LC	Resident	A	S	Carnivorous
52	Jungle Babbler	*Turdoides striata*	11	LC	LC	Resident	B	BS	Omnivorous
53	Kalij Pheasant	*Lophura leucomelanos*	22	LC	LC	Resident	B	W	Omnivorous
54	Large-billed Crow	*Corvus macrorhynchos*	33	LC	LC	Resident	B	BS	Omnivorous
55	Large Cuckooshrike	*Coracina macei*	5	LC	LC	Resident	F	BS	Insectivorous
56	Variegated Laughfingthrush	*Garrulax variegatus*	19	LC	LC	Resident	B	W	Omnivorous
57	Lemon-rumped Warbler	*Phylloscopus chloronotus*	10	LC	LC	Resident	F	W	Insectivorous
58	Long-tailed Minivet	*Pericrocotus*	9	LC	LC	Resident	B	W	Insectivorous

		ethologus							
59	Long Tailed Shrike	*Lanius schach*	13	LC	LC	Resident	B	BS	Carnivorous
60	Maroon Oriole	*Oriolus traillii*	2	LC	LC	Resident	F	W	Omnivorous
61	Olive-backed Pipit	*Anthus hodgsoni*	5	LC	LC	Resident	A	W	Insectivorous
62	Oriental Magpie Robin	*Copsychus saularis*	11	LC	LC	Resident	B	BS	Insectivorous
63	Oriental Turtle Dove	*Streptopelia orientalis*	37	LC	LC	Resident	B	BS	Granivorous
64	Oriental White-eye	*Zosterops palpebrosus*	7	LC	LC	Resident	B	BS	Omnivorous
65	Paddy-field Pipit	*Anthus rufulus*	13	LC	LC	Resident	A	BS	Insectivorous
66	Plain Flowerpecker	*Dicaeum concolor*	3	LC	LC	Resident	B	W	Nectarivorous
67	Pied Bush Chat	*Saxicola caprata*	21	LC	LC	Resident	B	BS	Insectivorous
68	Plumbeous Water Redstart	*Rhyacornis fuliginosus*	10	LC	LC	Resident	B	BS	Insectivorous
69	Purple Sunbird	*Cinnyris asiaticus*	2	LC	LC	Resident	A	S	Nectarivorous
70	Red-Billed Blue Magpie	*Urocissa erythrorhyncha*	22	LC	LC	Resident	B	BS	Frugivorous
71	Red Rumped	*Hirundo daurica*	15	LC	LC	Resident	A	S	Insectivorous

	Swallow								
72	Red-Vented Bulbul	*Pycnonotus cafer*	100	LC	LC	Resident	B	BS	Omnivorous
73	Common Pigeon	*Columba livia*	19	LC	LC	Resident	B	BS	Granivorous
74	Rufus Bellied Woodpecker	*Dendrocopos hyperythrus*	1	LC	LC	Resident	F	S	Insectivorous
75	Rose-ringed Parakeet	*Psittacula krameri*	34	LC	LC	Resident	B	BS	Frugivorous
76	Rufous Fronted Tit	*Aegithalos iouschistos*	2	LC	LC	Resident	F	W	Insectivorous
77	Rufous Sibia	*Malacias capistratus*	5	LC	LC	Resident	F	W	Omnivorous
78	Rufous Treepie	*Dendrocitta vagabunda*	38	LC	LC	Resident	B	BS	Frugivorous
79	Russet Sparrow	*Passer rutilans*	10	LC	LC	Resident	F	BS	Granivorous
80	Scaly Thrush	*Zoothera dauma*	1	LC	LC	Resident	F	W	Omnivorous
81	Scaly-breasted Munia	*Lonchura punctulata*	7	LC	LC	Resident	B	W	Granivorous
82	Scarlet Minivet	*Pericrocotus flammeus*	6	LC	LC	Resident	F	S	Insectivorous
83	Shikra	*Accipiter badius*	4	LC	LC	Resident	B	S	Carnivorous
84	Slaty-headed	*Psittacula*	22	LC	LC	Resident	F	BS	Frugivorous

	Parakeet	*himalayana*							
85	Spiny Babbler	*Turdoides nipalensis*	5	LC	LC	Resident	F	BS	Insectivorous
86	Clamorous Reed Warbler	*Acrocephalus stentoreus*	3	LC	LC	Winter migrant	F	W	Insectivorous
87	Spotted Dove	*Streptopelia chinensis*	14	LC	LC	Resident	B	BS	Granivorous
88	Striated Prinia	*Prinia crinigera*	38	LC	LC	Resident	B	BS	Insectivorous
89	Tickell's Leaf warbler	*Phylloscopus affinis*	7	LC	LC	Resident	A	W	Insectivorous
90	Western Crowned Warbler	*Phylloscopus occipitalis*	10	LC	LC	Passage migrant	F	S	Insectivorous
91	White Browed Wagtail	*Motacilla maderaspatensis*	4	LC	LC	Resident	A	BS	Insectivorous
92	White Capped Redstart	*Chaimarrornis leucocephalus*	8	LC	LC	Resident	B	BS	Insectivorous
93	White-throated Fantail	*Rhipidura albicollis*	3	LC	LC	Resident	B	BS	Insectivorous
94	White-throated Kingfisher	*Halcyon smyrnensis*	3	LC	LC	Resident	A	BS	Carnivorous
95	White Wagtail	*Motacilla alba*	4	LC	LC	Winter migrant	A	W	Insectivorous

96	White-throated Laughing Thrush	*Garrulax albogularis*	8	LC	LC	Resident	F	BS	Omnivorous
97	Yellow-bellied Fantail	*Rhipidura hypoxantha*	3	LC	LC	Resident	F	W	Insectivorous
98	Yellow-bellied Prinia	*Prinia flaviventris*	2	LC	NT	Resident	A	W	Insectivorous

IUCN = International Union Conservation of Nature, MS = Migration Status, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, DD = Data Deficient, B = Both Habitat, A = Agriculture Habitat, F = Forest Habitat, W = Winter Season, S = Summer Season, BS = Both Seasons.

Appendix 2 List of birds recorded in different seasons and habitats.

S.N	Common Name	Winter season	Summer season	Agricultural habitat	Forest habitat
1	Aberrant Bush Warbler	29	0	19	10
2	Alexandrine Parakeet	37	20	43	14
3	Ashy Drongo	3	0	3	0
4	Asian Barred Owlet	1	1	2	0
5	Asian Koel	0	13	6	7
6	Barn Swallow	17	36	53	0
7	Bar-tailed Treecreeper	1	0	0	1
8	Black Bulbul	49	17	8	41
9	Black Drongo	12	10	9	10
10	Black Faced Warbler	4	12	0	14
11	Black Headed Jay	3	0	1	2
12	Black Kite	2	3	4	1
13	Black Lored Tit	8	6	5	9
14	Black Redstart	2	0	2	0
15	Black-throated Thrush	13	0	13	0
16	Black-throated Tit	7	5	0	11
17	Blue Capped Redstart	5	0	5	0
18	Blue Rock Thrush	6	6	10	2
19	Blue Whistling Thrush	12	11	8	9

20	Blyth's Leaf Warbler	14	0	5	9
21	Booted Warbler	8	0	8	0
22	Brown Shrike	2	0	1	1
23	Buff Barred Warbler	2	0	0	2
24	Chestnut Crowned Bush Warbler	8	0	0	8
25	Chukar Partridge	18	12	25	0
26	Common Chiffchaff	4	0	4	0
27	Common Hoopoe	2	1	1	2
28	Common Myna	126	94	109	29
29	Common Stonechat	15	17	22	6
30	Common Tailorbird	8	5	8	2
31	Crested Kingfisher	2	1	2	0
32	Dusky Warbler	4	0	1	3
33	Great Barbet	2	3	0	5
34	Great tit	14	20	19	8
35	Green Backed Tit	10	9	0	19
36	Greenish Warbler	14	0	4	10
37	Grey Breasted Prinia	23	14	33	0
38	Grey Bush Chat	9	7	14	0
39	Grey Hooded Warbler	10	13	10	11
40	Grey Sided Bush Warbler	2	0	0	2
41	Grey Treepie	14	12	8	16

42	Grey-capped pygmy woodpecker	2	0	0	2
43	Himalayan Bulbul	105	69	72	63
44	Himalayan Vulture	0	2	2	0
45	House Crow	0	6	6	0
46	House sparrow	34	48	56	5
47	Hume's Bush Warbler	3	0	3	0
48	Hume's Leaf Warbler	2	0	0	2
49	Indian Golden Oriole	0	3	3	0
50	Indian Roller	4	2	4	0
51	Intermediate Egret	0	3	3	0
52	Jungle Babbler	7	4	2	9
53	Kalij Pheasant	22	0	2	20
54	Large-billed Crow	21	18	23	10
55	Large Cuckoo Shrike	2	3	0	5
56	Variegated Laughfingthrush	19	0	5	14
57	Lemon-rumped Warbler	10	0	0	10
58	Long-tailed Minivet	9	0	4	5
59	Long Tailed Shrike	4	11	7	6
60	Maroon Oriole	2	0	0	2
61	Olive-backed Pipit	5	0	5	0
62	Oriental Magpie Robin	4	8	10	1
63	Oriental Turtle Dove	24	17	23	14

64	Oriental white-eye	3	4	3	4
65	Paddy-field Pipit	5	9	13	0
66	Plain Flowerpecker	3	0	2	1
67	Pied Bush Chat	15	14	16	5
68	Plumbeous Water Redstart	5	6	8	2
69	Purple Sunbird	0	2	2	0
70	Red-billed Blue Magpie	13	13	2	20
71	Red Rumped Swallow	0	15	15	0
72	Red-Vented Bulbul	66	87	67	33
73	Common Pigeon	9	14	7	12
74	Rufus Bellied Woodpecker	0	1	0	1
75	Rose-ringed Parakeet	19	21	17	17
76	Rufous Fronted Tit	2	0	0	2
77	Rufous Sibia	5	0	0	5
78	Rufous Treepie	30	21	21	17
79	Russet Sparrow	5	9	0	10
80	Scaly Thrush	1	0	0	1
81	Scaly-breasted Munia	7	0	1	6
82	Scarlet Minivet	0	6	0	6
83	Shikra	0	4	3	1
84	Slaty-headed Parakeet	22	15	0	22
85	Spiny Babbler	2	3	0	5

86	Clamorous Reed Warbler	3	0	0	3
87	Spotted Dove	6	11	11	3
88	Striated Prinia	20	18	33	5
89	Tickell's Leaf Warbler	7	0	7	0
90	Western Crowned Warbler	0	10	0	10
91	White Browed Wagtail	1	3	4	0
92	White Capped Redstart	3	5	5	3
93	White-throated Fantail	2	1	2	1
94	White-Throated Kingfisher	3	2	3	0
95	White Wagtail	4	0	4	0
96	White-throated Laughing Thrush	4	4	0	8
97	Yellow-bellied Fantail	3	0	0	3
98	Yellow-bellied Prinia	2	0	2	0

Appendix 3 Total Orders and Families of the Birds Recorded in Study Area

S.N	Order	Family	No of species
1	Accipitriformes	Accipitridae	3
2	Bucerotiformes	Upupidae	1
3	Columbiformes	Columbidae	3
4	Coraciiformes	Alcedinidae	2
		Coraciidae	1
5	Cuculiformes	Cuculidae	1
6	Galliformes	Phasianidae	2
7	Passeriformes	Acrocephalidae	1
		Certhiidae	1
		Estrildidae	1
		Locustellidae	1
		Nectariniidae	1
		Rhipiduridae	1
		Stenostiridae	1
		Sturnidae	1
		Zosteropidae	1
		Aegithalidae	2
		Hirundinidae	2

		Laniidae	2
		Oriolidae	2
		Passeridae	2
		Turdidae	2
		Campephagidae	3
		Dicruridae	3
		Paridae	3
		Pycnonotidae	3
		Cisticolidae	4
		Motacillidae	4
		Leiotrichidae	5
		Scotocercidae	5
		Corvidae	6
		Muscicapidae	10
		Phylloscopidae	10
8	Pelecaniformes	Ardeidae	1
9	Piciformes	Megalaimidae	1
		Picidae	2
10	Psittaciformes	Psittacidae	3

11	Strigiformes	Strigidae	1

Appendix 4 Logistic regression models describing the occurrence of the bird species in Dullu Municipality, Nepal (Figure 1) during 2020, ranked according to the Akaike Information criterion adjusted for small sample size (AICc). Model parameters include Canopy Cover (%), distance to settlement (m), Forest (m), distance to the road (m), distance to the water source (m), and elevation (m) as predictive variables and abundance of bird species as response variables. K is the number of parameters, ΔAICc is the difference between the AICc value of the best-supported model and successive models, and wi is the Akaike model weight.

Models	K	AICc	ΔAICc	Wi
Canopy Cover + Distance To Water Source + Forest	4	391.2	0	0.196
Canopy Cover + Distance To Water Source + Elevation + Forest	5	392.3	1.18	0.109
Canopy Cover + Distance To Road + Distance To Water Source + Forest	5	393	1.8	0.08
Canopy Cover + Distance To Settlement + Distance To Water Source + Forest	5	393.1	1.92	0.075
Canopy Cover + Distance To Settlement + Distance To Water Source + Elevation + Forest	6	394.2	3.04	0.043
Canopy Cover + Distance To Road + Distance To Water Source + Elevation + Forest	6	394.2	3.05	0.043
Canopy Cover + Elevation + Forest	4	394.5	3.3	0.038
Canopy Cover + Distance To Settlement + Distance To Road + Distance To Water Source + Forest	6	394.6	3.42	0.035
Canopy Cover + Distance To Water Source	3	394.6	3.47	0.035
Distance To Water Source + Elevation + Forest	4	395	3.85	0.029

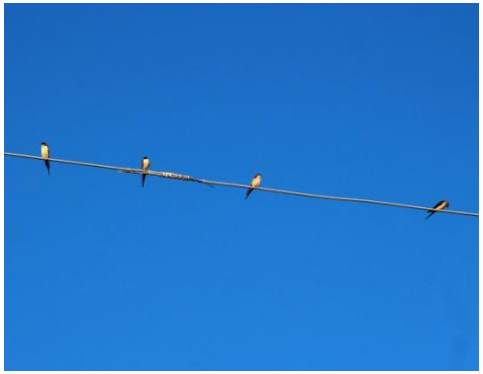
Elevation + Forest	3	395.7	4.54	0.02
Canopy Cover + Distance To Settlement + Distance To Road + Distance To Water Source + Elevation + Forest	7	395.8	4.62	0.019
Distance To Water Source	2	395.9	4.75	0.018
Canopy Cover + Distance To Road + Distance To Water Source	4	396.2	5.09	0.015
Canopy Cover + Distance To Settlement + Distance To Water Source	4	396.4	5.24	0.014

9. PHOTO PLATES

 **Chukar Partridge**	 **Intermediate Egret**	 **Himalayan Vulture**
 **Shikra**	 **Black Kite**	 **Oriental Turtle Dove**

 **Spotted Dove**	 **Slaty-headed Parakeet**	 **Asian Barred Owlet**
 **White-throated Kingfisher**	 **Crested Kingfisher**	 **Indian Roller**

 **Great Barbet**	 **Fulvous-breasted Woodpecker**	 **Scarlet Minivet**
 **Long-tailed Minivet**	 **Long-tailed Shrike**	 **Rufous Treepie**

 **Red-billed Blue Magpie**	 **House Crow**	 **Large-billed Crow**
 **Great Tit**	 **Red-rumped Swallow**	 **Himalayan Bulbul**

 **Red-vented Bulbul**	 **Variegated Laughingthrush**	 **Common Myna**
 **Blue Wishtling Thrush**	 **Blue-capped Redstart**	 **Oriental Magpie Robin**

 **White-capped Redstart**	 **Plumbeous Water Redstart**	 **Scaly-breasted Munia**
 **White Wagtail**	 **Paddyfield Pipit**	 **Common Stonechat**

		
Pied Bushchat	**Lesser Racket-tailed Drango**	**Black Drongo**
		
Brown Shrike	**Yellow-bellied Fantail**	**Russet Sparrow**

		
White-throated Laughingthrush	**Blue Rock Thrush**	**Green-backed Tit**
		
Black Bulbul	**Tickell's Leaf Warbler**	**White-throated Fantail**